UNIVERSITY OF BORÅS
SCHOOL OF ENGINEERING

Small scale Renewable Energy (SSRE)

A Supply Chain Design Case Study

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Abstract

This master thesis was handed out by Miljöbron 2011 and the thesis has been carried out at Small scale Renewable Energy (SSRE) which is a newly launched company in Tidaholm, Sweden. SSRE offers small scale solutions for green energy solutions, wind turbines and solar panels, targeting private individuals and small enterprises. The purpose with the report is to, with the help of scenarios, present information to SSRE before they design their supply chain for a future expansion. This report will look into one of SSRE's products, the VT which is a wind turbine consisting of basically three parts; frame, wings and generator. Interviews have been carried out in order to establish concrete and qualitative information.

Two markets have been researched; United Kingdom and Mexico. These markets are actual markets for SSRE with a future expansion because of previous/present requests from these countries. The report has been carried out in a way that different scenarios became created for give SSRE help on deciding how their supply chain could look like and/or if they should start their production in respectively country. Today the supply chain is consisting of basically two parts SSRE themselves, producing wings and generator, and Mechanical Production Company (MPC) that are producing the frame also located in Tidaholm. SSRE don't want to be produces and with the help of the different scenarios they can decide how to make changes in the chain in a good manner. Results between the UK and Sweden scenarios were not that different, while the difference was bigger compared with Mexico. The generator part could become a bottleneck when high cost almost forces the production to be located in China. Conclusions made are that with the small differences in some of the scenarios it is recommended for the two markets keeping production in Sweden for the UK and further research the opportunity in having production in Mexico.

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1 Introduction

In the following introduction chapter the background for the report subject, objects and its reasons becomes explained and the purpose of the thesis and the limitations will be described as well.

1.1 Background

1.1.1 Renewable energy

Energy can be divided into two main categories; conventional and renewable, (Patel 1999). The conventional energy, more known as fossil fuel, comes from coal, nuclear, oil, natural gas and all contribute to global warming. Renewable energy on the other side comes from mainly biomass, wind and solar stations. Maczulak (2010), headlights the world's increasing energy consumption between one to three percent per year and thus renewable energy technologies are a critical subject. He makes a comparison with today's utilization of resources and that it is in relevance of 1.21 earths supply needed to support the world consumption. Maczulak (2010) explains, that renewable energy means natural processes that can be replaced over time, but that this could take some time replacing (the sun and the wind are not always shining and blowing). In the total energy supply world over about 25 percent comes from renewable energy sources, (Sørensen 2004).

1.1.2 Wind turbine

The principle of a wind turbine is in practice simple, but can be some more difficult in theory. Air mass that gets heated and warmed by the sun rise meanwhile air masses that are or become colder are heavier and therefore sinks. The different temperatures from the cold and warm air creates a turbulence which in turn creates air currents, kinetic energy, or i.e. wind blowing, (Manwell, McGowan and Rogers 2009). They also describe the sea acting as a big source of energy, creating different pressure resulting in movements of the air. It is the kinetic energy from these air currents that with the help from the air turbines becomes transformed into electricity. When it is blowing the wind generates speed for the wings on the wind turbine and in turn a generator gets going where the energy is generated for creating electricity. Before the energy becomes applicable electricity, it must be transformed and transported out on the power grid, (The market director 2011). The transforming is executed by an inverter and the energy becomes electricity. The water power station can store its energy in reservoir, opposite to the wind turbines that only can utilize the generated energy when it blows.

Humans have used air currents for many reasons and for many centuries. In the ancient Egypt they first used the currents for long sailing and in the 1200 century it became introduced in Europe to be used for wind mills that is a forerunner for the wind turbines of today. The present wind turbines can be categorized into two categories with either a vertical or horizontal axis machines (Figure 1), (Sathyajith 2006). The arrows in figure 1 shows in what directions the turbine can generate the wind from.

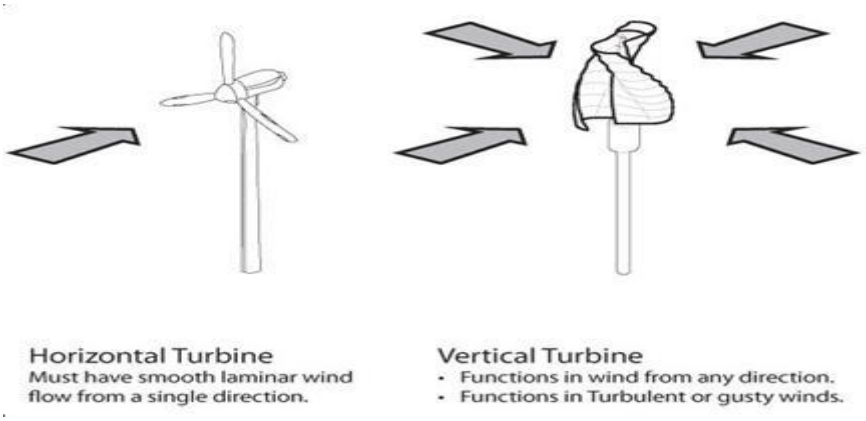

Figure 1 –Horizontal and vertical turbine, Igreenspot (2011)

Wind turbines with horizontal axle have higher efficiency, (Manwell, McGowan and Rogers 2009), even though a vertical axle can generate energy from any direction. A wind turbine could generate energy during 90 percent of one year's total hours with normal wind conditions, (Gipe 2004, Vattenfall 2011 and Svensk Energi 2011). Some wind turbines are built to be self-constraining when the wind is too powerful and can control the rotation on the wings by using self-regulating brakes or with help of a transmission, (Gipe 2009). This is to not create unnecessary tearing on the turbine as well as it is a safety factor. Turbines manufactured today are created to resist storms up to 40 m/s which could be compared to the Swedish storm Gudrun 2005, (Vattenfall 2011).

The energy utilized for producing, installing, maintenance and dismantle of a wind turbine is paid back with generated energy 80 times that during the turbine's life time, (Vattenfall 2011). An active turbine has a life cycle of 20-25 years and concern both land based turbines as well as sea based, (Wengenmayr and Bührke 2008). The size of the rotor diameter matters in terms of generating energy and can differ from 0.5 meter up to nearly 100 meter in diameter generating 20 watts respectively about 3,000,000 watts, (Gipe 2004). He divided the turbines into household-size, medium-size and large wind turbines (see figure 2). The household turbines can generate up to 10kW, the medium-size between 10 kW – 3 MW and the large 3 MW and rising. There can also be seen from figure 2 that household-sized wind turbines are about 25 meters high compared to the large that are above 80-100 meters.

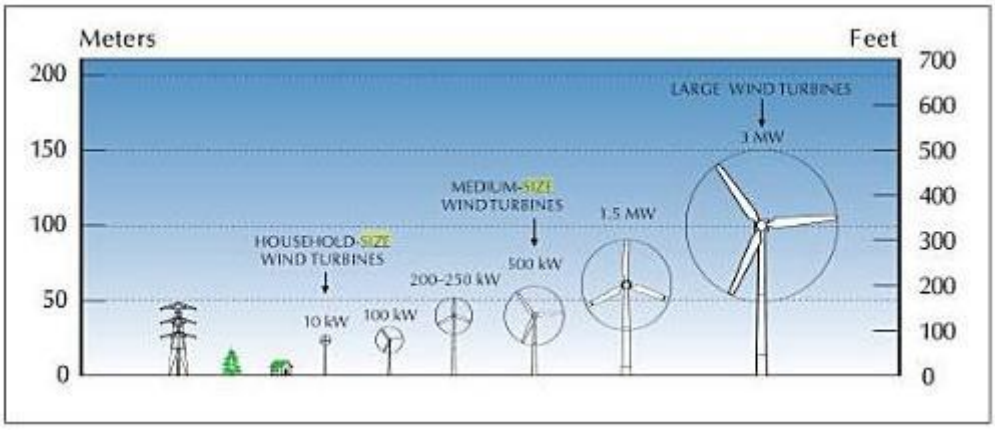

Figure 2 – Different wind turbines sizes and categories, Gipe (2004)

Turbines located at sea would generate about 50 percent more energy due to more wind, (Wengenmayr and Bührke, 2008). The biggest turbines in Sweden generate three megawatt (MW) in

comparison to Europe's that is six MW and in the future designs for reaching 10-20 MW are developing, (Svensk Energi 2011). It is important to choose the right design for a turbine for the air conditions for its contemplated location, i.e. how much air currents there is and how the wind differs over time, (Gipe 2004). Wizelius (2007) shows, how the effect that is generated work in relation with the diameter of the wings. A turbine designed with a relative big rotor (long, big wings) and a small generator (low effect) is good to utilize low wind speeds, generating energy for many hours during a year, but will only generate energy in constrained form at higher wind speeds, (Vattenfall 2011). A turbine with the opposite relations (small wings and big generator) is more efficient at high wind conditions and less efficient at low wind conditions.

1.1.3 Wind turbines in Sweden

A modern wind turbine in Sweden could generate 1-2 MW a year which is about two million kilowatt-hours (kWh) and this is equivalent to support approximately 100 households with electricity as well as to heating the house using electricity, (Sevens Energy 2011).According to Vattenfall (2011), the horizontal turbines are those with the most effect to produce energy safe and economically. They also (2011)discuss, for building wind farms (more than seven wind turbines) permissions according to miljöbalken is required and for building less than seven turbines and lower than 150 meters high in one area there is an possibility for just applying for a building license. The building license is applied for in the municipality that it concern.

At the end of 2010 there were 1700 wind turbines in Sweden generating energy about 3.5 TWh. The government has set a goal for 2020 to increase up to 30 terawatt-hours (TWh) from which 10 TWh should come from sea based turbines, (Svensk Energi 2011). This in turn could lead to that the power grid has to be updated in order to be able to respond on the energy from the wind turbines depending on where they are located. The total production and consumption of electricity in Sweden today is 150 TWh whereof 50-75 TWh are generated from water power, (Svensk Energi 2011).

1.1.4 Wind turbines in focus world over

Japan are today the country with the most renewable energy coming from wind turbines and the catastrophe with their nuclear reactor wills most certain put more focus on renewable energy world over, thanks to that the wind turbines manage the earthquake 2011 and it will become even more important for the Japanese, (Sevens Vandenberg 2011). In the US Google and two Japanese companies is planning of building the world biggest wind farm in the state of Oregon and are planned to generate 845 MW equivalent of giving electricity to 235 000 houses, (Svensk Energi 2011). This in turn could also yearly save the pollution of 1.5 million tons carbon dioxide from coal plants. In Europe the wind energy stands for 4.2 percent of the total energy consumption and is set to be 14 percent in 2020 by EU.

1.2 Problem Background

This master thesis was handed out by Miljöbron, which is a non-profitable organization with an environmental perspective, (Miljöbron 2011). They connect students with companies and

organizations. Miljöbron also supervise and support, offering help for the students to a certain extent. The company in this report will be referred to as Small scale Renewable Energy (SSRE) and the contact persons interviewed will be named the market director and the inventor. The real name of the company and the interviewed persons will not be mentioned, since the report contains information and data, sensitive to the company. For the same reason the vital subcontractor of the frame will be referred to as Mechanical Production Company (MPC).

Small scale Renewable Energy is a newly started company that provides small scale solar and wind energy solutions for private persons and small companies. They have developed a vertical wind turbine, the VT which will be ready for limited promotional sales in Sweden during 2011. However, demand is by far larger outside Sweden as 80 percent of the sales are estimated to be made in foreign markets in the future, (The market director 2011). The VT wind turbine consists of three main parts with different manufacturing processes, wings, generator and frame. SSRE does not want to own the manufacturing, thus procurement will be outsourced to subcontractors, (The market director 2011). Currently close collaboration with a subcontractor manufacturer of the frame is ongoing while subcontractors for the wings and generators are still being prospected. For the wings, a Swedish subcontractor is of most interest. For the generator a SSRE collaboration partner experienced in the Chinese market is currently evaluating options for sourcing the generator from China.

1.3 Problem Description

When export of the VT vertical wind turbine come in question, SSRE want to supply the markets at low cost and environment impact, i.e. the flow of goods should be optimized in regard to these parameters, (Miljöbron 2011). The research question is where subcontractor manufacturing for each of the three main parts is best located to supply foreign markets. United Kingdom and Mexico were decided as reference markets as they are circumstantially different and because SSRE find them interesting, (The market director 2011). United Kingdom is a closer market with a European Union membership in common with Sweden. Mexico is a distant market with regulated import, (Johannisson 2011). Scenarios describing these supply chain setups will be compared in regard to estimated manufacturing and logistics costs, lead times and discussion about circumstances and possible environment improvements. The price of the VT is set to an equivalent of 70,000 SEK after value added tax (VAT) is added, (The market director 2011). The estimated costs per VT unit in each scenario will be compared to the revenue, i.e. the price before VAT is added. Since VAT tariffs vary globally, the revenue depends on the levels in UK and Mexico respectively.

1.4 Purpose

The purpose is to compare the scenarios to point towards a strategically better supply chain setup. A comprehensive comparison is purposed, including both measurable and comparable data as well as circumstantial descriptions to give a more complete picture.

1.5 Limitations

The VT wind turbine is in an early stage of the product development. Many processes such as package design have not yet been decided upon, thus cost or physical property data entries could be obtained. In this case estimations have been made in consultation with SSRE and in other cases the data entries have been left out as variables. This limitation should not affect the results significantly since, a) scenarios with the same absent data entries are still comparable in relation, b) the missing data entries have been accounted for.

Since SSRE want to distribute the VT via resellers yet unknown, research of the supply chain stops at arbitrary border locations in UK and Mexico respectively were the resellers are responsible for further handling of the goods. Further, the supply chain research stops at the subcontractors in the other direction since their procuring processes are included in the costs and lead times. Finally, demand is left out in any means except that the final consumer supposedly accepts a price of 70,000 SEK.

2 Company Description

The company and its products will become known and an introduction of the markets, United Kingdom and Mexico, will be described.

2.1 Organization

SSRE is a newly started company in the middle of Sweden, Tidaholm. Their business idea is to produce and sell small-scale wind turbines and solar panels to private customers and small companies, who want to be self-producing of green renewable energy. Their products are designed and manufactured in order to be bought and installed without a building permission. Solutions for both wind turbines and solar panels are offered, so-called hybrid system combining them together. The products are quality tested and come with a long guarantee certificate. In the management board at SSRE there are people with high knowledge and experience such as professors, engineers, industry designers, constructors, innovators and economists. SSRE are working with partners within energy extraction, battery technology, house constructions and illumination and offer their clients a whole package energy solution with the products from their partners' companies. The renewable energy system is a good complement to the regular connection but the power supply cannot replace it by 100 percent. The company has many new started projects within green energy such as self-supporting summer residences and many more.

2.2 Products

SSRE have three different wind turbines on the market; the VT, SpeedX and Windstar 3000. It is only the VT that have vertical axle and the other two have horizontal axles. All are small-scale turbines and can be installed without building permission. The SpeedX is the smallest of the three with a rotor diameter of 1,8meters, while the other two have a rotor diameter of 3meters. All three are designed to be quiet when they are in use and able to be connected to solar panels, a hybrid system. The wind turbines and the solar panels can be connected to the same battery and the same electricity inverter when they are in a hybrid system. A complimentary product is a stand which enables the solar panels to change directions, following the sun as it changes. This is a solution which enables the best capacity utilization of the sun's energy. The solar panels come with a guarantee certificate which secures them to utilize 80 percent of its capacity after 25 years. The VT is their newest product and they have high expectations for it. The VT starts itself when the conditions are right in order to produce energy which makes it interesting compared to turbines with horizontal axels, which needs a specific wind speed before being able to generate.

2.3 Production

At the moment, only prototypes have been made of the VT and during the year of 2011, SSRE plans to produce around ten units for commercial targeted sales. This strategy is in order to establish their name on the market and get good references. The frame is being produced at MPC in Tidaholm,

while the wing and the generator will temporarily be produced at the inventor, the inventor`s place close to Tidaholm, (The market director2011).

This is only a temporary solution and will not become standard. In the future when the volumes are expected to increase they will use subcontractors for the supply of generators and the wings. It is mentioned that they want to offer high standard and high quality of their products, (The market director 2011). This strategy keeping the production in a tight and close area gives better control in the ramp-up stage and for keeping a high quality and security of the products.

2.3 Markets

The goal for SSRE is to use retailers for selling their products, set to 2012, but this is not the situation today, as they sell their products themselves. Stock is currently situated at their facilities; MPC and are also in the future wanted to be located at the retailers.

2.3.1 Sweden

As said before the Swedish market is mostly interesting in the beginning when establishing their name and products on the market. The Swedish market is important but not seemed as the main market at this moment. It is estimated that exported sales will amount to 80 percent of the total sale, (The market director 2011). He further says that for the Swedish market to become more of an interest to SSRE, the regulations concerning self-producing energy must become more favorable for the private individual.

2.3.2 United Kingdom

According to RenewableUK (2011) the potential of small wind systems (see table 1) is big in the United Kingdom considering the annual growth of 65 percent registered 2010.Next coming year it is estimating to grow more and especially in large grid-connected turbines. Today there are more than twenty UK-based manufactures of small wind systems. Table X shows the classification of small wind turbines, how much capacity they produce, the annually energy produced, total height and the cost for installing them. Also there can be seen how much kWh the average UK household consumes in a year, 4,400 kWh.

Table 1 – Small wind systems, RenewableUK (2011)

Figure 1: Small wind systems				
	Power (kW)	Annual energy production (kWh)	Total height (m)	Total installed cost (£k)
Micro wind	0 – 1.5	Up to 1,000	10 – 18	0.5 – 5
Small wind	1.5 – 15	Up to 50,000	12 – 25	2 – 50
Small-medium wind	15 – 100	Up to 200,000	15 – 50	50 – 250

Note: The average UK domestic household consumes approximately 4,400 kWh per year.

It is estimated to be a potential for the future to install 600,000 small wind systems in UK, compared to about the 20,000 installed today, (RenewableUK 2011). Here it can also be read that the total small-scale installed capacity is about 43 MW compared to the governmental goal of 1,300 MW year 2020.The highly increasing interest could be thanks to the attractive Feed-in-Tariff in combination with that people becoming more aware of the environmental situation and heavily increased consumer prizes of fossil fuel. The feed-in-tariff is divided into two areas: generation and export where the generation part gives a fixed income for every kWh generated and used and the export part gives an additional fixed income for every kWh generated back to the grid, (Feed-in tariffs UK 2011). The UK government has set a goal for 2020 to reach 15 percent renewable energy of the total consumption, of some include small-scale turbines, (Department of energy & climate change 2009). About 19,000 small wind systems have been exported from the UK, (RenewableUK 2011). Figures from the report shows that horizontal axis designed turbines today is the most common model but discusses that the vertical axle which is a relatively new design will probably grow in coming future.

2.3.3 Mexico

Wind energy is at its very beginning in Mexico, but has a goal to reach six percent at national level year 2030 and the theoretical wind potential is enormous, (Klapp, Cervantes-Cota and Alcalá 2007). One problem is mentioned concerning the wind energy; the legalization for electricity generated by the private person, due to the political control over the electricity business. There is also said that Mexico lacks of knowledge about renewable energy and that this could influence the economy.

Smith and Taylor (2008) discuss, that the Mexican economy depend on oil energy up to almost 60 percent of the total consumption, but that the reliance of imported oil have brought potential for renewable energy as a solution in energy security. They mention that one of the barriers, when implementing renewable energy in Mexico, was taken away in 2003 and through a new law net metering was allowed when according renewable energy.

Renewable energy sources such as geothermal power, that is accessible only in limited areas, are utilized in Mexico who is the third in the world in producing this energy, (Klapp, Cervantes-Cota and Alcalá 2007). Due to that geothermal power has long project development times, is costly and holds high risk, wind turbines and other alternatives are scouted. A long-term goal was stated at the end of 2008 to reduce greenhouse gas emissions with 50 percent compared with the level of2000 by the year 2050 and a “Sustainable Energy Program” was launched2009, (Liu, Meyer and Hogan 2010). Other things mentioned that are under consideration are green building legislation which has high potential. The installed wind-energy capacity of2006 was 85 MW in Mexico and the total energy production consisted of 90 percent fossil fuels, (Klapp, Cervantes-Cota, and Alcalá 2007).

2.3.4 Customer segment

SSRE produce and aim their sells toward private individuals and small-scale companies that want to be self-supplying of energy, (The market director 2011). He also mentions that there are three main customer segments concerning the private individuals that SSRE aim for: villa owners’ living sparsely populated, summer cottages and farmers. These customer segments seem to be the best for utilizing

their products due to recommendations regarding the distance needed between the turbine and surrounding objects. SSRE market their products to all individuals without restrictions to prior knowledge of self-supplying energy production. In order to assemble such a turbine it is helpful if one is handy or experienced so the customer may need to consolidate with a friend or rent help when installing the system if not experienced, (The market director 2011). The UK market is well established, similar to the German market, where small-scale energy solutions are a big market, (The market director 2011).He also mentions that SSRE has a contact located in Mexico working with house projects. Some of these projects are self-producing and -supplying of energy, which makes SSRE products interesting to similar future projects in Mexico.

3 Methodology

In this chapter methodology methods are presented and the thesis validity and reliability are discussed.

3.1 Quantitative and qualitative

Quantitative and qualitative means how the data has been collected, produced and analyzed based on the information gathered. Quantitative research are those that are measuring data collections, statistic processing and analyze methods, (Patel and Davidsson 2008). While qualitative are explained research where the data collection are focused on “soft” data e.g. interviews, interpret analysis and often verbal analyzing method of text material. Both qualitative and quantitative data has been collected from the interviews. The qualitative in form of information of strategies, conditions, how long they are in the developing stage etc. and the quantitative in form of lead times, costs digits, pictures etc.

3.2 Primary and secondary data

Primary data are collected of oneself, while secondary data are collected from external sources and are more risky, often from books and articles, (Boone, Kurtzh, MacKenzie and Snow 2007). Also discussed are the gathering of primary data which are more time-consuming and often more expensive to obtain. In the report, interviews and a field study were carried out in order to gather primary information. Secondary data such as theories and other suitable information were collected from literature. The gathered primary information has been compared and discussed against the secondary data for further evaluation and enabled a better result in the report.

3.3 Case study

In case studies detailed information is collected over a sustained period of time and the researchers explores in depth a program, an event, an activity, a process, or one more individuals, (Stake 1995). Action research in case studies means actively participating in the project, often changing process in an organization, connected with system thinking, (Checkland 1993), while in ethnographic case studies the key is observing, (Silverman 1993).An explorative research means gathering as much information as possible in a specific area, with great creativity and a wealth of ideas, (Patel and Davidsson 2008). Yin (1989), discuss the strength in case studies to be the key elements, building a chain of evidence, during the project. Gillham (2000), on the other hand discuss that in a case study it is important to be aware of prejudice such as “I expect to find” and “What I want to find”, or else the result can become misjudging. This case study could be seen as explorative gathering of as much information as possible concerning the future expansion for SSRE. The prejudice of “I expect to find” has been the one to be aware of, due to that the authors are seemed as an outside part of the company. SSRE on the other hand could be more aware to the prejudice of “What I want to find”.

3.4 Abductive, deductive and inductive

Kovàcs and Spens (2005) explain and discuss abductive, deductive and inductive as following: Deductive methodology reasons from a general law, a theory, to a specific case, testing already existing theories. The inductive methodology moves in the opposite direction of deductive and reasons from a specific case or several cases, facts, into a general law, theory. Abductive methodology is believed that neither pure deduction nor pure induction leads to new advances. The abductive methodology encourages looking at the situation from different perspective and must not follow a logical approach. The creative aspects of an abductive methodology makes it suitable in a research concerning early processes, creating hypothesis and propositions that later are tested in a deductive phase. Kovàcs and Spens (2005) distinguish the divergence between the three different approaches showing indication of: The starting point, the aim and the point in which they draw their final conclusions. This thesis started in an inductive way going from a specific case and information towards theories. The theories gathered then were analyzed and evaluated in a deductive way in order to see if useful. This shows that it can be argued that the thesis has been carried out in an abductive way. The thesis concern early processes where hypothesis are created as well as propositions, which also argues that it is abductive (KovàcsandSpens2005).

3.5 Interview techniques

Before the interviews, background information about the case was sent in combination of the questions to the interviewed person. After the interview the answers gathered at the interview were sent to the individual interviewed for consolidation. The questions were of open-ended character allowing unlimited answers and qualitative data was gathered and documented.

3.6 Method issues

3.6.1 Reliability

In the written report, people with expertise knowledge in different areas have been interviewed in order to get the best result. The interviews have been open-ended and the result has been confirmed by the one interviewed. Articles that have been used are of relevance due to that they only concern new and recent written information. The result has not been of the authors' interest, being an outside part whose only interest lies in the report, but for the case company the final result is more of value. Therefore it can be argued to been executed without any positivistic or optimistic thinking. Direct observations at MPC give a better understanding of the product and the whole situation. The use of both qualitative and quantitative information could be seen as strength.

3.6.2 Validity

For getting high validity many sources, methods and much primary as well as secondary data collected, have been used in order to get as correct data and information as possible. By reflecting

the independent variables, internal validity, it can prove if the result is affected, (Yuen, Terao and Schmidt 2009). While external validity concern the generalization of the study's result and at which extent it could be applied on similar situations. For getting internal validity in the report interviews with people involved were executed and variables were kept to the purpose, while the external validity could be gathered of interviews from external parts and general literature studies for the subject.

4 Literature review

The theories chosen and introduced in this chapter are further to be used in the analysis chapter. They will facilitate in designing a supply chain and to know when and why to use different strategies in a supply chain.

4.1 Supply chain and logistics management

Logistics management could basically be described as how to handle storage and how to create efficient material flows transporting objects from point A to point B, which could be both internal and external for a company, (Johnsson and Mattsson 2005). The exchange of information that arises from transporting objects from A to B concerning planning and organization are to be considered as well as the real movement. Supply chain management is basically an extension of the logistics management concerning all activities involved for logistic supply and demand across companies, (CSMP 2011).

4.2Perspective of logistics and management control structure

The perspective of the logistic system could concern a company internally, externally or in a network, (Johnsson and Mattsson 2005). They also discus that it could be divided into three different time concerning perspectives: operational, tactical and strategic (figure 3).

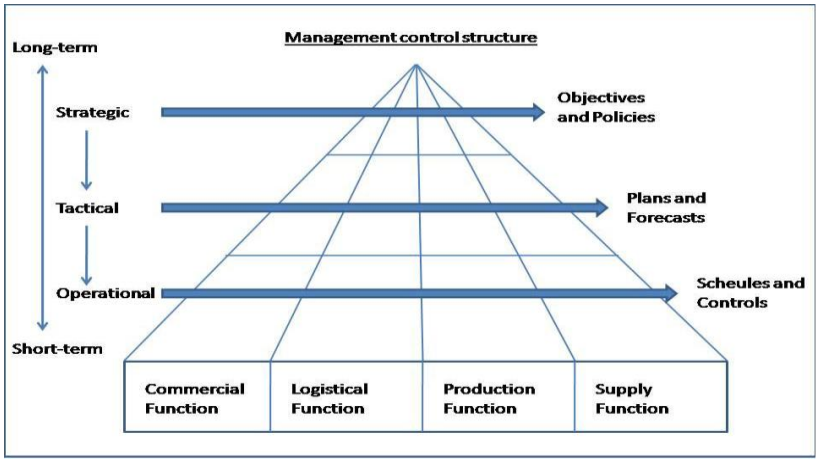

Figure 3- Management control structure, based on Houlian (1985)

The operational is executed on a weekly or day to day basis and refers to create high efficiency of the company resources. Examples of operational decisions are: create a specific order, decide a route for transportation vehicles and are in many cases constrained by the tactical.

Tactical decisions refer to reorganize and develop already existing resources in a company. The time perspective is not as long as in the strategic, but could be seen in months and is sometimes constrained by the strategic. Examples of tactical decisions are: choice of distributor for a specific item, changes in the warehouse such as where to store a specific item or the quantity of ordered items from a supplier.

Meanwhile the strategic perspective is to create the best conditions and effectiveness for a future logistic system. This term involves resource investments, customers, competitors and company policies as well as the business strategy. Such decisions will cover long term of planning and are discussed in years e.g. if the company should install a new warehouse or factory and where it should be installed, if they should outsource, if they should produce against order or toward stock.

It is not always possible to distinguish the decisions from each other on the different levels which they operate due to that the decisions interact and affect each other e.g. a decision in change of packing material or size of package could have big consequences for the customer's ability of handling the product.

4.3 What is your product?

When constructing a supply chain it is important to know the different features and constraints of a product, both from a supplier's view point considering the parts and towards the end customer, i.e. the market. To be able to create a suitable supply chain, these parameters need to be known in the first stage of planning.

4.3.1 Matching Supply Chain with product

Fundamentally, before taking any decisions on the outlay of a company's supply chain, we must know the product and consider the nature of demand. Roughly we can divide product demand in functional and innovative products. Functional products are non-complex commodities with stable, predictable demand and long-life cycles. The simplicity in forecasting and production, with allowance for long lead-times invites competition and push-down profit margins.

Innovative products typically involve unpredictable demand, with shorter product life cycles and higher variety requires shorter lead times. The risks for forecasting errors and stock-outs are higher but typically profit margins are higher. These simplified product characteristics benefits from different supply chain configurations. Functional products require a physically efficient supply chain, where predictable demand is supplied at the lowest cost with high production utilization, low inventory keeping and short lead times only if cost is not increased. Product design should focus on maximized performance and minimized costs. Suppliers should be chosen on basis of cost and quality.

Innovative products require a market responsive supply chain that can act quickly on changing demand, preventing stock-outs as well as obsolete stocks. Here, higher profit margins cover unutilized capacity as long as demand opportunities are utilized. Therefore, aggressive investment in lead time reduction, excess production capacity and buffer stocks are allowed to be able to respond quickly. Product design should here be modular, postponing differentiation as long as possible. Suppliers should be chosen on basis of flexibility, speed and quality. (Fisher, 1997)

As the supply chain should be matched with product demand nature, the different parts contributing to the end product can be arranged and evaluated in parameters of availability on the market and relative dependence on part. Kraljics matrix (figure 4) is built from these parameters to determine

adequate supplier relational levels. The higher importance and the lower availability of a specific part, the more reason to increase the relational (strategic) level with respective suppliers. On the contrary, regarding non-critical suppliers, simplified and efficient transactions are preferred, keeping cost down and efficiency up.

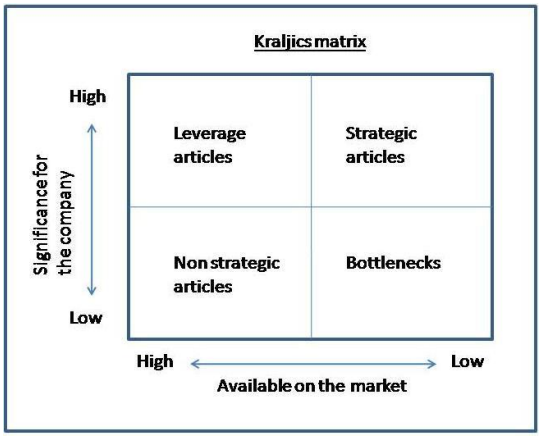

Figure 4 – KRALJICS MATRIX, Jonsson & Mattsson, 2005

4.3.2New product development

New products with low or no historical data as a base for forecasting in combination with misalignment will be costly creating limited availability, disappointed customers and last minute fixes, Remko and Chapman (2007). When designing a supply chain strategy, delivery and availability should be considered first, before efficiency, (Fisher 1997 and Porter 1996).

4.3.3Adjust supply chain to the product

Appelqvist, Lehtonen and Kokkonen (2004), present a framework for supply chain decision-making where they discuss reengineering, breakthrough, continuous improvement and design for logistics, (see figure 5). Hence, a company could be in several quadrants at the same time.

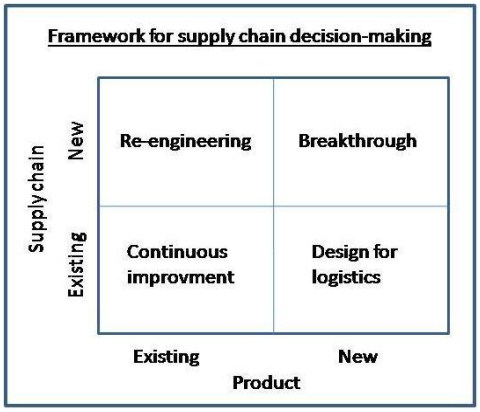

Figure 5 - Appelqvist, Lehtonen and Kokkonen (2004)

- The re-engineering means making changes in the supply chain without changing the structure of the product in hope of improving the business process.

- Breakthrough is the challenge of having a newly developed product and to design its supply chain.
- Continuous improvement is when companies try to be more efficient without affecting the product or the supply chain.
- Products produced for a certain supply chain should be designed to fit it. So the chain can operate without problems having to adapt to the product.

Depending on where to be in the matrix (figure 5) a company can agree upon its supply chain can be matched and better used.

4.4Where is the market for your product?

The market location and characteristics determine how the supply chain should look like and act. Theories about location, distance, size, capacity, culture, demand etc. will be brought up. Especially when entering new market areas.

4.4.1 Market relations

In a supply chain of today it will most certain engage companies at different places around the world. The distance between companies in a supply chain is important creating efficient and stable chains. It means three different dimensions to consider when planning from a logistic perspective: room dimension, time dimension and culture dimension, (Jonsson and Mattsson 2005). The first mentioned involves geographical distance in-between companies. Short distance brings lower transportation costs and short lead-times while long distance means higher in both parts and closer relations in the chain also involve that frequent meetings can be held. The second dimension mentioned (time dimension) concern signification differentiations in time between buying company and delivering company. If the distance is big, time zones can differ from location to location which brings different working hours and puts limits on the communication and flexibility. It could also be big difference in holidays and could mean hard or impossible to reach or get merchandises in time. Last mentioned dimension (the cultural) concern the diversity in language, custom and business thinking. Even if English is an international language when doing business, misunderstanding can arise when exchanging information which create disturbance in the material flow. These three dimensions contain high risks if they are not managed and supervised properly, (Jonsson and Mattsson 2005). If key suppliers do not live up to the promises of the focal company, reputation can easily be damaged. Other regulatory, cultural or normative deviations also need to be looked into before decision can be made (Kumar, Hong and Haggerty 2010).

4.4.2 Risk management in supply chains

Christopher (2005) describes, supply chain as Risk=Probability of disruption x Impact and that it is important to understand that there are risk involved with supply chains and how to deal with them. Walters (2007) describes that there are two risks in a supply chain; internal and external risks. The internal risks are located in normal operations e.g. late deliveries, human errors, fault in the information system and financial risks, etc.; and external risks come from outside the supply chain

e.g. nature catastrophes, wars, financial irregularities, etc. The European Foundation for Quality Management (2005) describes four ways how to treat risks: Terminate: Avoid or eliminate the loss exposure, cease related activities to the risk. Threat: Risk and loss control activities, plan to manage the likelihood and consequences. Tolerate: Accept level of risk. Transfer: Insurance or non-insurance, moving the impact of the risk. Lawler and Worley (2011) discusses, the weight of building scenarios when searching for possible risks, and also that those scenarios should not be developed and then trashed, but instead analyzed, evaluated and used. It is mentioned that those scenarios should account for economic, social and environmental trends and should also be neither optimistic nor pessimistic, but neutral.

4.4.3 Planning of the freight

In order to keep high filling rates on carriers the capacity utilization must be well planned and should not only be based on how many hours it is in use, (Jonsson and Mattsson 2005). The capacity can be calculated in volumes, cubic meters, or by maximum weight, tons. Depending on what carrier that is used the filling rates are of different dependence, road carriers have often a high loading volume and are more constrained by the maximum allowed weight, (Jonsson and Mattsson 2005). A fully loaded carrier measured in volume, could mean less then fully loaded measured in weight utilization.

4.4.4 Package

The packaging is of high importance concerning international logistics, especially at sea, getting the units safe, and the right units to the right place, (Voortman 2004). Transferring of goods between carriers adds stress to the package and there could be risks when handling the package with forklifts, cranes etc. The material used must be strong in order to permit stacking in international transportation, (Voortman 2004). He also describes that there are benefits of having a good package, such as cost and space savings, as well as fewer returns.

4.4.5INCO terms 2010 and combiterms 2000

Incoterms stands for *international commerce terms* and is the International Chamber of Commerce's interpretations for the importance of delivery clauses in the world trade (Schenker 2011). Jonsson and Mattsson (2005) describe the incoterms as, rules on allocation of freight costs, risk commitment and the handling of documentation between customer and buyer in liaison to delivering goods. Also mentioned is that there are different categories of the incoterms depending on how the transport is performed (by sea, rail, road or flight) and who is responsible, taking the risk as well as customs. The combiterms are guidance in interpretation of the difficult legal aspects of the incoterm between buyer and seller, showing costs that can arise at transports crossing borders.

4.4.6Pricing of transportations

Figure 6 shows how capacity and costs is in relation to how the lead time and service level are affected. Shipping something by a vessel will most certainly be less expensive than shipping it by plane, but on the other hand it will take longer time and much capital can be tied up and the service

level will decrease. A vessel can take the biggest shipment sizes letting a company send a large amount of items, but it is the slowest which gives low service level. Meanwhile a shipment by plane is the most costly and will only take smaller shipments, but have a high service level regarding time efficiency instead.

Figure 6 –Transportation types compared in price, Jonsson and Mattsson (2005)

There are many factors that have a role when pricing transportation. Jonsson and Mattsson (2005), describe seven different parameters: The transportation distance e.g. longer distance equals more fuel and working hours which result in higher price. Looking at shipment volume, fully loaded vehicles will result in a lower cost per shipped item (cost of distance, administration, loading, unloading etc.).The density of the freight meaning the transportation over a specific distance is usually charged by the weight (cost per ton). How the physical shape of the freight is plays an important role e.g. if it is easy to handle when loading and unloading. If the freight needs to be kept at a special temperature under the transportation will also give a higher cost. The risk of the freight means if it is sensitive for transportation damages e.g. does it need special care in documentation and handling, and is it more desirable to steal. How the transportation selection and demand look like e.g. if the demand and selection is not balanced the utilization would be 50 percent. In other words, if the transport can be shipped loaded one way and bring something back on the return it would help carrying the transportation cost and thus give a lower cost.

The contract and the tariff method are the most used methods to determine the price level of transportation services, (Lumsden 2011). He says that the contract method is often used when there is an agreement between the vendor and buyer, normally valid for a single delivery or a number of deliveries over a defined period of time. When there are multiple buyers on the market with little influence the tariff method is used.

4.5What is the right supply chain for your product?

Answering of 1 & 2 will lead to the answer of 3. Depending on how the product and market characteristics there are a number of well-known theories in the SCM literature. Here we will discuss suitable theories and their necessary components.

4.5.1 Trade-offs in a supply chain

When a company makes a certain choice about one thing it will mean certain consequences for another. To achieve a business goal could mean that a company would weigh trade-offs against each other and determined which one would bring the best result. Trade-offs means that even if both choices are good, one have to be picked.

Simchi-Levi, Kaminsky and Simchi-Levi (2003) describes different trade-offs between:

Lot-size vs. Inventory: Manufacturing companies wants to have large lot-sizes so that per unit setup cost will be reduced. This in turn could lead to inventory increases due to instable demand and that the demand does not come in large lot sizes.

Lead-time vs. Transportation: If companies want to wait with shipments to fill up and send fully loaded carriers the lead time will be suffering in the supply chain. To decrease the lead time the shipments should be done immediately after being produced, which leads to lower filling rates in the transportation and increases the cost. Communication and information should be quick, correct, open to both partners and constant to reduce impact.

Inventory vs. Transportation: For the most beneficial economic situation companies want to order or send fully loaded shipments. In order to disperse the transportation operating costs over largest possible items. By shipping or ordering fully loaded shipments with an uncertainty demand the inventory cost will increase trying to decrease the transportation cost.

Cost vs. Customer service: All trade-offs mentioned above are examples of the trade-off between cost and customer service. Reducing inventories, costs in the manufacturing process and transportation costs are typically done at the expense of customer service. Customer service should be maintained, decreasing these costs by using information and suitable supply chain designs.

4.5.2Matching supply chain strategy with products

A push strategy equals mass production with a known demand and reduced production costs. Pull strategies are more used when demand is unknown, producing in answer to particular customer demand, making it hard to achieve efficient batch production and transportation filling rates, (Terry et al. 2005). Functional products hold a rather predictable and stable demand, long life cycles and satisfy customers' basic demand. Market winner for these products is availability and might not generate high profit, Fisher (1997). He describes innovative products to be introduced by companies in fashion or technology giving customers new and added reasons for buying their products (e.g. Starbucks Coffee with lots of innovative flavors and concepts). Innovative products might create higher margins in profit but have shorter life cycles with high unpredictable demand compared to functional products and here the market winner is price. The functional products are well suited for a lean supply chain with its relatively stable and predictable demand and the innovative products are more suited towards an agile supply chain.

4.5.3Supply, demand and product complexity

The complexity of the product, the amount of suppliers and the availability of raw materials determine how much of the supply chain that needs to be managed, (Cooper et al. 1997). Relations in the supply chain will differ depending on the length of the chain and the number of suppliers as well as customers. Some relations should be kept closer due to the material/components critical level of value for avoidance in shutting down production lines or late deliveries to customer, (Cooper

et al. 1997). Key suppliers and key customers should be closely coordinated and manage further up in the chain meanwhile others could be less close.

4.5.4Supply chain mapping

Lambert and Cooper (2000), discuss a supply chain management framework consisting of three closely interrelated elements: the supply chain network, the supply chain business processes and the supply chain management components. The framework should be used when deciding the complexity and dimension of the chain by identifying members of the chain being primary or supporting. Primary members are defined as companies or strategic business units that in the business process create value-adding activities. While supporting members are defined resources, knowledge or assets providing companies for the primary members in the chain e.g. companies that lease trucks, provide warehouse space or banks for loan. Hence, members could be both primary and supporting.

4.5.5Supply chain strategies

Suitable supply chains for different products can only be achieved when full understanding of the product type, marketplace and management is reached.

Agile supply chains are when companies take advantage of profitable opportunities in an unstable market by using market knowledge and a virtual corporation, (Naylor *et al*. 1999). The agile supply chains focus on customized and demand-driven activities. Lean supply chains are formed by getting rid of all waste or muda in a value stream, including time, which ensure a leveled scheduling and reduced costs, (Naylor *et al*. 1999). Planning and standardized activities are more focused in lean chains.

Figure 7 shows market qualifiers and market winners for the agile and lean supply chains. The agile chain focuses on the service level with customized products while the lean has more focus on keeping the costs down with more standardized products.

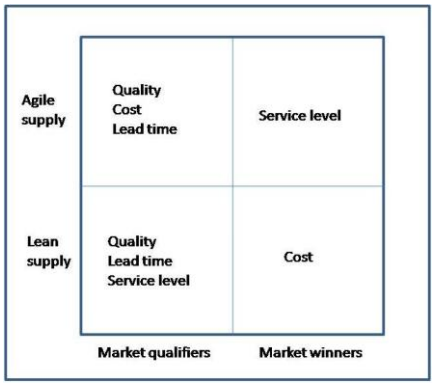

Figure 7 market winners – market qualifiers matrix for agile versus lean supply - Mason-Jones, R., Naylor, J.B. and Towill, D.R (2000)

The leagile supply chain wants to combine the lean supply chain's focus on keeping costs down with the agile supply chain's high service level. An optimal leagile supply chain is reached by creating a compromise between the two extremes where one can be the gaining emphasis which enables companies to respond to unstable demand downstream as well as to provide a leveled scheduling upstream from the market, (Naylor *et al*. 1999). The point as where the chain converts from agile to lean in the leagile chain is called the decoupling point. The decoupling point is the point where order driven and forecast driven activities meets and is the point, as a rule, where a main stock point should be held supplying customers, (Hoekstra and Romme 1992). Moving the product differentiation closer towards the decoupling point, the end user, and this would create more efficiency in the supply chain, (Qi, Xu and Zhiyong 2007). The authors also states that by postponing the decoupling point "mass-customization" could be reached and the risk of stock outs would be lower as well as the total amount of stock. Vollmann et al. (2011) describe, the decoupling point "*as the point which demand changes from independent to dependent*". The authors also describe different postponements (figure 8) to as when a product is to be entirely produced and complete:

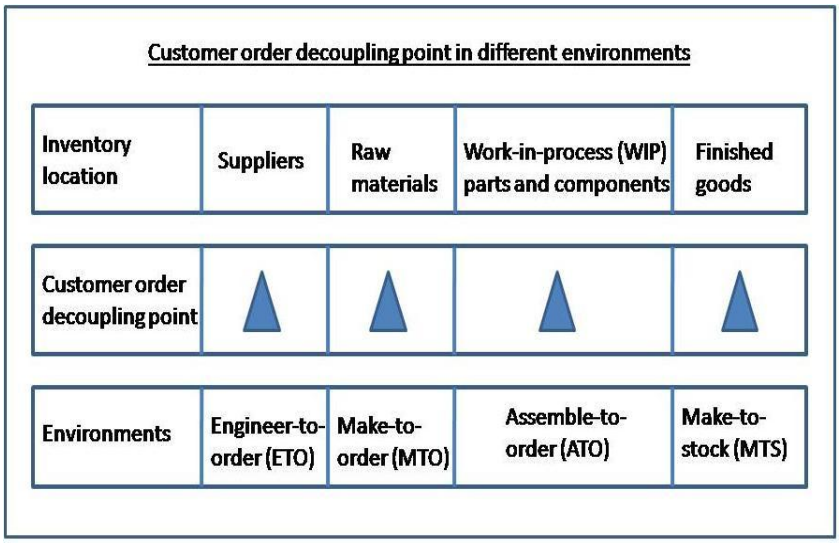

Figure 8 – Customer order decoupling point in different environments (Vollmann et al. 2011)

Engineering to order - ETO: the firm works close to the customer, designing the product together with the customer and then the firm construct it from purchased materials.

Make to order - MTO: the firm produces products towards orders that have been received.

Assemble to order - ATO: the firm keeps multiple parts that can be combined into a product and assembled when an order is received.

Make to stock - MTS: the firm serves its customers' orders from its stock with already produced products.

Depending on the company's strategy the decoupling point can be effective.

4.6 Third party logistics

The three-way relation or the logistic triad are the interception between the buyer of goods and its supplier as well as a logistic service provider moving and/or storing the goods between buyer and supplier, (Larsen and Gammelgaard 2001). Today these activities are being taken care of by third party logistics (3PL) service providers, providing transportation and warehousing services, (Stefansson 2006). The term 3PL was introduced in the 80s and has had a big role in logistics. Tanks to the growing market, 3PL companies with different backgrounds and new technology can offer more and more innovative and tailor made solutions for its customers. In order for companies to focus and continue improving their core business processes, the enterprises can outsource non-core business activities to 3PL companies, (Wong 2010). The task of a third part logistics company is to provide e.g. lower costs, better service or bigger geographical covering in the transport part, refinements or warehousing, (Olsson and Olsson 2006). Solutions could be offered from rather simple logistics to more advanced, including merge-in-transit setup activities, (Stefansson 2006).

4.6.1Third party logistics and environment

As environmental friendly products and services may be well developed in certain areas today, logistics solutions lag behind. Logistics can be seen as the missing link in the ambition to provide ever greener products, (Wu and Dunn, 1995). As logistics environmental impact and outsourcing of logistics to third party is growing paired with globalization, the issue is distanced from the logistics service buyers. In studies, third party logisticians have noticed increased environmental concerns from their customers, but still purchase decisions are made based on price, lead time and quality etc., (Wolf and Seuring). Minimum requirements, as ISO 14001-certification was implemented while a larger supply chain management perspective was lacking.

4.6.2 Fourth party logistics

Fourth part logistic (4PL) is similar to 3PL and provides the same services, but differs in that the companies do not own their resources for physical moving and transporting freight themselves. They are described to have a broader perspective and are on a more strategic level where they want to develop the whole supply chain for the customer, (Jonsson and Mattsson 2005). The 4PL companies carry out the most administrative activities and leave the physical handling to the 3PL companies, (Bumstead and Cannons 2002).

4.7 Electronic data interchange (EDI)

EDI are used for transferring different data between companies and organizations and are most useful when there is frequent and big information transferring, (Jonsson and Mattsson 2005). It is also mentioned that those systems are expensive and therefore more found in larger companies, but that on later years a web-EDI has been developed, a basic version allowing smaller companies to communicate with bigger companies. Information that can be transferred is shown in figure 9 and thanks to the EDI the information becomes much easier and faster.

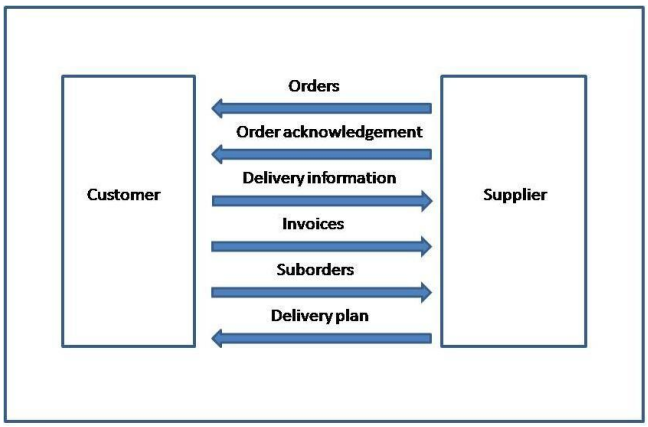

Figure 9 - Electronic data interchange, (Jonsson and Mattsson 2005).

4.8 Merge-in-transit

The merge-in-transit model consolidates shipments from different destinations into a single shipment which in turn creates only one delivery for the customer (see figure 10), (Bradley et al., 1998; McLeod 1999; Dawe 1997).

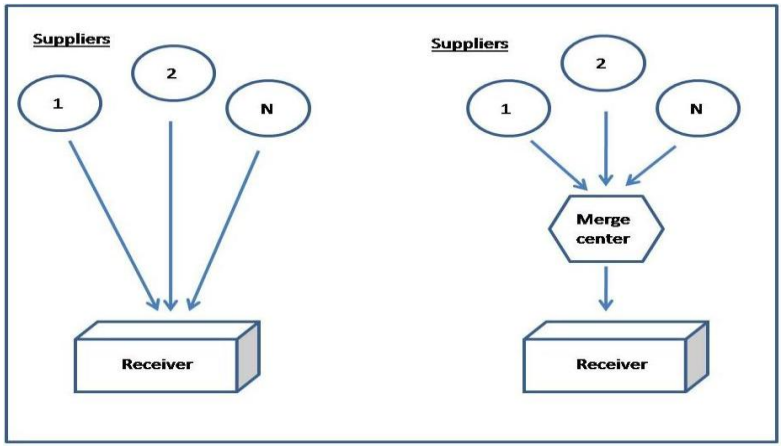

Figure 10 – Delivery from supply to receiver with and without Merge-in-transit, (Diaz 2006).

Bradley et al. (1998), discuss that the customer service increases, inventory are reduced, cycle times of delivery are enhanced, transportation costs are reduced and the supply chain process are improved. Companies with high technology products often have high inventory costs and therefore those companies especially benefit from time postponement available of merge-in-transit distribution, (Pagh and Cooper, 1998).

4.8 Logistics costs

4.8.1 Transportation costs and resource utilization

Transportation costs can be viewed from many angles and the total parameters depend on the circumstances and perspective. Further, different authors categorize the costs differently. Following costs are revised out a transportation buyer's viewpoint. A comparison between two author's definitions can be found below:

Lumsden, 2007 – Buyer's view	Jonsson and Mattsson, 2005 – General
Storage and handling	Transportation and handling
Transportation movement	Packing
Damage/Insurance	Stock-keeping
Capital accumulation	Administrative
Dispatching	Order costs
Own administration	Capacity related
Return handling	Shortage/Delay
Labeling and identification	Environment
Delivery	
Data communication	

In transportation, cost per additional shipped unit (marginal cost) might be constant until the capacity level is reached (e.g. approximately fixed cost for one container shipped). When additional capacity is needed a whole new container will be utilized with additional cost. This cost pattern can be said to increase stepwise. (Lumsden 2007)

Trailers, containers and pallets are example of non-adapted load carriers, i.e. not conformed to the goods transported. The resource utilization can be measured as the utilized resources divided to the available resources in regard to weight or volume for example. Higher resource utilization leads to lower resource costs and thereby higher productivity. There is a strong connection between productivity and profitability. An additional issue may be the returning of empty load carriers if the total flow of goods in a system is directed in one way. (Lumsden 1998)

Volume adjustment strives to achieve full container loads (FCL) or full truck loads (FTL) by adapting the goods flow to the resource flow. This utilization is not only dependent on the amount resource units loaded but the utilization within the pallets. A high fill rate within each pallet resource unit is also required in order to achieve optimized total fill rates. (Lumsden 2007)

Cost analysis of distribution are complex, minimizing one cost element might actually increase total costs, so called sub-optimization. Lower delivery frequencies might increase stock-keeping related costs, for example. Merely increasing transportation efficiency without regarding the customer may lead to decreased service levels and sales. (Lumsden 1998)

4.8.2 Customs duty costs

Customs duty is an additional cost tariff for export or import of various products. Depending on product type, originating country the harmonized code tariff decide the actual rates, (Kumar, Hong and Haggerty, 2010). The harmonized codes are eight digits for export and ten digits for import ending with -90 in Sweden, (Tullverket 2011).

4.8.3 Currency fluctuations

The relative change between two or more currencies is called fluctuation. When purchasing products or services (e.g. transportation), priced in foreign currencies, a strong native currency is beneficial (Kumar, Hong and Haggerty, 2010). Naturally, the opposite is true when selling products or services; a relative weaker native currency renders higher revenues.

5Empirical data

5.1 Product

The VT vertical wind turbine is designed in two versions. In this study we will only regard the larger VT, described in figure 11. This version contains less fixed welding and more assembled parts which improve packaging and transportation possibilities. The supporting braces are longer, reaching to the axle, thus making it even more robust. Further, dependent on the previous arguments, the large version VT will be promoted and manufactured alone during the small scale start-up year of 2011. From here on, when the VT is referred to, the large version is implied.

Table 2 – The market director (2011); Mattsson (2011)

VT - Data	
Rotation	Vertical axle
Startup	Automatic
Max. Effect	2500 W
Rotor diameter	3000 mm
Height	5000 mm
Total weight	256 kg
Power system	24/230 volt
Start wind	2 m/s
Stop wind (automatic)	14 m/s
Consumer net price	70000 SEK

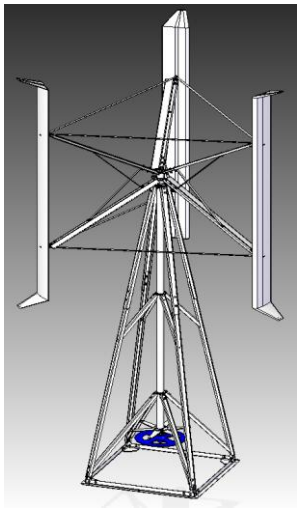

Figure11 – VT CAD, (Mattsson 2011)

Table 2contains basic VT features data and the standard price aimed for. The wind turbine essentially consists of three main parts. Each part requires different manufacturing specialization and SSRE do not wish to own the production in the long run, (The market director 2011). Thus three different suppliers are wanted. The wing, frame and generator are explained in the following three sections, with regard to function, features, costs and procurement alternatives.

5.2 Frame

The construction described in figure12is a steel skeleton with the ability to rotate its upper part vertically and transfer the rotation through the axle to the bottom center and in table 3 there is some technical data. Though it is partly welded, none of the angles are. When disassembled all individual parts are straight and can be stored side by side.

Even though the frame is the simplest part of the three when it comes to innovation, it far surpasses the others in number of pieces, weight, length, production cost and lead time.

The frame is the only main part with a dedicated supplier. MPC system AB (2011) describes themselves as system/component subcontractors with the material flow of the customer in aim. They have previously assisted SSRE in the production of prototypes.

In the beginning of 2011 MPC presented a cost proposal on demand for three levels of production quantities per year as can be found in table 4.

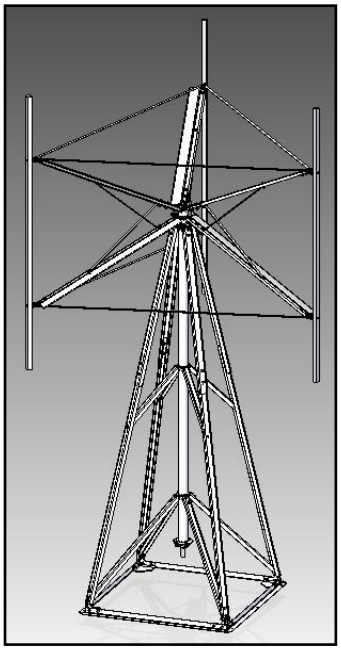

Figure 12 – VT CAD, (Mattsson 2011)

Table 3 – The market director (2011); Mattsson (2011)

Data	
Manufacturer	MPC
Material	Welded steel
Surface treatment	Powder lacquering
Weight	221,9 kg
Longest part	3500 mm
Lead time (Initially)	15-30 days

Table 4 – The market director (2011); Mattsson (2011)

Production cost (SEK)			
Batches (units)	10	50	100
Work	17000	15100	14100
Material (paint)	4000		
Material (frame)	5000		
Material markup (10 %)	900		
Total cost	26900	25000	24000

SSRE reacted to the relative low cost difference of only 2900 SEK when increasing the order quantity tenfold. This was explained by MPC to be natural due to the low setup times required, (The market director 2011). As a result, higher utilization results in smaller efficiency increase.

The interest in manufacturing abroad increased as the information of manufacturing costs was presented to SSRE, (The market director 2011).The decrease of material costs is insignificantly up to around 100 units, if the number surpasses 100 units savings in material cost may be achieved, (Mattsson 2011)

The lead time for the construction is initially 30 days, where five days are dedicated for surface treatment. However, MPC can reduce the total lead time by preparing larger batches of less expensive parts down to around 15-20 days. In case of larger order quantities over time, a continuous flow allow the lowest lead time of 15 workdays. During a visit early in the study at MPC, it was presented that they had been able to cut the lead time of another specific product drastically by continuous process improvements as experience increased over time (Mattsson 2011).

5.3 Wings

The wing is an advanced aerodynamic construction design (Figure 16 and 17). While operating, one of the three wings will always be directed against the wind, counteracting the rotation flow. The other two wings must create a suction overpowering the resistance at any time. This is critical during the rotation in the initial startup phase. SSRE make a simile by the lifting of an aircraft during takeoff. In other words, the design of the wing is critical for a successful vertical wind turbine. This construction reaches a solid state at 14 meter per second, when self-retardation inhibits higher speeds. This self-regulation is very practical; making additional start and brake mechanisms obsolete, (The market director 2011).

Table 5 – The market director (2011); Mattsson (2011)

Wings Data		
Manufacturer	SSRE	Subcontractor (SWE)
Productioncost	10000 SEK	5000–10000 SEK
Blade material	Glassfiber Composite	
Wings/turbine	3 units	
Weight	4 kg	
Length	2700 mm	
Leadtime	1-3 days	

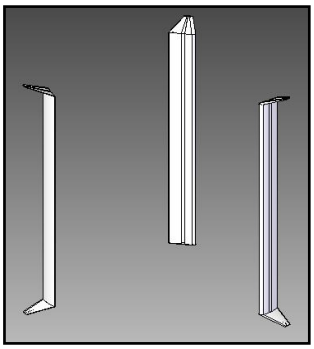

Figure 13 – VT CAD, (Mattsson 2011)

The manufacturing process requires knowledge in fiberglass composite materials. SSRE have been communicating with a Swedish boat manufacturing company to work out an agreement on supply. However it was decided that during 2011 the wings will be produced at the inventors' house in small scale, (The market director 2011). The manufacturing cost for a set of wings has been estimated to 5,000 SEK with a lead-time of 1-2days once the Swedish subcontractor starts production, (The inventor 2011). A different estimate for the same scenario is a cost of 10,000 SEK and lead time of 2-3 days, (The market director 2011). The later estimation will be used in the report while the possible cost variation should be considered.

5.4 Generator

The generator described in figure 14 transfers the kinetic energy from the wind turbine into electricity. Without going to deep in the science of wind power generators, the design is a friction and gear free magnetic generator which operates at low RPM´s (rounds per minute). Complementary inverters are needed to transform the output into either 24 Volt for batteries or 220 volt for connection to the power grid. Battery packs and inverters are not included in the standard price but offered separately by SSRE. (The market director 2011)

Since the required features could not be found in any "on-the-shelf" product on the global market, SSRE are looking for subcontractors able to custom build them at reasonable prices. A SSRE contact specialized in the Chinese market has come up with a suggested supplier. The cost per unit is set to 9,500 SEK with freight excluded which is seen as acceptable by SSRE.

The cost of the generator is highly dependent on the unstable global market price of magnets. To lower the production cost in the future, SSRE believe reducing the number of magnets could be made without efficiency reduction. (The market director 2011)

Table 6 – The market director (2011), Mats (2011)

Data		
Manufacturer	SSRE	China
Essential material	Neodymium magnets	
Weight	22,1 kg	
Diameter	700 mm	
Leadtime	X days	50-70 days
Production cost (+ FOB/CN)	X SEK	9500 SEK
Freight cost	N/A	100-200 SEK

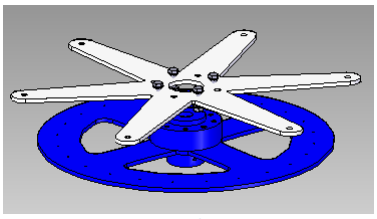

Figure14 – VT CAD, (Mattsson 2011)

As a supplier of the generator has not yet been contracted, the production will be located atthe inventor´s house in small scale during 2011. A final version of the magnetic generator has been tested during the spring of 2011 and SSRE believe that they are now close to a suitable design, ready for subcontracting in the future, (The market director 2011). In figure 19 data from Chinese and Swedish production is compared. The Swedish production costs are not of interest since this solution is temporary and the total costs not comparable, (The market director 2011).

A SSRE cooperation partner is currently evaluating possibilities on the Chinese market. Subcontracting and own production are currently compared. Though the later choice may be expensive in the start-up phase, the gain in control is an important advantage in distant markets, (Gustafsson 2011).

The production start-up phase will require some time due to testing and configuration etc. When production is established, estimated production lead times are two to just over four weeks, depending on volumes and if the product will differ from regular production, (Gustafsson 2011).

Roughly estimated production price is calculated around 9500 SEK per unit, in FOB-terms to a yet unspecified port in southern China. However this cost was calculated during 2011 when the price of neodymium had doubled from previous year. In the future the price on neodymium may continue to rise.(Gustafsson 2011)

From experience, air freight is too expensive of a freight mode. The most probable scenario is shipments by sea. If batches of 33-45 units are to be shipped, a rough freight cost estimate would be just over 100-200 SEK per unit depending on the dimensions (volume) of the final construction. In comparison, estimated air freight costs lie around 1800 SEK per unit. However, the most economical solution would be to fill a 20 feet container. The speed of ocean vessels from southern China is lowered to save fuel costs, resulting in five to six weeks of transportation lead time. (Gustafsson 2011)

5.5 Packaging

The VT still is in a pre-market stadium and packaging has not yet been thought of. For the purpose of estimating transportation circumstances, following estimated package dimensions have been created in cooperation with SSRE. The reasoning is based on the euro pallet standard. The pallet measures 800 mm wide, 1200 mm long and 144 mm high. It is a wooden construction and weighs around 20-25 kg in dry condition. The tare weight is (1000 kg in any spot or) 1500 kg evenly distributed. (ISO 3766:1983 2011)

When transported, the packages will need to be piled in order to utilize capacity, thus each package will need to fulfill the minimum requirements of bearing capacity in regard to the total weight of the packages piled above, (Lökholm 2011).

SP Research Institute of Sweden is a former governmental company, now privatized, which offer testing and consultancy within transportation and packaging, (SP 2011). Unfortunately they did not have the possibility to contribute to this study, but they mention that there could be some special rules for the package material used in shipments to Mexico. For this study, we assume that the tare weight requirements for piling are fulfilled by the packaging. Supply and costs for package material will be kept as variables.

5.6 Total VT package

This package represents a complete, disassembled VT. We assume that the weight can be sufficiently distributed even. The dimensions to the right in table 7are calculated using the extreme values of the widest and longest disassembled parts and then adding ten centimeters. The height is a qualified estimation made by MPC and SSRE, (The market director 2011). The dimensions to the left represent the total package loaded on three euro pallets.

Table 7 – Comparison of package and pallet, (The market director 2011; ISO 3766:1983 2011)

Package		**Euro pallet package**	
Height:	500 mm	**Height:**	650 mm
Width:	800 mm	**Width:**	800 mm
Length:	3500 mm	**Length:**	3600 mm
Weight: 256 kg + package		**Weight:**	331 kg + package

The interior height of a 40 foot container is 2684 mm which means four 650 mm containers should be piled for highest utilization. The interior of a truck is normally 2400 mm which allow for staples of three 650 mm units, (Lökholm 2011 and Johannisson 2011).

Known weight data for each total package is 256 kg for the VT and 75 kg for three pallets. Unknown is the total weight of the total packaging material. Three euro pallets allow for 4500 kg, evenly distributed. If four total packages are piled, the euro pallets allow the packaging material to weigh maximum 1083 kg.

Depending on legal jurisdictions requirements may vary on packages when piled. Physically, the minimum bearing capacity of a package should be three complete euro pallet packages. Including local requirements the tare weight formula will be:

3x(331 kg + package) + legal/policy buffer

5.7 Package of wings

Since packaging has not yet been thought of, a rough estimation of the amount of wings fit into one complete VT package can be seen as a suitable comparison for shipments, (see table 8).

Table 8 – Description of wing package, (The market director 2011)

Dimension	Measure	Argument source	→	Source	Weight
Height	650mm	VT complete package		Wing	4 kg
Width	800 mm	One euro pallet		Pallet	25 kg
Length	3600mm	Three euro pallets		Package	Unknown

The wings measure 2700 mm, (VT CAD 2011) and will therefore unfortunately require three euro pallets since the limit for two pallets is surpassed by a least 300 mm. From a transportation economic view, would like to maximize the amount of wings in each package and each truck or container.

5.8 Package of generators

The generators will be sourced from China, (The market director 2011). If routed through Tidaholm they might need to be re-packed due to inspection and testing or to achieve optimal quantities. Since packaging has not yet been thought of, a rough estimation of the amount of wings fit into one complete VT package can be seen as a suitable comparison for shipments, (see table 9).

Table 9 - Description of generator package, (The market director 2011)

Dimension	Measure	Argument source	→	Source	Weight
Height	800 mm	Generator diameter		Generator	22,1 kg
Width	800 mm	One euro pallet		Pallet	25 kg
Length	1200 mm	One euro pallet		Package	Unknown

5.11 Third party logistics

Third party logistics is the only reasonable choice for a small and newly started company and due to time limits DB Schenker has been chosen as representative third party logisticians. Of course SSRE should compare relevant alternatives for any given destination, but for the comparison of whether to export from Sweden or manufacture abroad there are argued that this example suffice.

5.12 Transportation to UK

This example describes a realistic case with the purpose of comparing export of the VT with production in the UK. Costs depend on currency fluctuations and are updated on regular basis.

5.12.1 Tidaholm – Gothenburg – Immingham

Transportation from Tidaholm to UK is hauled by trucks via DFDS freight ferries, from the port of Gothenburg to the port of Immingham. The route from Tidaholm in Sweden to Immingham is seen as a separate fixed route, with a separate cost. The schedule for the freight ferries is captured in table 10. Sea transportation takes about 26 hours. If a delivery leaves port at Monday 20:00 it will arrive on Tuesday 22:00 and will be handled on Wednesday morning. The distance from Tidaholm to Skandiahamnen in Gothenburg is around 160 km. In this example, we have transportation lead time of around 36 hours plus the transportation time from Tidaholm to Gothenburg which will add up to around a total of 40 hours, (Lökholm 2011).

Table 10 - Departures and arrivals Sweden – UK, (DFDS seaways 2011)

Departure from Gothenburg	Arrival at Immingham	Departure from Immingham	Arrival at Gothenburg
Monday 20:00	Tuesday 22:00	Tuesday 04:00	Wednesday 08:00
Tuesday 20:00	Wednesday 22:00	Wednesday 05:00	Thursday 08:00
Wednesday 20:00	Thursday 22:00	Thursday 05:00	Friday 08:00
Thursday 15:00	Saturday 04:00	Friday 05:00	Saturday 14:00
Friday 20:00	Saturday 22:00	Saturday 11:00	Sunday 14:00
Saturday 22:00	Sunday 24:00	Sunday 05:00	Tuesday 08:00

5.12.2 Immingham – UK destinations

The distribution from Immingham to resellers at various UK locations has been partly exemplified by some strategic close and distant examples. Liverpool in UK and Aberdeen in Scotland are regular DB Schenker destinations, (Lökholm 2011). Since distribution within the UK can be seen as approximately equivalent in the cases of export to; and production within UK this information is complementary, to give a more complete picture of costs and lead times.

If the goods are handled on Wednesday morning, as in the example above they can be expected in Liverpool by Thursday and Aberdeen by Friday. The lead times are equivalent for any close/distant locations within the UK, (Lökholm 2011). This approximately adds an additional 24 – 56 hours transportation lead time.

We were recommended a total freight solution from SSRE (Tidaholm) directly to UK resellers in order to decrease complexity of responsibly and agreements, (Lökholm 2011). Further, it was mentioned that vessels passing the Northern Sea require specific loading security due to motions of the sea.

5.12.3 Transportation Capacity

Trucks trafficking UK are allowed maximum length of 18, 5 meters, compared to 25, 5 meters in Sweden. In general, truck trailers measure 2, 42 meters wide and 2, 4 meters high. Some trucks have smaller wheels allowing 2, 8 meters of storage height, (Lökholm 2011). As for capacity exemplification we will use the standard measures of 18, 5 x 2, 42 x 2, 4 (L, W, H). This capacity will be matched with the different VT packages for cost approximations.

The optimal transportation solution is to utilize complete trucks. Full truck loads are recommended from a transportation economic view as a contrast to shipping to demand. The point is to minimize the amount of truck loads. It is possible to transport single packages to UK and pay per volume or weight but both costs and lead times will increase due to consolidation with other goods, (Lökholm 2011).

5.12.4 Storage and merge in transit

DB Schenker provide merge in transit solutions with stock keeping and repackaging etc.

Maria will also come back with information about estimated costs, regarding the “manufacture in UK” scenario where two of the three parts will be shipped from Sweden and merged at the Immingham distribution center.

5.12.5 Transportation insurance

In case of lost or damaged goods, DB Schenker compensates 10 SEK/kg by standard. Since a complete VT weigh 256 kg without packaging and is expected a net price of 70,000 SEK, additional transportation insurance is recommended.

5.12.6 Information handling

DB Schenker requires their customers to send orders by EDI systems. While some EDI vendors are certified and recommended orders may as well be put by DB Schenker web based service, (Lökholm 2011).

Further, a TA system for transportation administration is required. For example, this system is used to print compatible standardized labels. If standardized labels are not used, an additional fee will be added. This solution is not recommended since additional complexity increases the risk for errors. Customers can follow transportations via a “mySchenker” profile online. Here invoices, costs, receipts and regularly asked for documents can be found (Lökholm 2011; DB Schenker 2011).

5.21.7 Transportation Costs

Packages over 2,4 meters are considered long goods and comply with special terms due to handling issues. UK is divided into five zones with different costs, (Lökholm 2011). The transportation costs

were received from DB Schenker in all cases except for one package delivery from Sweden, (see table 11).

Table 11 – Cost offer for UK, (Lökholm 2011)

Route	Currency	Cost	Unit
Tidaholm – Immingham:	EUR	1900	Truck
Tidaholm – Immingham:	EUR	X	Complete VT package
Immingham – Liverpool:	EUR	78	Complete VT package
Immingham – Aberdeen:	EUR	120	Complete VT package
Immingham – Immingham:	EUR	47	Complete VT package

Some additional costs depend on more specific data entries. Insurance value (CIF value) is equal to the merchandize value and freight cost plus 10 %, (Stöth 2011). The insurance cost is 0, 25 % of the insurance value. They are represented as following (Lökholm 2011):

Cost reason	Cost source	Factor
Transportation insurance	all routes	(Value + freight) x 110 % x 0, 25 %
Storage insurance*	Immingham	Calculated on (Value + freight) x 110 %
Storage cost*	Immingham	Nature of commitment
Merge in transit	Immingham	Nature of commitment
Fuel compensation	all routes	current oil price and distance

**Total storage costs and insurance could not be obtained because they vary of by the nature of commitment.*

5.13 Transportation to Mexico

This example describes a realistic case with the purpose of comparing export of the VT with production in Mexico. Costs depend on currency fluctuations and are updated on regular basis.

5.13.1 Tidalholm - Vera Cruz/Alta Mira

This scenario is calculated on one 40 feet high cube container shipment from Tidaholm to Mexico. The container will be shipped by sea from the port of Gothenburg to the port of Vera Cruz or Altamira. The container will be delivered to Tidaholm and loaded by SSRE. A truck will then forward the container to Gothenburg for sea freight. According to DB Schenker, this setup should be in order since large flows of goods already traffic this route. For example, a large steel exporter is mentioned. (Johannisson 2011)

When one complete container is utilized the lead time is approximately 17 days from Gothenburg to Alta Mira or Vera Cruz. If, instead fewer packages are sent by consolidation the total lead time is estimated to 21 and 22 days respectively from Tidaholm. The ship leave Gothenburg every Tuesday and booking must be made in good time before departure. Transit time of a couple of days, up to one week is expected for consolidated goods. (Johannisson 2011)

5.13.2 Transportation capacity

The standard issued 40 feet high cube container is described in table 12. Shipping by container is recommended for transportation economic reasons but few or single unit transportations are possible as well. The cost tariff is set by weight or volume. As single units may be sent for testing purposes, at least quantities of five complete VT units are recommended as a smallest quantity. (Johannisson 2011)

Table 12 – Container capacity, (Johannisson 2011)

40' High Cube Container	
Interior Dimensions:	Length: 39'6.5", 12.056m Width: 7'8 1/4", 2.347m Height: 8'9.5", 2.684m
Door Opening:	Width: 7'8", 2.340m Height: 8'5 3/4", 2.585m
Tare Weight:	6,393lbs, 2,900kg
Cubic Capacity:	2,684 cubic ft., 76.0cbm
Payload:	65,256lbs, 29,600kg

5.13.3 Tax and import costs

The import duty is set to regulate national markets and depend on the nature of the product, (Johannisson 2011). The Harmonized Commodity Description and Coding System (HS) is an eight digit international code describing world trade goods, (Tullverket 2011). For generator based wind turbines the code is 85023100which results in the import duty cost presented in chapter 5.13.5, (Tullverket 2011). Further a cost tariff for customs handling and facility utilization (DTA), and regular import tax is added, (Johannisson 2011).

5.13.3 Storage and merge in transit

According to DB Schenker there are possibilities to stock products at the destinations in Mexico but costs vary depending on commitment, (Johannisson 2011).Inquiriescan be made via a form provided by the third party logistics provider. However this will not be explored further in this study.

5.13.4 High cube 40 feet container transportation costs

Transportation of a 40 feet high cube container from Tidaholm to one of the two suggested ports carries the costs seen in table 13.

Table 13 – Cost offer for Mexico, (Johannisson 2011)

Location		**Inco terms**		
From:	Tidaholm	FCA		
To:	Vera Cruz/Alta Mira	CFR (Cost and freight)		
Cost source			**Currency**	**Cost**
Container hauling chassis*			SEK	3300
Fuel24,4 % container hauling*			SEK	805, 20
Terminal fee 1250 SEK per container			SEK	1250
Port fee 265/380 SEK per 20''/40''			SEK	380
Expedition fee 525 SEK per B/L			SEK	525
ISPS Security fee 90 SEK per container			SEK	90
Printing ED document 265 SEK per delivery			SEK	265
Forwarding fee 505 SEK per shipment			SEK	505
AMS / ACI 30 USD per shipment			USD	30
Sea freight 40HC 2300 USD per container			USD	2300
Bunker addition 483 USD per TEU			USD	966
SUM (SEK)			**SEK**	**14820, 20**
SUMMA (USD) (1 USD = 6,35 SEK) USD 3296			**SEK**	**20929,60**
TOTAL SUM (SEK)			**SEK**	**28049, 80**
Insurance				
Transportation Insurance (IF, Approximation)**			SEK	7700

One hour free loading time included, 475 SEK per hour thereafter.

*** The buyer is responsible for the insurance.*

5.13.5 Tax and import costs

The tax and import duty is paid by the buyer for CFR terms, (Stöth 2011). Value of the goods for one 40 feet container of 33 units is approximately USD 363,760(1 USD = 6, 35 SEK). Each wind power station has an approximate value of USD 11,023,(see table 14).

Table 14 – Import duty, (Johannisson 2011)

Cost source		**Currency**	**Cost**
Import Duty (HS Code) 15 % over CIF value		USD	54564
DTA (customs processing) 0, 8% over customs value		USD	2910, 08
Import Vat /Tax 16% over (CIF value +Duty+ DTA)		USD	63185, 11
SUM (SEK)	(1 USD = 6,35 SEK)	**SEK**	**401225, 45**

5.13.6 Three pallets transportation cost

The cost offer is calculated on three euro pallets as required for one complete VT package, (see table 15).

Table 15 – Single VT package transportation cost, (Johannisson 2011)

Variable cost source		**Cost (USD)**	**Cost (SEK)**	
Vera Cruz		101/cbm	641, 35	
Alta Mira		87/cbm	662, 45	
Location			**Inco terms**	
From:	Tidaholm		FCA - Free collection	
To:	Vera Cruz/Altamira		CPT – Cost and freight	
Cost source				
Domestic transportation (Piled)			SEK	1200
Fuel24,4 % of domestic transportation			SEK	292,80
Terminal fee, Gothenburg 315 SEK per ton			SEK	425,25
Expedition fee incl. SEK per B/L			SEK	Included
ISPS securityfee9 SEK per CBM			SEK	50,58
ED document (if needed) 265 SEK per document			SEK	(265)
Forwarding fee 505 SEK per shipment			SEK	505
Sea freight 87 USD per CBM (min. USD)			USD	488,94
Bunker addition (BAF)			USD	Included
Currency addition (CAF)			USD	Included
AMS fee 30 USD per shipment			USD	30
SUMMA (SEK)			**SEK**	**2 738,63**
SUMMA (USD)*(1 USD = 6,35 SEK) USD 518,94*			**SEK**	**3295, 27**
TOTAL SUMMA (SEK)			**SEK**	**6033, 90**

5.14 Environmental concerns

One way to maintain or strengthen SSRE profile as environmentally responsible is to utilize agendas, profiles and commitments pursued by their suppliers. Third party logisticians supply transportation, an area were environmental concerns become ever more important and potential for improvement is high.

Most third part logisticians profile themselves as environmentally progressive. DB Schenker provides detailed information on divisions and locations fulfilling the ISO 14001 standard. In Gothenburg DB Schenker is certified for all oceans and land freight involved in this case study, (DB Schenker 2011). The competitor, DHL is ISO 14001 certified for global freight forwarding in many European countries, Sweden included, (DHL 2011).

In cooperation with the third party logistician, best practice solutions can be evolved. At DB Schenker for example, customers may discuss priorities with logisticians to develop a "greener" flow, avoiding and reducing transportations as well as compensating for emissions, (Holm 2011).

5.15 Market

5. 15.1 Export and import between countries

Almost all kind of merchandises can be imported and exported between EU countries without any custom processes needed, (Swedish trade council 2011). One condition is that the merchandises are in free circulation in the EU, i.e. that it is native produced or that are imported into the EU and the import duty has been paid. This means that exporting to UK from Sweden will not be problematic when both countries are members in EU.I n this case value added tax (VAT) is paid in UK only, if the buyer has a VAT register number, (HM Revenue & Customs 2011).Export to Mexico will be more complicated as import duty and fees have to be paid in addition to VAT.

To be able to decide the level of import duty, the merchandise code (harmonize code) for the specific goods must be decided. This code is used in almost all countries worldwide, (Swedish trade council 2011).These codes can be obtained here in Sweden from the Swedish trade council or the Swedish custom.

5.15.2 Comparison of industrial labor cost

In a study made by Larsson 2011 (see table 17), salaries for Sweden, UK, and Mexico industry workers were gathered and shown. The study´s facts are gathered and based on statistics collected by the US Department of Labour and their unit of Bureau of Labour Statistics (BLS).

Table 17 – Salary and costs for industries workers 2008, shown in SEK per hour, (Larsson 2011).

Country	Salary for workedtime	Salarycost	Payrolltaxes
Sweden	143	169	253
United Kingdom	125	144	182
Mexico	*15	15	21

* salary are presented as payroll cost for countries that BLS not present salary for worked time

Salary for worked time: Payment received by the workers.
Salary cost: Salary for worked time and for the time not worked. Included in salary for not worked time holiday pay, sick pay and other compensations or benefits are included.
Payroll taxes: Included are the payroll taxes, health insurances, regular insurances, pensions etc.

There can be a big difference between countries concerning insurances, pensions and other things when comparing what is included in the payroll taxes, (Larsson 2011). In Sweden all parameters mentioned are included in the payroll taxes. For example, in Mexico these are paid to the worker whom are presumed to pay his/hers insurance and pensions self. The figures are gathered for comparison of salaries to show the difference between countries. Total cost calculations based on these numbers does not give a complete picture as other factors may differ.

6 Analysis

The report has been executed on a strategic level, designing the supply chain for the future expansion of SSRE. Today the company is preparing for the product launch which makes it important to construct an adequate supply chain, (Appelqvist, Lehtonen and Kokkonen 2004). Being in an early stage, as SSRE is on the market and with their products, the supply chain should be aiming for availability before efficiency, (Fisher 1997 and Porter 1996).

6.1 The product and production

SSRE products are new on the market and in the beginning of the ramp-up stage. The VT could be defined as both functional and innovative. It satisfies a basic demand from customers, electricity, but is of more interest to customers that search for innovative solutions, green and self-producing energy. The market qualifier for the VT will be the availability on the market as well as the price, while the market winner will be the function, its effect, and its design. Today in the production the wings and the generator can be seen as bottlenecks. From Kraljics matrix the wings and the generator will then be seen as strategic important parts, due to technical functions, and the relational level with its supplier in the future should be kept at the strategic level, for keeping control and high quality. Suppliers for both the generator and the wings have been looked for during the past winter and spring of 2011. Regarding the generator, China is the most attractive sourcing country and a SSRE contact is currently scanning the market. One manufacturer has offered a price of 10,000 SEK per unit excluding freight. This is seen as acceptable once the production can be started in some quantities. One issue is the unstable global market price of magnets needed in the manufacturing. SSRE is currently looking for a way to reduce the amount of magnets without lowering the output effect, (The market director 2011). For having better control, not risking valuable data on the manufacturing process of the generator etc., it would be best for SSRE to own the production in China, not using subcontractors. The wings can be produced at a local propeller manufacturer with an estimated price of 10,000 SEK for each set of three wings. During 2011, production is better of kept local, due to the low predicted quantities, (The market director 2011). Reasoning on producing the frame abroad will follow further down.

6.2 The supply chain

The supply chain today is kept short, with all parts manufactures located in Tidaholm, but in the future when and if the manufacturer of generators in China will be used the chain will become longer. Also the wings will be moved to another location, but still be located in Sweden. The longer chain could bring problems, due to the dimensions of room, time and culture, (Johnsson and Mattsson 2005). Lead-times will become longer and the communication will probably be harder. It is important to develop good packages for easier transportation and handling, (Lumsden 2007) but this will not be concerned in this work. All suppliers are today seen as primary for the high technical and quality parts, but the 3PL company that will handle transportation in the future could be seen as supporting. For the year 2011 when only a small group of turbines will be sold the agile supply chain could be used in order to provide high service level, for establishing their name and products. The years after SSRE should focus on a lean supply chain instead, due to a high cost and advance product

that the VT is most certainly only bought once in a life time and therefore the customer is more willing to wait for it. A 3PL company will probably be the best solution for handle the transportations. Not forcing SSRE to invest in carriers and containers, which mean a big cost save. Most 3PL companies require that information is transferred through an EDI-system but an alternative is available online.

6.3 Export to United Kingdom

As long as booth UK and Sweden are members of the European Union the customs of export and import will probably not be a problem. The transportations between the countries are fairly easy operated and products shipped from Tidaholm could arrive to the end customer about four days later. Important to think of when sending freight over the Northern Sea is that there are special rules to follow regarding securing of the freight.

6.3.1 Full truck load cost analysis

Capacity

For optimal transportation economy efficiency we want to fill one truck (FTL) at a time, (Lumsden 2007). Comparing the inner measures of a standard truck to the approximation of a complete VT package dimensions result in 3 x 5 x 3 (W, L, H), i.e. 45 units, (see table 18).

Table 18 – Capacity analysis

Width	2420/800	= 3, 025 → 3 units	One euro pallet wide
Length	18500/3600	= 5, 388 → 5 units	Three euro pallets long
Height	2400/650	= 3, 692 → 3 units	2400/600 or 2800/650 → 4 units

Since the euro pallets measure 800 x 1200 mm in width and length respectively, there is not room for much improvement. However, the height is a fair estimation. If total height could be lowered well under 600 mm, an additional fourth layer of complete VT packages could be piled, resulting in 3 x 5 x 4, i.e. 60 units in total. In this scenario the possible volume per shipment increases 25 percent. Another way to reach the same result if smaller packages are not possible would be to utilize small wheel trucks with 2800 mm internal loading height. In our cost calculations, however we will use the regular truck with calculated capacity of 45 units.

Procurement costs

The total procurement cost for all main parts from supplier to Tidaholm vary depending on the batch sizes of the frame, (The market director 2011). The maximum offered batch size of 100 units per year was studied first resulting in a total procurement cost of 1,966,500 SEK, (see table 19). Excluded costs are the procurement transportation costs within Sweden for the wing-sets and generators as well as the VT complete packaging work and materials.

Table 19 – Procurement costs

Main part	Cost/Units	Proc. Cost	Total Cost
Frame	24000x 45	1080000 SEK	
Wing-set	10000 x 45	450000 SEK	1,966,500 SEK
Generator	9700 x 45	427500 SEK	

Value added tax

If customers have a valid VAT registration, SSRE are exempted from Swedish VAT of 25 percent (Skatteverket 2011). Since SSRE aim to sell the VT wind turbines with installation excluded standard VAT rate of 20 percent is applied. If instead installation would be included, a reduced rate of 5 percent would be applied since any materials are included, (HM Revenue & Customs 2011). If the VT is sold directly to consumers a gross price of 58,333 SEK would result in price of 70,000 SEK as desired by SSRE, (see table 20).

Table 20 – Reduced VAT

Offer	VAT level	Net price	Gross price	Difference
VT	20 %	70000 SEK	58333 SEK	8337 SEK – Install costs
VT+Install	5 %	70000 SEK	66667 SEK	

Insurance

Shipping from Tidaholm to Immingham cost 17,062 SEK per truck. An optional insurance is available at 7,266 SEK. An insured full truck load to Immingham costs 24,328 SEK. In table 21 insurance and freight are summarized for one 18, 5 meters truck. While a total summarization can be found in table 22 for total costs until delivery to predetermined destinations of varying distances in SEK per VT unit. Included in distribution costs is an insurance of approximately 163 SEK.

Table 21 – Insurance and freight

Freight	1900 EUR x 8.98 EUR	= 17062 SEK
Insurance (Freight)	(2624985 + 17062) x 1, 1 x 0, 0025	= 7266 SEK (≈ 162 SEK/Unit)
Insurance (Distribution)	(58333+ 422/700/1078) x 1, 1 x 0,0025	≈ 163 SEK/Unit

Total costs

The total known costs represented below depend on currency fluctuations and current tariffs amongst other factors as well as they are partly estimates**.** Lumsden (2007), and Jonsson and Mattsson (2005) present logistics cost parts from different views. Present costs are procurement costs except transportation costs within Sweden for the generators and Wings and distribution costs from Tidaholm to United Kingdom, including insurance but excluding the last mile actual destination, (Lökholm 2011).

Table 22 – Total costs

Route	Proc. Cost	Freight cost	Distr. Cost	Total Cost
Tidaholm – Immingham 1	43700	703	–	44403 SEK/unit
Tidaholm – Immingham 2	43700	703	585	44988 SEK/Unit
Tidaholm – Liverpool	43700	703	863	45266 SEK/Unit
Tidaholm – Aberdeen	43700	703	1241	45644 SEK/Unit

Other excluded costs identified from the literature and interviews are:

- Stock keeping costs in Tidaholm and Immingham (Lumsden 2007; Lökholm 2011)
- Capital interest cost for goods stored and transported (Lumsden 2007)
- Packaging (Jonsson and Mattsson 2005)
- Labeling and identification either own or by 3PL provider(Lumsden 2007; Lökholm 2011)
- Administration and data communication such as TA-systems (Lumsden 2007; Lökholm 2011)
- Environmental costs, e.g. consulting a 3PL provider (Jonsson and Mattsson 20005; Holm 2011)
- Reseller percentage (The market director 2011)

Potential marginal profits

Given that SSRE want to pursue their idea of selling VT wind turbines for consumers to assembly, known marginal costs will cover approximately 76 – 78 percent of the marginal revenue, resulting in potential marginal profits after the difference is subtracted to all unknown costs carried by the VT, (see table 23).

Table 23 –Potential marginal profits

Route	Total known cost	Revenue	Difference
Tidaholm – Immingham 1	44403 SEK/unit	58333 SEK/Unit	13930 SEK
Tidaholm – Immingham 2	44988 SEK/Unit	58333 SEK/Unit	13455 SEK
Tidaholm – Liverpool	45266 SEK/Unit	58333 SEK/Unit	13067 SEK
Tidaholm – Aberdeen	45644 SEK/Unit	58333 SEK/Unit	12689 SEK

This scenario might be more valid initially as SSRE aim to sell directly to customers at first, (The market director2011). It is then important that the customers have valid VAT registration numbers, or Swedish VAT of an additional five percent units will be applied (Skatteverket 2011). However, if resellers are involved, their percentage taken might be leveraged by negotiation of sharing costs of installation and the tax reductions of 10 percent units, (HM Revenue& Customs 2011). Adding value to the customer and reducing costs from the supply chain may be beneficial for all parts involved.

Volume adjustment scenario

Volume adjustment involves not only optimizing the amount of units per truck but optimizing the unit itself to fit into available capacity, (Lumsden 2007). If volumes per truck are increased to 60 units, the only lowered cost is the freight cost from Tidaholm to Immingham. The insurance fee will be lowered insignificantly per unit, (see table 24). The total freight cost will be 445 SEK per unit, a reduction of 258 SEK per unit.

Table 24 – Insurance and freight

Freight cost	17062/60	= 284 SEK/Unit
Insurance Freight	(3499980 + 17062) x 1, 1 x 0, 0025	= 9672 SEK (≈ 161 SEK/Unit)

While this solution may reduce transportation costs slightly, other associated issues need to be considered. Fewer and larger shipments result in higher stock keeping in Immingham, with related costs and increased frozen capital, if demand is constant, (Lumsden 2011).

6.3.2 Single VT unit cost analysis

This data was not obtained and the scenario cannot be evaluated completely. Single unit deliveries may be interesting for SSRE in short term to supply few customers initially. However, if export is going to represent 80 percent of the total sales in the future, this solution should be regarded as ineffective. Costs and lead times will clearly increase. Therefore this cost information would only have served as a reference for comparison to full truck loads (FCL). For example, the cost intersect between sending a number of consolidated units and a number of units in a less than full truck load (LCL) would have been interesting to calculate.

6.4 Manufacture of the VT frame in UK

The comparison of the salaries between industrial workers shows that the difference between production of the frame in Sweden and UK are not that large. Transportation costs are calculated on the package volume, due to the product are seemed light, from the transporters point of view. When having the frame produced in UK the total volume of the package would decrease and the transportation cost would most certain decrease as well. Since there still are parts that are shipped from Sweden the cost for transporting those must be further researched in order to see how much and if the cost will go down. If one full truckload would be used for sending the wings and generators from Sweden the transportation cost per package would probably be the same, but the cost per unit that are sent could decrease. If the difference is not that large it could be preferred to have a little more expensive total cost (production and transportation) of the VT for having better control and keep the Swedish quality mark desired by SSRE.

6.4.1 Manufacturing cost scenario for frame

The manufacturer of the VT frame in UK is assumed to be equivalent with MPC concerning commitment and cost structure, with different work costs only. MPC charges 14,100 SEK for work costs at batch sizes of 100 units, (The market director 2011). General relation between UK and Swedish industrial salaries are 125/143 in comparison, (Larsson 2011), resulting in an approximated manufacturing cost of 12325 SEK. Setting the material cost equal to the Swedish manufacturer result in a total cost of 22,225 SEK.

6.4.2 Procurement of wings and generators

The amount of wings fitting into full a complete VT package and generators fitting into a pallet with rims is impossible to decide without thorough testing. However, to get an estimate, rough calculations have been made, (The market director 2011). For comparative purposes 99 wings are estimated to require 9 complete VT packages. Filling a whole truck result in that 11 x 45, i.e. 495 units will fit in the truck. The freight cost per VT unit is 17,062 SEK divided to 165 wing sets, equaling 103 SEK. The generators will be shipped directly from China and the individual cost for 33 units is estimated to equal Swedish sourcing, i.e. 200 SEK per unit (Gustafsson 2011).

6.4.3 Merge-in-transit costs

Manufacturing one part closer to the market requires consolidation of all parts into complete VT packages, which incur additional costs. The costs should cover additional stock keeping of parts, repackaging, handling and distribution. Merge-in-transit enables complete VT package deliveries to the customers, (Bradley et al., 1998; McLeod 1999; Dawe 1997). The challenge is where to locate the merge center. If the frame subcontractor is responsible the repackaging and distribution could be reduced. In this scenario the subcontractor becomes a key supplier with higher strategic importance. Distant markets involve issues of time lag and business culture. Therefore a close relationship with frequent communication is recommended, (Jonsson and Mattsson 2005). If a key supplier underperforms in regard to the promises of SSRE, company reputation might be damaged, (Kumar, Hong and Haggerty 2010).

6.4.4 Potential marginal profit estimation

The total known costs are procurement of wings, generators and frame to the merge center excluding packaging and domestic UK distribution costs, (see table 25). Further, all costs brought up earlier in this chapter must be covered by the revenue.

Table 25 – Export wing scenario

Merge-in-transit	Total known cost	Revenue	Difference
Wings(FTL)	42028 SEK/unit	58333 SEK/Unit	16305 SEK

Merging the goods at the frame subcontractor would save transportation of the heaviest and bulkiest part. However, this scenario involves a lot of unknown parameters since no subcontractor have been researched yet. DB Schenker provides merge solution at Immingham and therefore a more adequate choice with present data. One issue with full truckloads of wings would be the risk of overly high stocks, since 165 wing sets is much more than the highest offered batches from MPC.

6.5 Manufacture complete VT in United Kingdom

If decision is made to manufacture the whole product in UK, control of the product would probably become lower and there is a risk that the quality also would be lower. It is hard to see, with the information gathered, if the unit would be less costly compared to manufacturing in Sweden, but just

looking at the salaries it seems that manufacturing costs would decrease. The transportation cost of 1,900 EUR would not be an obstacle and the lead times of four days would also disappear. Due to SSRE's close and developed collaboration with its Chinese market contact and Chinas recourses of cost intensive neodymium, manufacturing in other countries will be irrelevant. This scenario is not possible to estimate since specific Swedish subcontractor cost offers do not exist yet. However if manufacturing of frames in UK would be relevant, this scenario should be further researched.

6.6 Supply chain and lead times

6.6.1Export complete VT to UK

The three parts of the VT wind turbine are sourced from Sweden and China. The frame is being produced in Tidaholm and does not require transportation to procure. The initial manufacturing lead time is quite long but can be halved if quantities reach 100 units per year, (Mattsson 2011). Manufacturing lead times of the wing is short in relation and should not be a bottleneck in the supply chain and transportation lead times can be neglected. However the generator procurement time is huge in comparison and requires the most planning in order to keep adequate stock levels. The transportation lead time to UK and its representative distribution locations is rather small in comparison, (see figure 15).

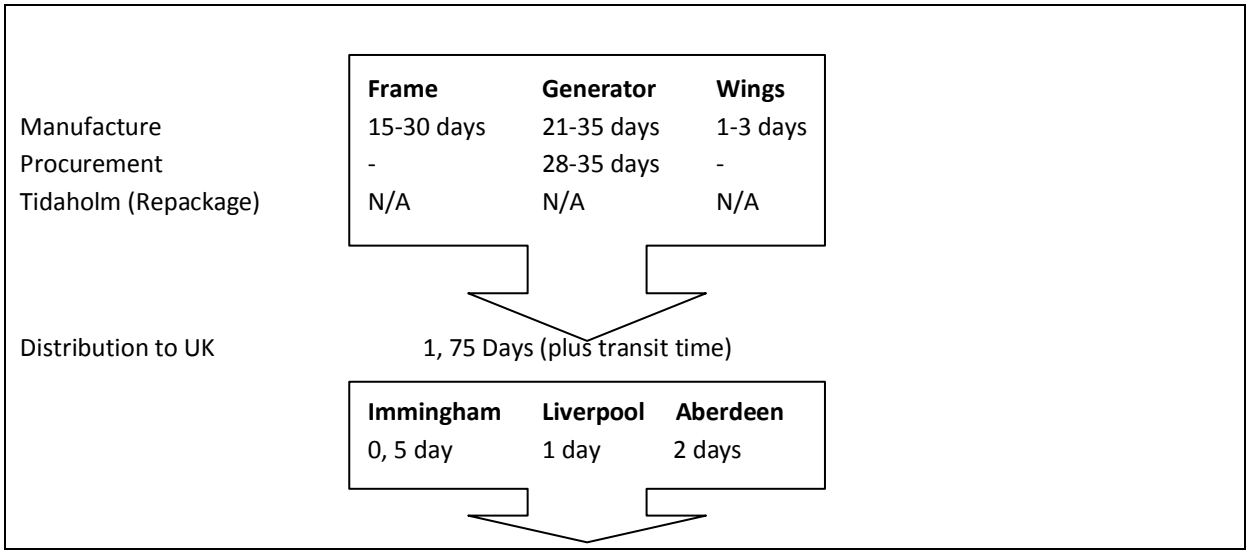

Figure 15 – Lead times UK, (Lökholm 2011)

6.6.2 Manufacture frame in UK

If the frames are manufactured in UK the transportation time of 1, 75 days can be reduced for this part. A production closer to demand is possible and limited lower capital interest costs can be achieved due to lower stocks and units in transportation for the frame. Still wings would be shipped from Sweden to match the demand and certain safety stock levels will be required. As very little lead times can be reduced for the frame, the increase complexity of a merger solution may overshadow these gains.

6.6.3 Manufacture complete VT in UK

In this scenario the generators are sourced directly from china. The very long procurement lead times will require planning for demand and safety stocks. However the transportation lead time of 1, 75 days from Sweden is vanished. This lead time reduction may be insignificant in comparison to the production lead times. However it may be possible to achieve synergy effects from keeping the organization within the operative market.

6.7 Comparison of UK scenarios

The choices presented are to export complete VT units, manufacture the frame in UK or manufacture complete VT units in UK, except for generators. The difference between the potential marginal profits in the two first cases is not very large considering the merger costs as an additional unknown cost entry, (see table 26).

Table 26 – Comparison of scenarios UK

Scenario	Potential profit	Comparable missing costs
Export (FCL)	13930 SEK/Unit	-
Manufacture (FCL)	16305 SEK /Unit	Merge cost

If any benefits could be gained from producing the frame in UK, it is not clearly visible in this research. Further, it should be mentioned that the work costs here are roughly estimated from work cost indexes. Therefore it is impossible to identify an obvious choice.

6.7 Export to Mexico

Mexico is a distant market for Swedish exporters and involves challenges as additional freight costs, longer lead times and import duty as a comparison to Swedish or European markets. The export to Mexico could bring special demand on the package material used, (SP 2011), which must be further researched. There is a lead time of 17 days for loading a whole container and up to 21 – 22 days for sending one or more units.

6.7.1 Full container load cost analysis

Capacity

For optimal resource utilization, the container need to be fully loaded (FCL), (Lumsden 2007). Comparing the inner measures of a 40 feet high cube container to the dimensions of a complete VT package result in 3 x 3 x 4 (W, H, L), i.e. 36 units, (see table 27). However, at DB Schenker, 33 units were approximated to fit while 36 should be seen as a maximum.

Table 27 – Capacity analysis

Width:	2347/800	= 3, 934 → 3 units	One euro pallet wide
Length:	12056/3600	= 3, 350 → 3 units	Three euro pallets long
Height:	2684/650	= 4,129 → 4 units	No improvement necessary

While the container width is close to take four euro pallets in width this cannot be seen as realistic to implement. The generator has a diameter of 700 mm and the package would need to be well under 586 mm to fit. Therefore the absolute maximum capacity can be seen as 36 units for a 40 feet high cube container.

Procurement costs

The total procurement cost for all main parts from supplier to Tidaholm vary depending on the batch sizes of the frame, (The market director 2011). We will study the maximum offered batch size of 100 units per year, resulting in a total cost of 1,442,100 SEK, (see table 28). Excluded costs are the procurement transportation costs within Sweden for the wing sets and generators as well as the VT complete packaging work and materials.

Table 28 – Procurement costs

Main part	Cost/Units	Proc. Cost	Total Cost
Frame	24000x 33	792000 SEK	
Wing-set	10000 x 33	330000 SEK	1,442,100 SEK
Generator	9700x 33	320100 SEK	

Value added tax, import duty an insurance

For wind turbines that are shipped under the cost and freight term (CFR) the buyer is responsible for import duty, taxes and insurance (Stöth 2011). Since SSRE aims to offer the VT at 70,000 SEK to final customers, the import duty and tax must be included. Deriving the formula for VAT/tax liability with the given transportation cost of 28,050 SEK and net price of 2,310,000 SEK (for 33 units) a customs value (gross price) of 58,012 SEK was obtained, (see table 29).

Table 29 – Import duty derivation

Import Vat /Tax = 16% over (CIF value +Duty+ DTA)

16 % x (CIF Value* + (15 % x CIF Value*) + (0, 8 % x VAL**)) = 2310000 – VAL	(1)
0,16 x 1,15 x 1,1 (VALUE + 28050) + 0,16 x 0,008 x VAL = 2310000 – VAL	(2)
0, 2024 x VAL + 5677, 3 + 0, 00128 x VAL = 2310000 - VAL	(3)
0, 20368 x VAL + 5677, 3 + 1 x VAL = 2310000	(4)
1, 20368 x VAL + 5677, 3 = 2310000	(5)
1, 20368 x VAL = 2304322, 7	(6)
VAL = 2304322, 7/1, 20368 = 1914398 SEK**	(Full container customs value)
1914398/33 = 580012 SEK	(Single VT unit customs value)

CIF value = (product value + freight cost) + 10 %, (Stöth 2011)
***Customs value is the price actually paid or payable by the buyer to the seller for the goods. (HM Revenue & Customs 2011)*

Since insurance is the buyer's responsibility it cannot be added as a cost for SSRE but is still a supply chain cost which must be covered in the net price of 70,000 SEK. The issue is where to put this cost. A fee of 7,700 SEK was estimated by DB Schenker, (Johannisson 2011). Divided on 33 units, each will bear an insurance cost of 233 SEK. To account for this cost without changing the import duty calculations we assume that the insurance is paid by SSRE.

Total costs

The freight cost from Tidaholm to the Mexican ports is 850 SEK per unit if full container loads are utilized, (Johannisson 2011). Ocean freight insurance included, total cost is 10,083 SEK, (see table 30). Distribution costs in Mexico are not included as the goods are responsibility of the buyer from the port of Gothenburg, (Stöth 2011).

Table 30 – Total costs

Route	Proc. Cost	Freight cost	Distr. Cost	Total Cost
Tidaholm – Vera Cruz	43700	1083	–	44783 SEK/unit
Tidaholm – Alta Mira	43700	1083	–	44783 SEK/Unit

Currency fluctuations between the Swedish crown (SEK) and the US dollar (USD) partly affects the freight cost, combined with regularly updated tariffs. Further, procurement transportation costs within Sweden are not accounted for. Other excluded costs identified from the literature and interviews are:

- Stock keeping costs in Tidaholm (Lumsden 2007)
- Capital interest cost for goods stored and transported (Lumsden 2007)
- Packaging materials and work (Jonsson and Mattsson 2005; The market director 2011)
- Labeling and identification either own or by 3PL provider(Lumsden 2007; Lökholm 2011)
- Administration and data communication such as TA-systems (Lumsden 2007; Lökholm 2011)
- Environmental costs, e.g. consulting a 3PL provider (Jonsson and Mattsson 20005; Holm 2011)
- Distribution costs within Mexico, (Johannisson 2011)
- Reseller percentage (The market director 2011)

Potential marginal profits

Since SSRE strategy on the long term is to distribute the VT through resellers, (The market director 2011), the distribution cost loses interest and the reseller percentage becomes important. Here SSRE will need to set a reasonable gross price to resellers combined with an agreed upon reasonable consumer net price. The reseller percentage would be the difference between the gross price towards reseller and consumers. If SSRE chose to sell directly to customers, it is strongly

recommended to exclude distribution regardless. Being responsible for the goods in a foreign market as an exporter require a DDP term which makes SSRE VAT responsible. This term is seldom used and incurs additional complexity and costs, (Stöth 2011). Table 31 describes the potential marginal profits for the two destinations.

Table 31 – Potential marginal profits

Route	Total known cost	Revenue	Difference
Tidaholm – Vera Cruz	44783 SEK/unit	58012 SEK/Unit	13229 SEK
Tidaholm – Alta Mira	44783 SEK/Unit	58012 SEK/Unit	13229 SEK

6.7.2 Single unit cost analysis

The basic cost for freighting one package of three pallets from Tidaholm to the Mexican ports is 6,033 SEK with an additional cost per cubic meter (CBM), (see table 32), (Johannisson 2011).

Table 32 – Volume cost tariff

Variable cost source	CBM	Cost SEK/Cbm	Volume Cost	Base cost	Total cost
Vera Cruz	1, 872	641, 35	1201 SEK	6033 SEK	7234 SEK
Alta Mira	1, 872	662, 45	1240 SEK	6033 SEK	7273 SEK

Adding import duty and tax result in the following calculations based on the derivation from table 29, (see table 33).

Table 33 – Price/revenue analysis

Vera Cruz:	1, 20368 x VAL + 0, 20368 x 7234 = 70,000
Alta Mira:	1, 20368 x VAL + 0, 20368 x 7273 = 70,000
Vera Cruz:	VAL = 56931 SEK
Alta Mira:	VAL = 56924 SEK

The potential profit is much lower, even if the procurement cost are calculated on 100 unit batches in production with the lowest costs on given offers. In reality, the motive for single unit shipments should be lower demand and lower production quantities which would raise manufacturing costs as well, (see table 34).

Table 34 – Potential marginal profit

Route	Total known cost	Revenue	Difference
Tidaholm – Vera Cruz	50934 SEK/unit	56931 SEK/Unit	5997 SEK
Tidaholm – Alta Mira	50973 SEK/Unit	56924 SEK/Unit	5951 SEK

If only ten frames would be produced during a year for ten single unit VT exports to Mexico, the price per frame would increase by 2,900 SEK. After these reductions the potential profit of 3,097 SEK to Vera Cruz. When neodymium generators are sourced from China in the same quantity, both freight and production costs are expected to rise. If other cost mentioned in previous chapters as packaging materials and work and Swedish procurement transportation costs are included it seem that breakeven will be hard to achieve. Therefore, a low production, single unit export solution seems optional, only for the purpose of promoting the product in short term.

6.8 Manufacture of the VTframe in Mexico

From the comparison of salaries between industrial workers it can be seen that workforce in Mexico are less expensive compared to Sweden. Therefore the manufacturing cost would probably become lower if the frame where constructed here. SSRE has stated that they want to have the Swedish quality mark on their products, but it is lost if they decide to produce in Mexico. There are trade-offs between production cost, the brand, the customer value and expectations of the product, (Simchi-Levi, Kaminsky and Simchi-Levi 2003).

6.8.1 Manufacturing cost scenario for frame

If a manufacturer, equivalent to the Swedish subcontractor, could be found for the VT frame with the exact same commitment and cost structure, the only difference would be the cost of work. At batches of 100 units, MPC charges 14,100 SEK, (The market director 2011). The relation in salaries is 15/143 in Mexico, compared to Sweden, in general (Larsson 2011). The work cost estimate will roughly be around 1,480 SEK. If material costs are seen as equivalent the total cost is 11,380 SEK. In this scenario, the import duty can be partly ignored.

6.8.2 Procurement of wings and generators

The amount of wings fitting into a complete VT package and generators fitting into a pallet with rims is impossible to decide without thorough testing. However, to get an estimate, rough calculations have been made. For comparative purposes 99 wings are estimated to require 9 complete VT packages. For filling a whole container this means that11 x 33, i.e. 363 units will fit in one container. The freight cost per VT unit is 28,050 SEK divided to 121 wing sets, equaling 232 SEK. Sending only three packages consisting of 11 per of wing sets the freight cost should be 7,234 x 3 divided to 11 wing sets, equaling 1,973 SEK per unit to Vera Cruse and 1,984 SEK to Alta Mira.

The generators will be shipped directly from China and the individual cost for 33 units is estimated to equal Swedish sourcing, i.e. 200 SEK per unit, (Gustafsson 2011).

The import duty tariff of wings and generators is unknown but calculated on customs value. The costs of wing sets and generators are 19,500 SEK compared to the cost of the frame of 24,000 SEK. As they represent less than half of the total value customs value could roughly be cut in half and the respective import duty costs should be less than half of one VT unit.

6.8.3 Merge-in-transit costs

Manufacturing one part closer to the market requires consolidation of all parts into complete VT packages, which incur additional costs. The costs should cover additional stock keeping of parts, repackaging, handling and distribution. Merge-in-transit enables complete VT package deliveries to the customers, (Bradley et al., 1998; McLeod 1999; Dawe 1997). The challenge is where to locate the merge center. If the frame subcontractor is responsible the repackaging and distribution could be reduced. In this scenario the subcontractor becomes a key supplier with higher strategic importance.

Distant markets involve issues of time lag and business culture. Therefore a close relationship with frequent communication is recommended, (Jonsson and Mattsson 2005). If a key supplier underperforms in regard to the promises of SSRE, company reputation might be damaged, (Kumar, Hong and Haggerty 2010).

6.8.4 Potential marginal profit estimation

The revenue is calculated on 16 percent Mexican VAT. As the additional import duty for wings and generators are not included, it should not exceed half of the original import duty of a complete VT package. The total known costs are procurement of wings, generators and frame to the merge center excluding packaging and domestic Mexican distribution costs, (see table 35).

Table 35 – Potential marginal profit

Merge-in-transit	Total known cost	Revenue	Difference
Wing container	33060 SEK/unit	58800 SEK/Unit	25740SEK
Wing single packages	31312 SEK/unit	58800 SEK/Unit	27488 SEK

6.9 Manufacture complete VT in Mexico

Locating the whole production of the VT in Mexico would probably be less costly than exporting, due to the custom duty, work costs and the transportation cost. There is a risk though, of decreasing control of the production as well as the risk that the quality decreases, if the production would be settled in Mexico. Due to SSRE´s close and developed collaboration with its Chinese market contact and Chinas recourses of cost intensive neodymium, manufacturing in other countries will be irrelevant. This scenario is not possible to estimate since specific Swedish subcontractor cost offers do not exist yet. However if manufacturing of frames in Mexico would be relevant, this scenario should be further researched.

6.10 Supply chain and lead times

6.10.1 Export Complete VT to Mexico

The three parts of the VT wind turbine are sourced from Sweden and China. The frame is being produced in Tidaholm and does not require transportation to procure. The initial manufacturing lead time is quite long but can be halved if quantities reach 100 units per year. Manufacturing lead times of the wing is short in relation and should not be a bottleneck in the supply chain and transportation lead times can be neglected. However the generator procurement time is huge in comparison and requires the most planning in order to keep adequate stock levels. Transportation to Mexico by 40 feet high cube container is the second longest lead time and the ship from Gothenburg leaves once a week which requires some planning, (see figure 16). Transportation lead time of consolidated goods is a little longer and incurs extra transit time.

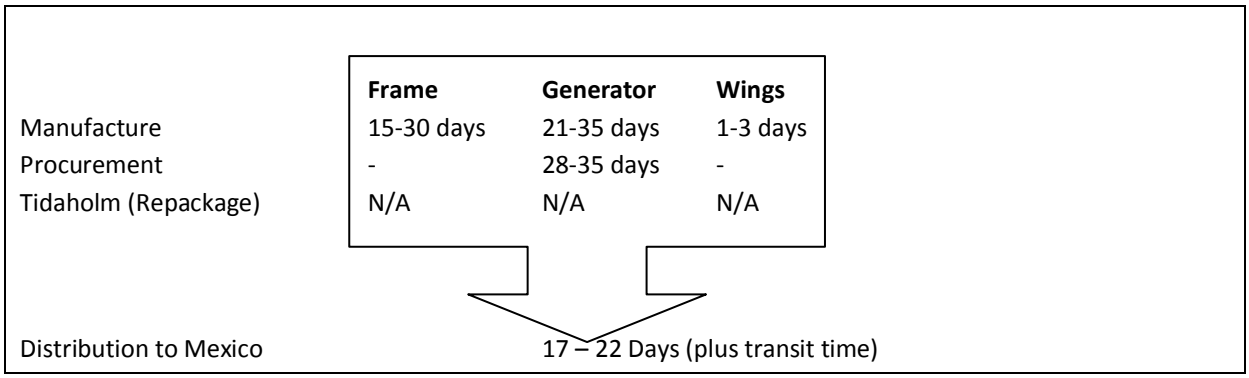

Figure 16 – Lead times Mexico, (Johannisson 2011)

6.10.2 Manufacture frame in Mexico

If the frames are manufactured in Mexico the transportation time of 17 days can be reduced for this part. A production closer to demand is possible and lower capital interest costs can be achieved due to lower stocks and units in transportation. Still the generators and wings would be shipped from Sweden to match the demand and certain safety stock levels will be required.

6.10.3 Manufacture complete VT in Mexico

In this scenario the generators are sourced directly from china. The very long procurement lead times will require planning for demand and safety stocks. However the transportation lead time of 17 – 22 days from Sweden is vanished. These weeks of reduced lead time increases responsiveness to market.

7Conclusion

This report will become more of a value to SSRE later, as they start sales abroad. Following tables show potential profits and the additional unknown costs that must be carried as well as subjective evaluations.

7.1 United Kingdom

In table 36 all scenarios are compared and unknown costs are mentioned as well as an evaluation of major circumstantial characteristics.

Table 36 – Conclusion UK

Costs / unit (SEK)	Export VT –Optimal (FTL)	Export VT – installation incl.	Export Wings – Optimal (FTL)	Export Wings – Installation incl.
Proc. cost	43700	43700	41925	41925
Freightcost	379	379	103	103
Insurance	162	162	–	–
Total cost	**44241**	**44241**	**41912**	**41912**
Net price	70000	70000	70000	70000
VAT (5 or 20 %)*	11667	3333	11667	33333
Revenue	**58333**	**66667**	**58333**	**66667**
Potential profit**	**14092**	**22426**	**16421**	**24775**
Unknowncosts		Installation	Merge in transit wings stock repackaging	Installation Merge in transit Wings stock repackaging
Common unknowncosts	VT packaging materials and work. Procurement transportation costs within Sweden. Reseller's percentage. Stock keeping costs and capital interest, (Lumsden, 2007) Administration, communication and labeling costs, (Lumsden 2007; Lökholm 2011). Shared overhead costs.			
Benefits	Simple Control	Simple Control Reduced tax	Slightly shorter leadtimes	Reduced tax
Disadvantages	Long lead times Highest costs	Unwantedcommitment	Complex Less control	Complex Less control Unwanted commitment

* In UK, VAT is reduced for installation of wind turbines, materials included.

** Potential profit must carry all costs not included in this research, e.g. installation costs.

7.2 Mexico

In table 36 all scenarios are compared and unknown costs are mentioned as well as an evaluation of major circumstantial characteristics.

Table 37 – Conclusion Mexico

Costs / unit (SEK)	Export VT –Optimal (FCL)	Export VT – Consolidated	Export Wings – Optimal (FCL)	Export Wings – Consolidated
Proc. cost	43700	43700	30880	30880
Freightcost	850	5093	232	1973
Insurance	233	–	–	–
Total cost	**44783**	**48793**	**31112**	**32853**
Net price	70000	70000	70000	70000
Effective VAT*	11988	13069	11200	11200
Revenue	**58012**	**56931**	**58800**	**58800**
Potential profit**	**13229**	**8138**	**27688**	**25947**
Unknowncosts			Merge in transit Wings stock repackaging	Merge in transit Wings stock repackaging
Common unknowncosts	VT packaging materials and work. Procurement transportation costs within Sweden. Reseller's percentage. Stock keeping costs and capital interest, (Lumsden, 2007) Administration, communication and labeling costs, (Lumsden 2007; Lökholm 2011). Shared overhead costs.			
Benefits	Simple Control	Simple Control	Short lead times Significantly lower work costs	Reduced tax Short lead times Low work costs
Disadvantages	Long lead times Highest costs	Very high transportation costs	Complex Less control	Complex Less control Unwanted commitment

* Import duty levels are determined by harmonized codes. In the "manufacture in Mexico" scenario, VAT is 16 % were import duty for wings and generator is not represented.

** The potential profit must carry all costs not included in this research.

8 Discussion

During the report progress there has been many changes in form of information regarding the products features and costs. Also the package solution is an estimation of what the package could look like and not a definite solution. This means that the result should not be seen as definitive, but merely be used as guidelines for SSRE. Manufacturing of the generators is not completely settled and an evaluation of SSRE owning the production in China or use of subcontractors should be performed. Subcontractors could mean a higher risk for company secrets and for having a higher security on manufacturing process than if manufacturing should be owned.

A wind turbine is here thought to be something that a consumer might only by once in a life time. In other words, nothing that one just walks in to a store and buys. The purchase is probably well thought-out and therefore lead times are not seen as an obstacle. Ocean transportation is the only option used between the countries, but air transportation could also be used probably against a high cost. With this in mind the best solution for their supply chain would probably be lean approach and not agile or leagile. Estimated procurement costs are currently rather high. Each of the three main part costs could be evaluated and compared to alternative procurement methods. For example, dedicated manufacturing in larger volumes may very well reduce marginal costs.

Optimized transportations as full container loads showed to result in very low costs even for very long distances as Sweden to Mexico. A mean to further optimize transportation costs is volume adjustment. Adapting goods or package volume to the loading space can further increase transportation cost savings per shipped unit. However these savings may be overshadowed by inventory costs and capital interest of stocks and transported goods if demand of the wind turbines is not equivalent. Especially, this may be an issue when transporting separate main parts such as wings optimally, as huge stocks may be obtained at merger centers. For example, 495 individual wings are estimated to fit in one 18, 5 m truck to UK, enough for 165 wind turbines.

Since there is no custom duty when exporting in EU it could be better to keep the production in Sweden than transporting it to UK and thereby have more control and at the same time keep the Swedish quality desired by SSRE. Another incentive would be increased production volumes in Sweden from the combined demand, keeping marginal procurement costs down.

If all costs related to procurement and distribution of the VT was known, a lowest quantity for achieving breakeven results could be calculated for certain revenues. This information in comparison to optimal quantities, i.e. full container or truck loads, can be seen as two extremes in an interval.

MPC might be used as a merge center to keep control and the short transportation lead times should be in favor. On the other hand it could be best having the whole production in Mexico, due to the custom duty, long lead time and transportation costs, but then the quality and control might decrease. The long lead time from Sweden to Mexico results in capital tied up which could be a problem and is something that must be considered.

9 Recommendations

In this chapter recommendation for the different scenarios will follow for respectively country. Keep in mind that the recommendations are made with some additional costs that still are unknown.

9.1 Recommendation for UK

From the scenarios it is seen that the difference between producing in Sweden, UK or transportation to respective country is not that large. Therefore the recommendation in this scenario is to keep all production in Sweden, with the generator shipped from China, for better control and keep the Swedish standards desired. This is based on the short lead times; that potential profit would not be that much larger and; that additional merging costs are not included. Further it is recommended to investigate the possibilities to include installation in the end customer sales. Though responsibility for sales is transferred to resellers this opportunity should be acknowledged by SSRE. The 15 percentage units in VAT reduction combined with significantly increased customer value results in two possibilities. First possibility is transferring the value to the customer by covering installation with the 15 percentage units of VAT reduction. Secondly there could be a possibility for an increase in price, increasing value to the supply chain. Additional profits may then be negotiated between SSRE and the resellers. Either way installation might possibly be too complex for the average layman to cope with.

9.2 Recommendation for Mexico

In the Mexico scenarios there could be a potential cost saving the production is local. The transportations lead times are shortened, the production cost could decrease and also the custom duties are removed from the VAT. Therefore it is recommended to execute a more thorough research for start production in Mexico. Since the manufacturing costs are mainly calculated from industrial labor costs, actual cost offers will be needed. If the frame and wings are to be manufactured in Mexico regular VAT of 16 percent is applied while the import duty tariff for the generator needs to be procured. Reduced lead times result in lower frozen capital and capital interest as well as quicker response to market. These benefits must be compared against the risks of manufacturing abroad. Well known possible issues are time differences, business culture and misunderstandings due to language. Eventual misbehavior of key suppliers can easily damage company reputation.

10 Further research

Whiteout concrete data it is suggested for further research to research following:

- Investigate how it the situation would look like if the whole production (al parts) were located in respectively country (UK and Mexico).
- Investigate if the package could be optimized and VT frame could be minimized in order to get more packages into the carrier. This for decrease the freight cost per turbine.
- There can also be further research of SIDA-projects.
- Efficient and appropriate packaging logistics needs to be researched and developed (approved material, stress and regulations). The VT design makes this issue event more important.
- Choosing third part logistic providers is a key strategic choice which needs much further research in regard to location, quantities, costs, quality and control etc.
- A study on import duty connected to the VT HS code on interesting markets is advised, since this showed to be a major cost that possibly inhibits export. In combination, finding ways totally elude import duty is advised.
- As the VT marketing matures, cost reduction needs to be considered at all levels in the supply chain.

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11.2 Interviewees

Name	Position	Interview
Market director, Small scale Renewable Energy	Market director	Meeting/Telephone/E-mail
Göran Stöth, Linnaeus University	Lecturer	Telephone/E-mail
Inventor, Small scale Renewable Energy	Product development	Meeting/Telephone
Maria Holm, DB Schenker	Environment	Telephone
Maria Lökholm, DB Schenker	Production Unit Manager	Meeting/Telephone/E-mail
MatsGöranGustafsson, MultiW	Chinese market expert	Telephone/E-mail
Ola Mattsson, MPC	Industrial engineer	Meeting/Telephone/E-mail

Pia Johannisson, DB Schenker	Custom care Division Air & Ocean	Telephone/E-mail
SP Technical Research Institute of Sweden	Customer support	Telephone
Tullverket	Customer support	Telephone