Ingeniørhøjskolen i København

European Project Semester

Design of global chain for wind turbines production

Group 3

Mehmet Gelgel

Oriol Guarch

Patricia García

Pierre Le Goff

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Mehmet Gelgel

German, 29 years.

Bachelor of international Sales and Purchasing in Engineering in (FH-Kiel).

Oriol Guarch

Spanish, 24 years.

Technical Industrial Engineering-Specialization industrial Electronics in Spain (UPC)

Patricia Garcia

Spanish, 25 years.

Industrial Engineering in Spain (UPCT)

Pierre Le Goff

French, 22 years.

Engineering School in Paris (ISEP).

Abstract

This project discusses perspectives for design global supply chain for wind turbine production aiming to a future political system supporting this development. We have to install wind farms in 6 countries (Denmark, Sweden, Norway, England and Finland).

The project is based on a fictive case where a major Danish energy conglomerate has decided on a new strategy to become the largest producer of clean energy in northern Europe. The fictive company is Dan Energy and is the leading Danish energy conglomerate. Nowadays, it focused on energies fossils like fuel and coal power station. For the future, the conglomerate wants to develop wind turbines power and its target is to become the largest producer of wind power in Northern Europe until 2014.

In particular, it suggests answers to the following questions:

- How should the production be divided? Are we going to produce in house or out house some parts of the wind turbine or we are going to produce some parts ourselves?
- Which governance system is the most suitable for our business situation?
- Where in the world should the factories be located for the best cost without good quality?
- What are being our suppliers and where are they?

Our supervisor is Samuel Larsen and he helped us with meeting each week on Monday for give us some advice in our report. He gives us also a contact in Dong Energy Company for asking to Mickael Sanggaard

Preface

We have chosen the project number four because it depends on manufacturing strategy and it is a main issue for us to learn as much as possible on how we can make business with others countries and how you can manage our project. For the management of projects, we need to control our project successfully to meet deadlines, costs and quality, has turned this area into a specific management function. Effective project management is essential to the profitability of any company.

That's why we have to work together as a team and use efficiently the skills of individual team members.

This EPS report project in European studies was delivered at the Department International Studies, Copenhagen University College of Engineering, in Ballerup, in Denmark. I would like to thank the Department of International Studies for providing the environment like the library who gives us a lot of used information within this work was carried out. We would like to thank to Mickael Sanggaard that we met in the company Dong Energy especially for providing us very useful information to this project.
In particular we would like to thank my supervisor Samuel Larsen for sharing his considerable expertise in the field of energy policy, which enabled us to do this study, as well as his persistent support whilst we were writing this report. This work would not have been possible without this help.

Ballerup, November 30th 2009

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1. Introduction

We are four international students from EPS Exchange for the project. We have chosen the project number four because it depends on manufacturing strategy and it is a main issue for us to learn as much as possible on how we can make business with others countries and how you can manage our project. For the management of projects, we need to control our project successfully to meet deadlines, costs and quality, has turned this area into a specific management function. Effective project management is essential to the profitability of any company. That’s why we have to work together as a team and use efficiently the skills of individual team members.

Wind power is the conversion of the wind into a useful form of energy, such as electricity, using wind turbines. At the end of 2008, worldwide nameplate capacity of wind-powered generators was 121GW. In 2008, wind power produced about 1.5% of worldwide electricity usage; and is growing rapidly, having doubled in the three years between 2005 and 2008. Several countries have achieved relatively high levels of wind power penetration, such as 19% of stationary electricity production in Denmark, 11% in Spain and Portugal, and 7% in Germany and the Republic of Ireland in 2008. As of May 2009, eighty countries around the world are using wind power on a commercial basis.

Large-scale wind farms are connected to the electric power transmission network; smaller facilities are used to provide electricity to isolated locations. Utility companies increasingly buy back surplus electricity produced by small domestic turbines. Wind energy as a power source is attractive as an alternative to fossil fuels, because it is plentiful, renewable, widely distributed, cleans, and produces no greenhouse gas emissions. However, the construction of wind farms is not universally welcomed due to their visual impact and other effects on the environment.

Wind power is non-dispatchable, meaning that for economic operation, all of the available output must be taken when it is available. Other resources, such as hydropower, and standard load management techniques must be used to match supply with demand. The intermittency of wind seldom creates problems when using wind power to supply a low proportion of total demand. Where wind is to be used for a moderate fraction of demand such as 40%, additional costs for compensation of intermittency are considered to be modest.

2. Case Description

The project that we are going to develop is based on the design of global supply chain for wind turbine production. First of all, we have to present that consist of the case, then what is going to be our work and how we are going to achieve.

We are an energy company called DanEnergy that has an excellent position in the energy market. Our source of energy is composed only by fossil fuels, but now we want to introduce into the renewable energies, like the wind market. Aside from this our target is clear, we want to become an important company, the largest producer in Northern Europe of wind energy before 2015, as shown our slogan:

Bigger is better 2015

To better understand DanEnergy company, we are going to explain the structure and present a new term called Vertical Integration.

The structure of DanEnergy is divided in several big parts corresponding with the different energy they produce, but focusing on the wind energy division, it has four main departments. Our work is on the windmill production and installation, showed in figure 2.1.

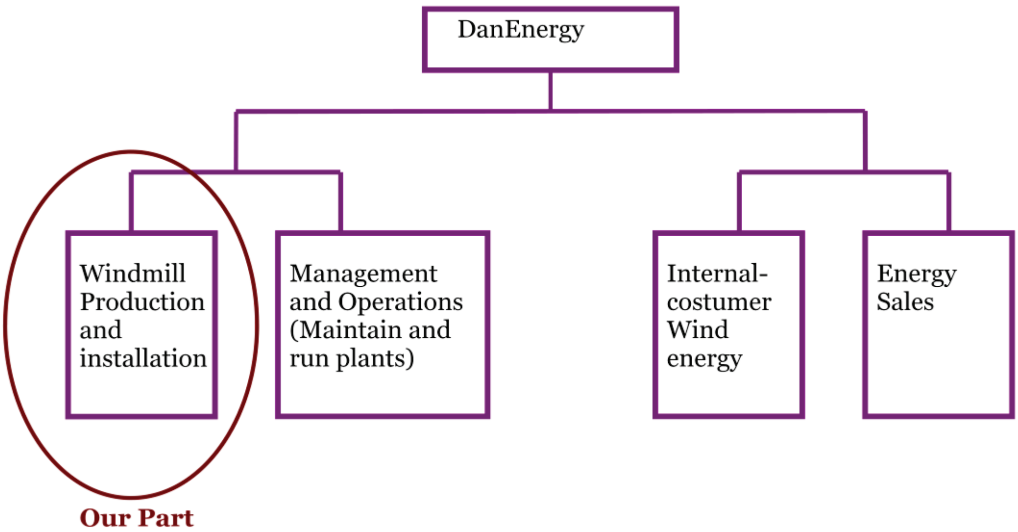


Figure 2.1: DanEnergy company structure

Otherwise we have another concept to bring the project within a good understanding. The vertical integration is a form of business organization in which all stages of production of a good, from the acquisition of raw materials to the retailing of the final product, are controlled by one company. In DanEnergy´s case, it is clear that is an energy company and now they want to introduce theirselves in the windmill production market. The vertical integration is like the union of two companies, as shown in figure 2.2.

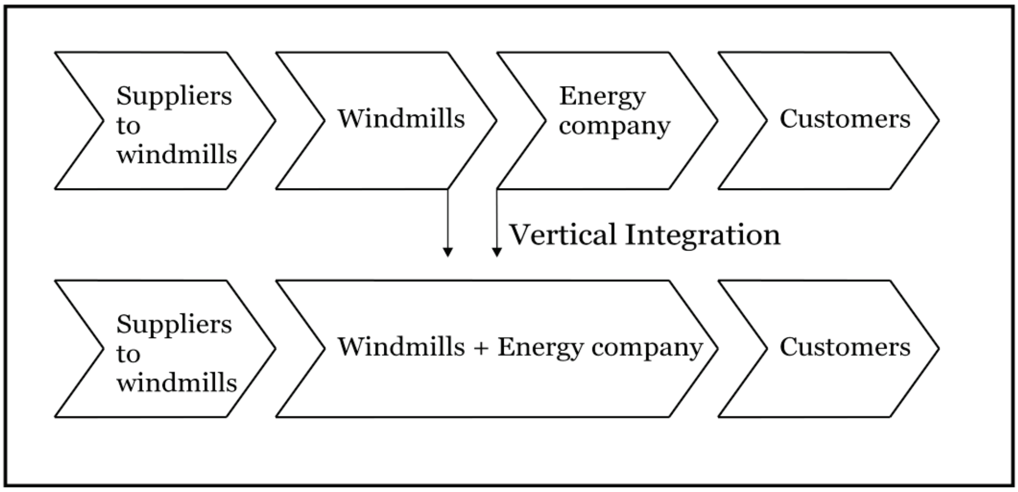
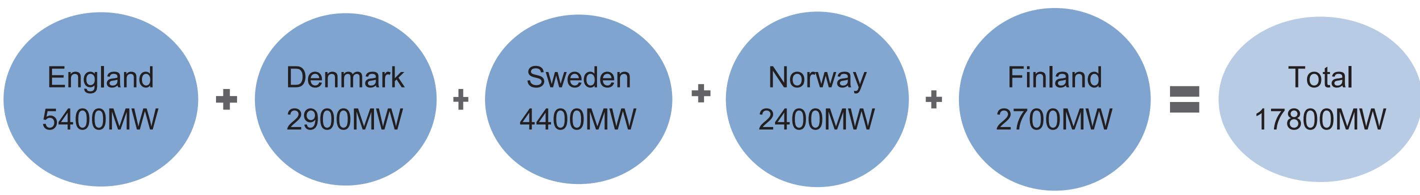


Figure 2.2: Vertical Integration *(source: Samuel Larsen)*

Now we are going to explain our work inside DanEnergy. Five countries are concerned in our business: Denmark, Sweden, Norway, England and Finland. All of them have a wind energy demand that we have to provide between 2011 and 2015.

Quantity of production (MW) for our customers:



We can see in figure 2.3 the evolution of our project and the different ways for the future of our business, because every year we have to produce a different percentage of MW.

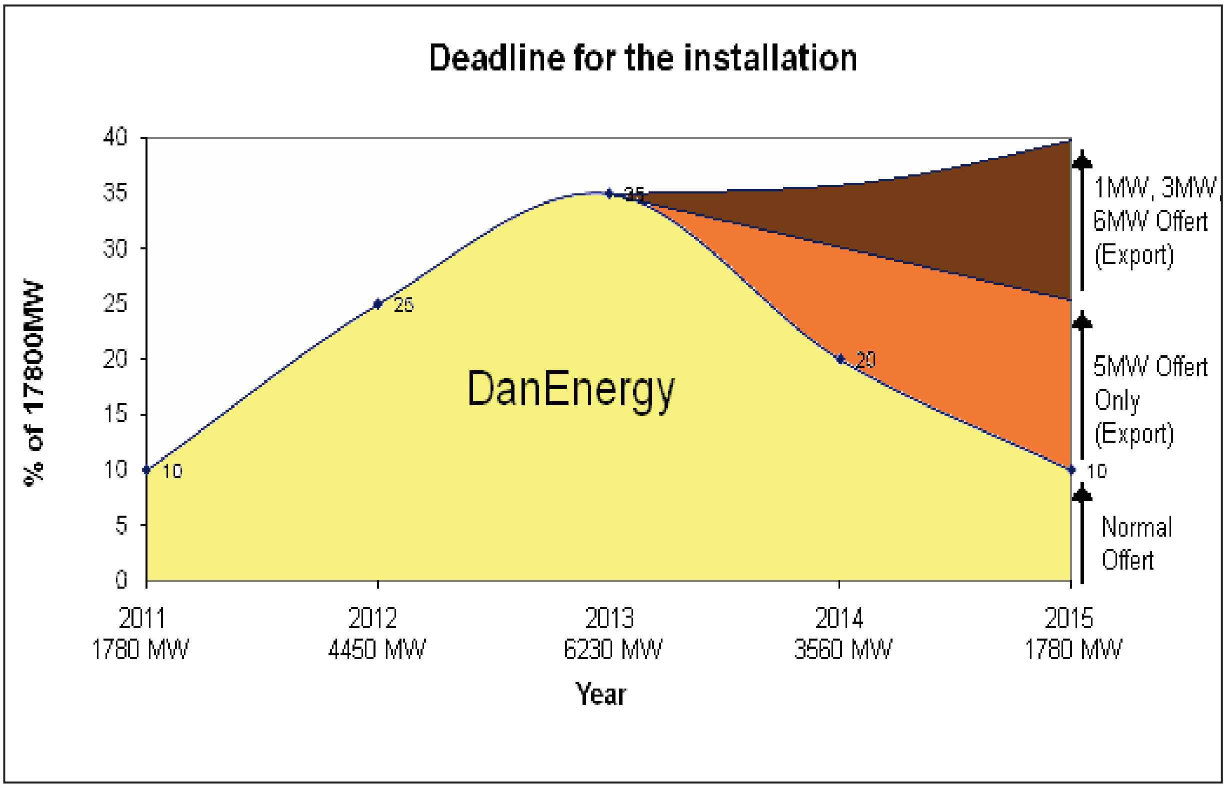


Figure 2.3: Yearly forecast of installation rate in MW.

The main period for our business is the beginning, because we have to make a big investment the first three years. So in 2013 our demand reaches the maximum value and then starts to decrease, but we are going to continue producing the same quantity or more because we want to export to other countries. We can see in figure 2.3 three different colors. The yellow part is directly focused on our project with our five customers. The orange part is focused on exportation with only one type of wind turbine. The last part in brown is focused on exportation of several types of wind turbines. The orange part is a wrong solution because if we offer just one product, our production will decrease and we don't want to get that way of market. Then the best solution we have chosen is to stay in the brown part of the graphic.

So our work is to think how we can do it and the tools that are going to help us will be the Operation Strategy, Manufacturing Strategy and Location Analysis and design. These topics are going to be explained in the following paragraphs.

3. Problem statement

The objective of every project is to resolve a problem statement. So in our case wouldn´t be less.

We have two main general questions:

- What is Operations Strategy?
- What should the structure of a windmill supply chain be?

Apart of the questions below, we have specific questions too.

- Do we have to focus more in cost, quality, speed, dependability, flexibility or all of them?
- Do we have to make or buy our parts?
- How should the production be divided? E.g. into subparts (tower, nacelle, blades, etc…)?
- Where in the world should the factories be located?

All these questions will be answered in the following chapters.

4. Methodology

This project is based on empirical analysis of different types. The main methods used have been are shown in the next points.

4.1 Operations strategy[1]

The main method we are going to use is based on the book Operations Strategy from Slack/Lewis. It provides a lot of help to reach our main aim of the project in making decisions in capacity analyzes and supply network, because it edits the problems systematically that we want to solve by reference to the Operations Strategy Matrix (O.S.matrix) shown in figure 4.1.

[1] Operations strategy is the total pattern of decisions which shape the long-term capabilities of any kind of operation and their contribution to overall strategy, through the ongoing reconciliation of market requirements and operation resources.

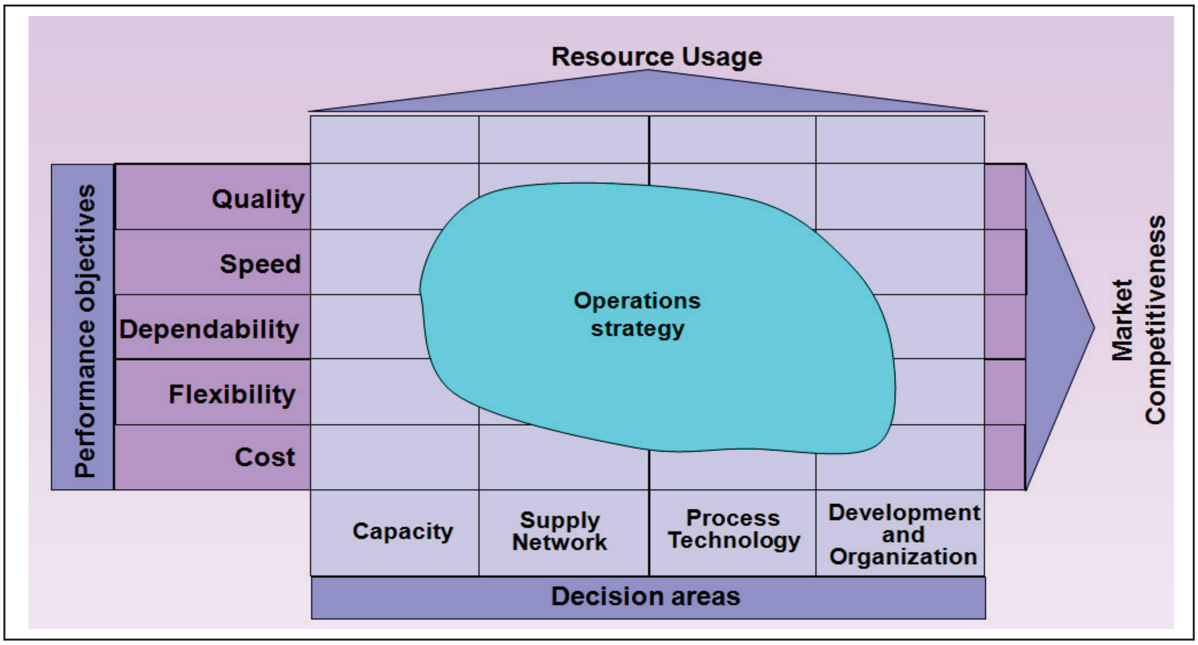


Figure 4.1: Operations Strategy Matrix *(source: Operations Strategy Slack/Lewis)*

This Figure shows us on the left side the performance objectives[2] quality, speed, dependability, flexibility and cost figure 4.2. These objectives are given from the market requirements and we have to determine on these objectives in which we want to compete.

Quality	Being Right
Speed	Being Fast
Dependability	Being on time
Flexibility	Being able to change
Cost	Being Productive

Figure 4.2: Market competitiveness *(source: Operations Strategy Slack/Lewis)*

[2] Performance objectives are the general classification under which we group competitive factors. Competitive factors are the dimensions of performance which define the company´s intended market position. "Operations Strategy Slack/Lewis"

On the other side are the decision areas capacity, supply network, process technology and development & organization. This is a set of decisions have to manage the resources of the operation.

Capacity	• Total capacity • Number, size of sites • Location
Supply network	• Network behavior • Supplier relationships • Supplier development
Process technology	• Rate of development • Integration • Subcontracted development
Development and organization	• Responsibility relationships • Performance and control • Product and service development

Figure 4.3: Resource usage *(source: Operations Strategy Slack/Lewis)*

This O.S. - matrix is a useful tool to make our decision and in not losing sight of the companies resources and being competitive at the same time. In conclusion it helps us to build a good strategy in the wind turbine market.

4.2 Supply Chain Management

4.2.1 What is a supply chain?

Supply chain is a network of activities that delivers a finished product or service to the costumer. These include sourcing raw materials and parts, manufacturing and assembling the products, warehousing, order entry and tracking, distribution through the channels and delivery to the costumer. An organization's supply chain is facilitated by an information system that allows relevant information such as sales data, sales forecasts and promotions to be shared among members of the supply chain. The following figure 4.2.1 shows a simplified supply chain model.

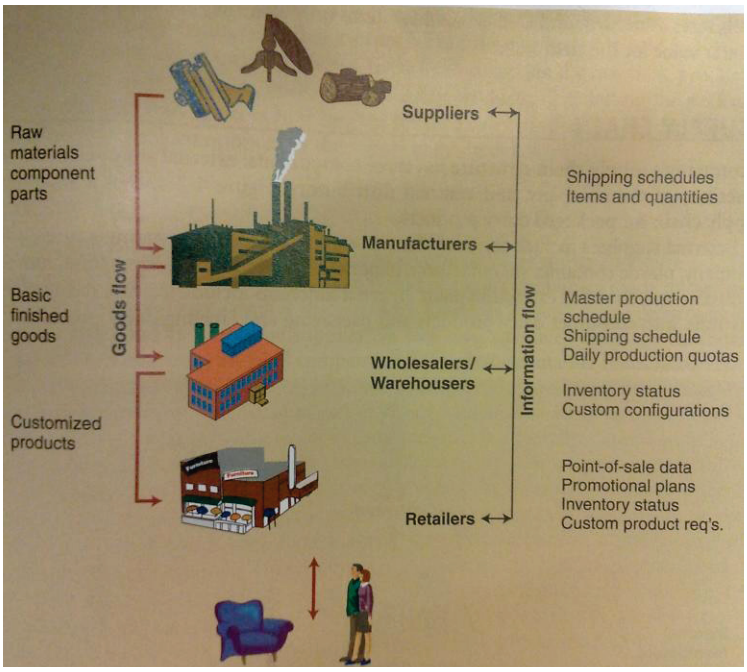


Figure 4.2.1 simplified supply chain model *(source: Operations Management)*

At the beginning of the chain are the external suppliers who supply and transport raw materials and components to the manufacturers. Manufacturers transform these materials into finished products that are shipped either to the manufacturer's own distribution centers or to wholesalers. Next, the product is shipped to retailers who sell the product to the customer. Goods flow from the beginning of the chain through the manufacturing process to the costumer. Relevant information flows back and forth among members of the supply chain.

Supply chain management is a business that coordinates and manages all activities of the supply chain, transporters, internal departments and information systems. Supply chain management contains

- Coordinating the movement of goods through the supply chain from suppliers to manufacturers, to distributors and to the final costumers

- Sharing relevant information such as sales forecasts, sales data and promotional campaigns among members of the chain

Supply chain management provides the company with a sustainable, competitive advantage such as quick response, low cost, state-of-the art quality design or operational flexibility. Therefore the management of supply network is very important for doing successful business and should be inside every company´s homework. Dell Computers operates well in using the main issues of managing its supply network. They offer customized computers at prices 10-15 percent lower than their competitors and delivers more quickly to their customers. A personal computer can reach his owner within 36 hours. This means that Dell can reduce his inventory cost because his suppliers needs just thirteen days to deliver the parts to Dell compared to Compaq needs twenty-five days. Most of the components are warehoused within fifteen minutes travel time to an assembly plant. This quickness in managing his supply chain gives Dell a big advantage to be cheaper than its competitors and makes him successful.

4.3 Developing Supply Network

After we have worked on the o.s.-matrix we will use some other approach to develop a competitive strategy in purchasing figure :

1. Outsourcing Vs. Insourcing → **Decide why!**
2. Vertical Integration → **When and who?**
3. Supplier evaluation → **Who is the best?**
4. Relationships → **What type?**

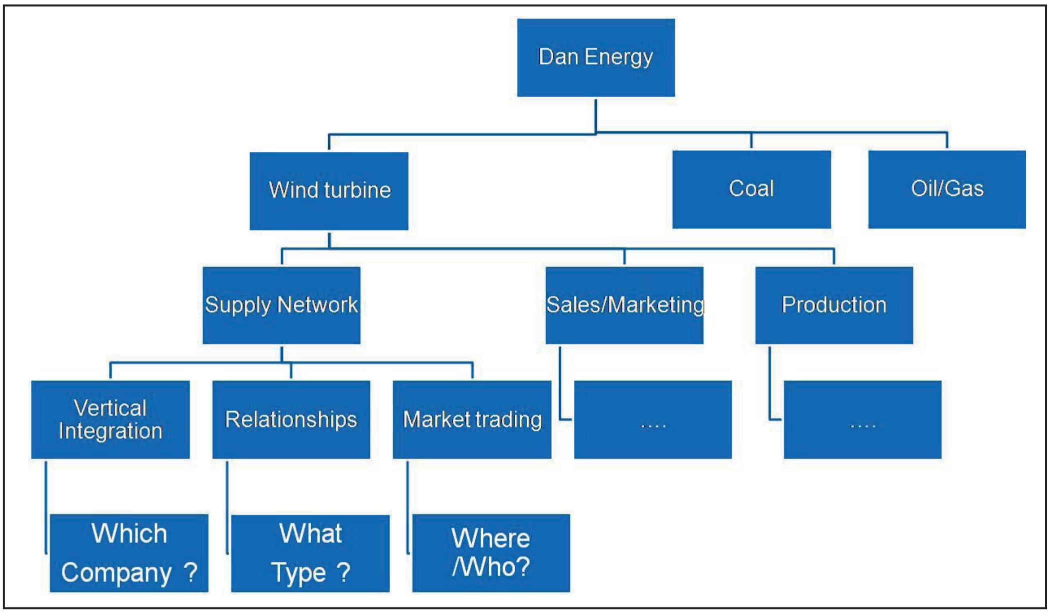


Figure 4.4: Developing supply network *(source: Operations Strategy Slack/Lewis)*

In order to choose some decisions in the supply chain these points will be analyzed precisely. Of course we are relating these points to the o.s.-matrix.

Also some analyzes will be figured out of the internet:

1. Discourse analysis by reading the reports and written material leading to the decisions made (from Ministries and public institutions such as EC BREC).
2. Analysis of articles in the newspapers and magazines: local and nationwide, as well as reports on the Internet sites.
3. Analysis of literature concerning RE (Renewable Energy).
4. Analysis of interviews in the following institutions and companies, respectively: Dong Energy

Furthermore capacity decisions, location analyzes and net present value calculations will be discussed.

Capacity strategy issues will be divided in:

1. How much capacity should the operation in wind turbines have?
2. How many separate sites should an operation have?
3. Where should capacity and location be located?

These questions will be discussed detailed in chapter 8.

Finally the net present value will be analyzed within all costs and if the business we are going to start is a success or a failure. We use for the calculation of the net present following:

1. Calculate the costs of facilities, employees and land → **Look for costs in Poland**
2. Compare with the best alternative of investment → **Look for good chances to invest**

5. Starting the project

5.1 Market Requirements

The main aim of our project is to find a good strategy to be the biggest producer of wind turbines in Scandinavian and Great Britain. In leaning on Operations Strategy (Slack/Lewis) it is possible to make a good strategy.

A company cannot satisfy all performance objectives in the same scale. Therefore it has to be made some decisions to compete with other companies and to content to the clients. After researches a balance in these objectives was found between maximizing client profits and minimizing company cost (figure 5.1).

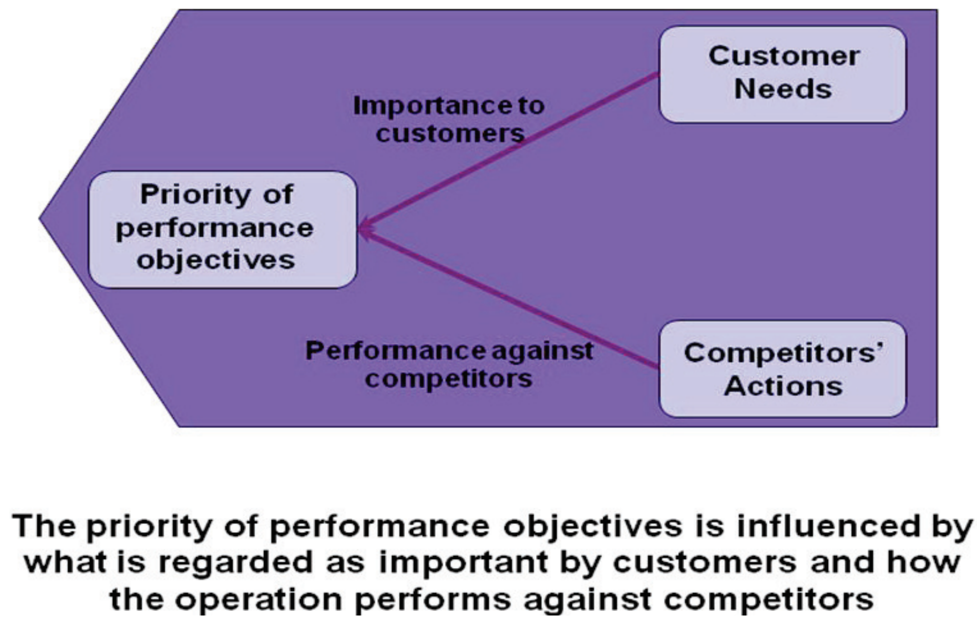


Figure 5.1 (Source: Operations Strategy Slack/Lewis)

According to this figure, customers always want all the performance objectives with the high importance, but in reality this is impossible to perform. Some of our clients want to have a good quality in products or services, usually meaning high specification, a low prizes and high availability too.

On the other hand we have another open front, the competitor's actions. We have to control them but know in what position they are in relation with us.

The priority for our performance objectives is to have a balance between these two points to be efficient.

So to have a good position between customers needs and competitor's actions to compete in the market we have decided two main objectives, availability (dependability and speed) and cost. Wind turbines are very expensive machines so it's clear that quality is a basic to compete with other companies, for this reason we have focused in another objectives like availability, because our development time in the project is short and we have to have good relationship with suppliers and in fact of this, we become dependent. Finally we chose cost, because in this area we have many competitors, we want to be the biggest and the cheapest wind turbine company to have much more customers. All these decisions are showed in figure 5.2.

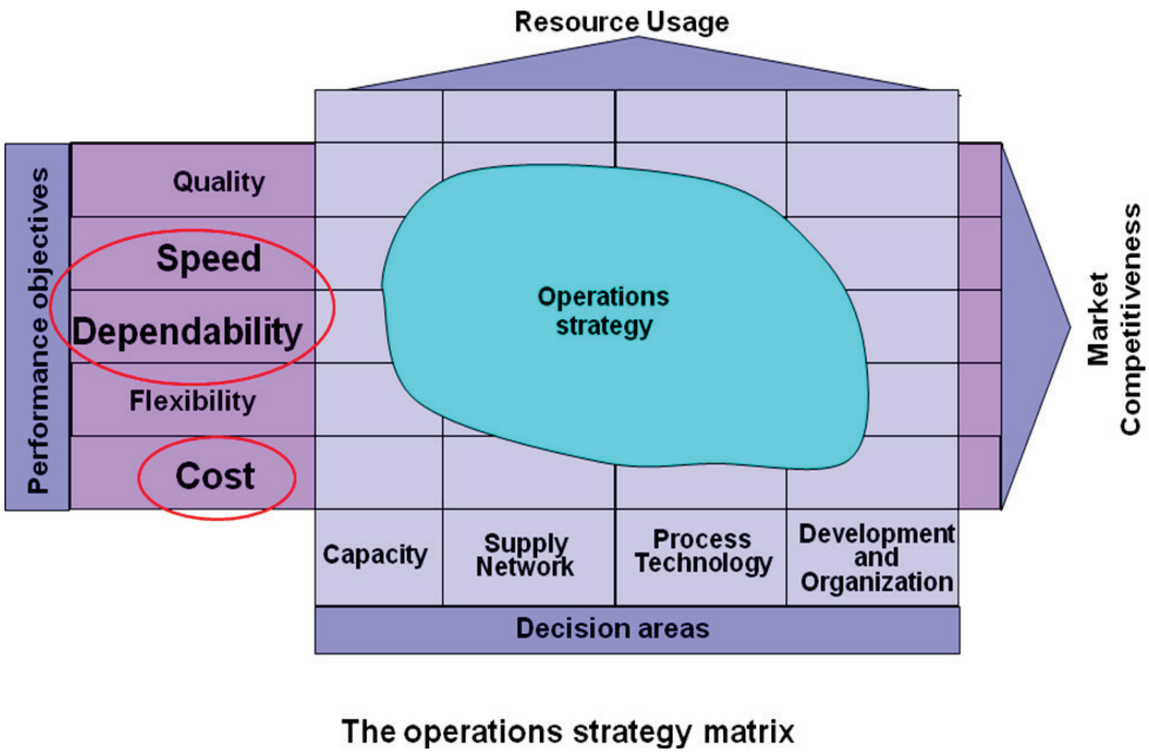


Figure 5.2: The operational strategic matrix *(source: Operations Strategy Slack/Lewis)*

5.2 Operation Resources

As a result of market requirements we have to operate in our resources to achieve our target. This relation between performance objectives and operations strategy resources is showed in the next figure:

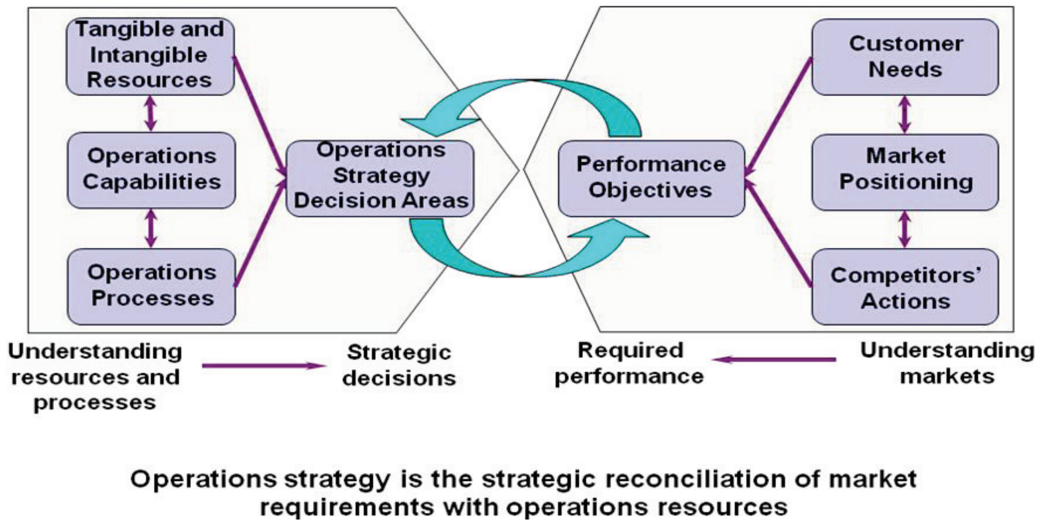


Figure 5.3 Overview of the content of operations strategy *(source: operations strategy Slack/Lewis)*

As we can see, Operations strategy is concerned with the reconciliation of market requirements and operations resources. It attempts to influence the way it satisfies market requirements by setting appropriate performance objectives and also the capabilities of its operations resources though the decisions it takes in how those resources are deployed.

Finally, following the Operations Strategy Matrix (O.S.matrix) structure and all said above, we have done our own O.S.matrix in figure 5.4:

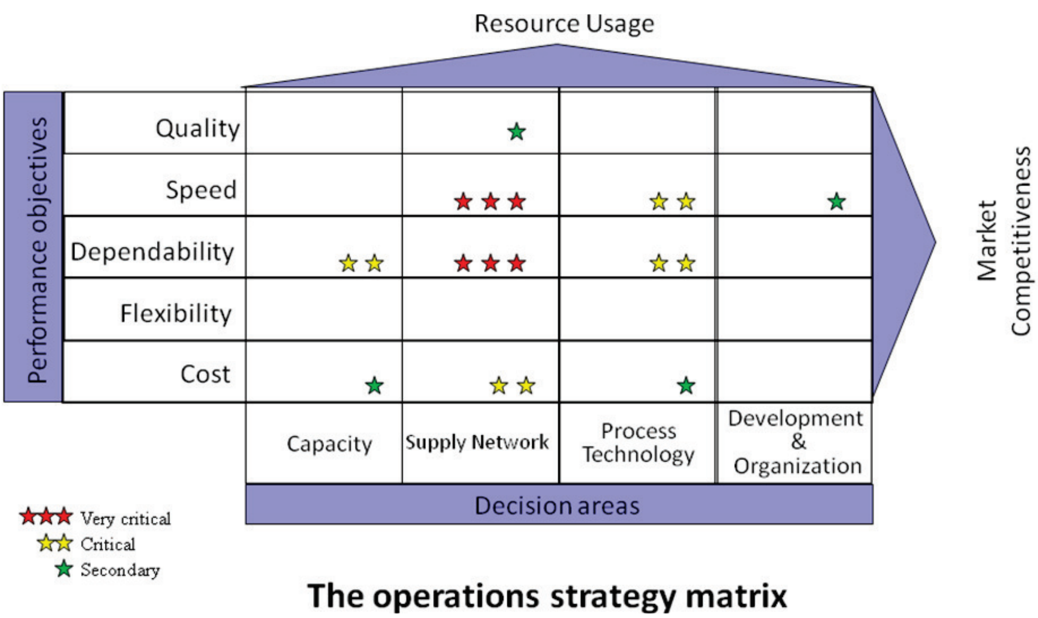


Figure 5.4: The strategic matrix *(source: Operations Strategy Slack/Lewis)*

According to this matrix, the most critical is speed and dependability with supply network because we don't have any knowledge, know-how and experience in the wind turbine market, so we have to purchase all the parts from suppliers and have a good relation with them. Going down with the importance, we have cost and supply.

In the area of process technology we put two stars in availability because we want to enhance the delivery time of the transport from the order of the customers until installing all the windmills.

Summarizing, speed and more concrete dependability is the most important objective in the majority of the decisions areas, on the opposite side we haven't taken into account development & organization, because we are not going to research in innovation.

6. Product Portfolio

DanEnergy is an important energy company and now wants to become a big producer of renewable energy, specifically wind energy.

For this reason, DanEnergy has studied all the different products that wants offer to its customer, with the intention that conform to the needs and the demand of our customers.

Varied studies and researches have been focused in three main aspects that help us succeed in our purpose.

6.1 Market research

6.2 Our Customers

6.3 Windmills capacity

6.1 Market Research

From a global perspective, the renewable energy sector has developed strongly due to the current energy situation, scarcity of fossil fuels and pollution, and the high development of renewable technologies.

Between all, the wind energy has been at the forefront of this growth and regardless of current economic conditions, is a sector of the present and future. The institutional commitment of major world governments (EU, U.S., China, etc...) for the development of this technologies and their contribution to sustainable growth makes think that the road ahead is long.

World wind generation capacity more than quadrupled between 2000 and 2006, doubling about every three years and the 81% of wind power installations are in the US and Europe. By 2010, the World Wind Energy Association expects 160GW of capacity to be installed worldwide. A total of 8,484 MW wind power capacity was installed in the EU in 2008, shown in figure 6.1. This puts wind energy ahead of any other power technology for the first time.

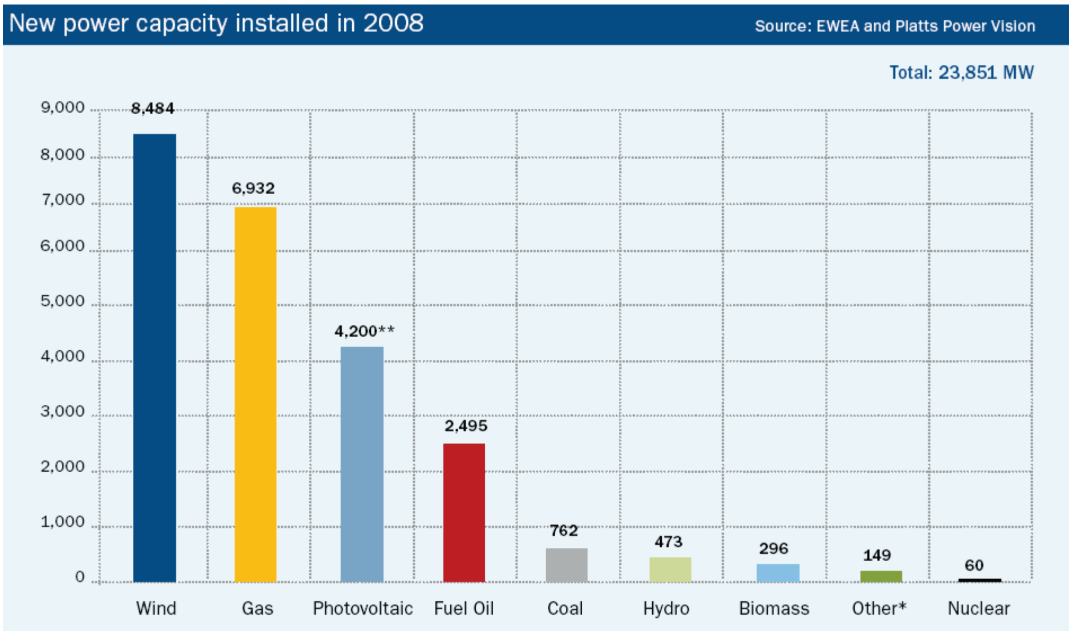


Figure 6.1: New power capacity installed in 2008 *(source: EWEA, European wind energy association)*

All new electricity producing capacity installed in the EU in 2008 was wind energy with the 36% followed by natural gas (6,932 MW - 29%), oil (2,495 MW - 10%), coal (762 MW - 3%) and hydro (473 MW - 2%).

A binding target of 20% renewable energy has been set for the EU to achieve by 2020, which would mean approximately 35% of electricity coming from renewable by then – up from 16% in 2006. After this whole vision and some concrete numbers, we are going to continue with the study.

The wind market is divided in two different types of wind turbine, on-shore, installed on the land, and off-shore on the seabed.

On-shore wind turbines in Spain

Off-shore wind turbines at North Hoyle in Wales, Britain.

6.1.1 Onshore Wind Activity

Onshore wind power provides an increasingly economic source of energy, with significant worldwide growth for the last ten years. The industry has been made viable through economic subsidies which have enabled development to take place.

For some countries, onshore wind power is both a key energy source and a major industry in its own right.

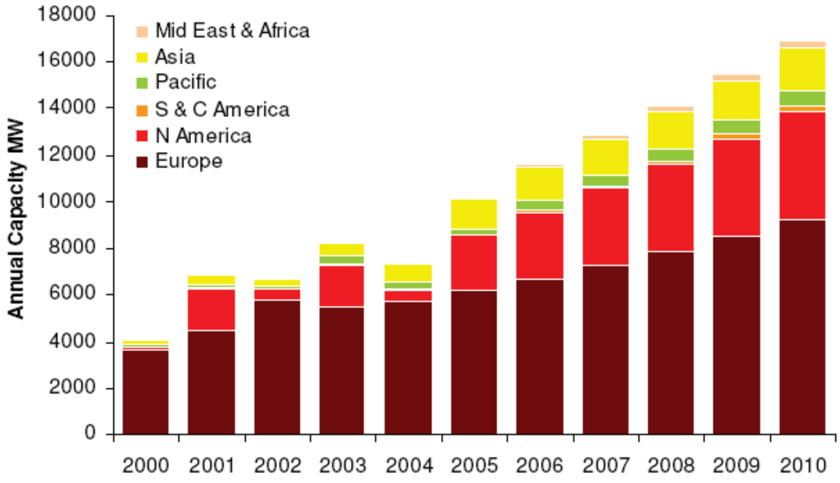


Figure 6.1.1: Onshore Wind – Annual Installed Capacity *(source: Doing Business with Wind Turbine Manufacturers)*

The onshore wind industry has seen year-on-year growth for the past 15 years – there are very few industries where such a growth rate has been seen to be sustained for so long.

There is an average global market growth of approximately 10% annually. Figure 6.1.1 shows that in 2005, the largest markets were the US (2,400 MW), Germany (1,800 MW), Spain (1700 MW), India (1400 MW) and China (500 MW).

The EU market for onshore wind grew by an average 32% per year in the 12 year period from 1992-2004. The strong market here is stretching turbine production in Europe as one major manufacturer stated. Some early leaders are now beginning to slow such as Germany; likewise Denmark has installed very little onshore capacity in recent years. To balance this, activity is strong in the massive Spanish market and significant new markets such as the UK are emerging.

6.1.2 Offshore Wind Activity

The first offshore wind turbines were installed at Vindeby off the Danish island of Lolland in 1991. The first ten years of the industry saw small projects being built in shallow, near-shore locations.

Offshore wind is an extremely important sector. It involves the installation of very large wind farms (many planned projects are around 1 GW in size) in an environment with a better wind resource and where visual impact is minimal.

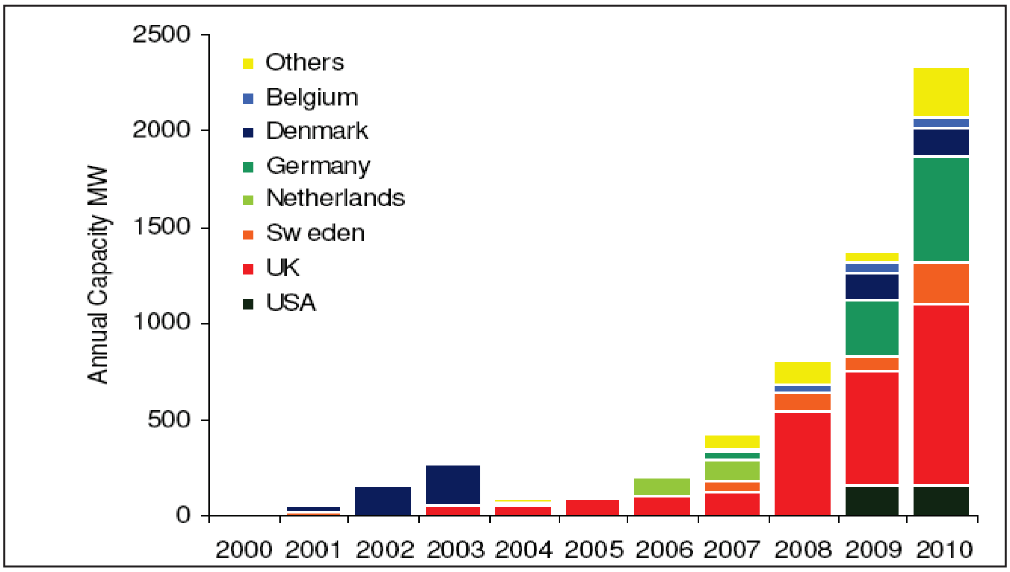


Figure 6.1.2: Offshore Wind – Annual Installed Capacity *(source: Doing Business with Wind Turbine Manufacturers)*

At the present time, Denmark is the world leader in installed capacity with 426 MW (60% of the world total), but the UK is making fast progress and now has 214 MW operational.

The offshore wind industry is flourishing. The European Wind Energy Association (EWEA) statistics show that on average in 2008, over 1 MW was installed per day, reaching a total of 1,471 MW worldwide by the end of the year.

It has stronger, more constant winds than on land, Europe is the leader in offshore wind technology and installation. Offshore wind provides jobs and regenerates coastal areas.

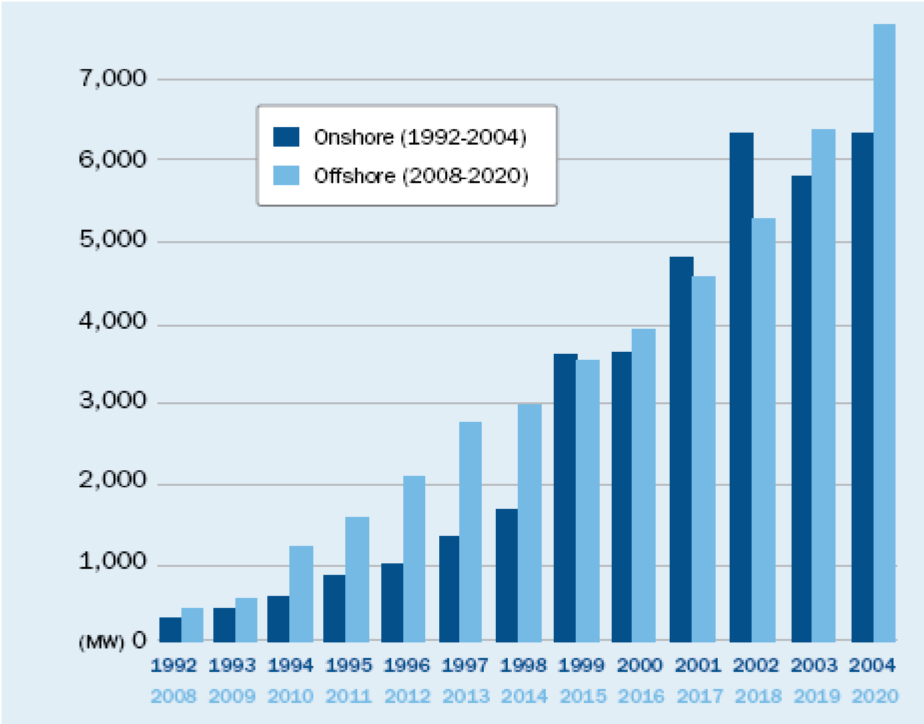


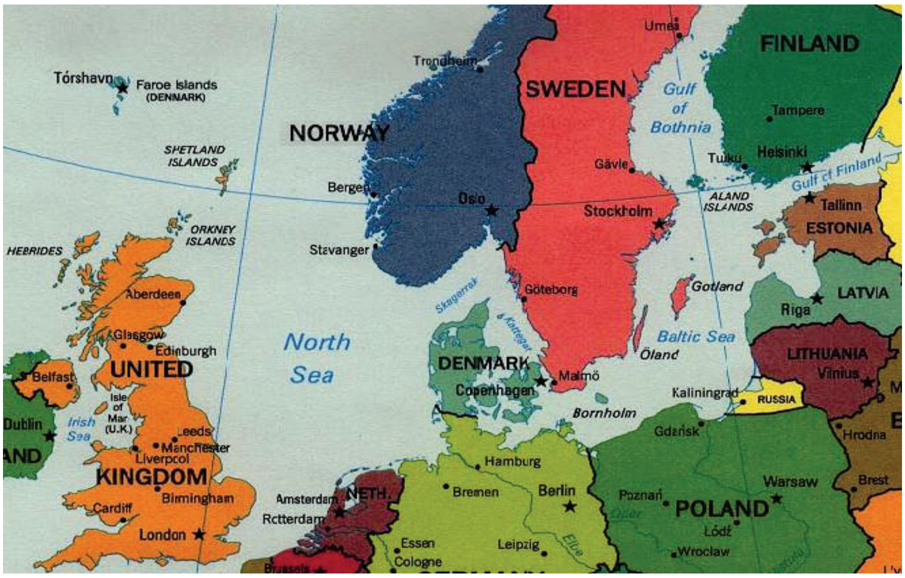
Figure 6.1.3: Historical on-shore growth compared with off-shore projection *(source: EWEA, European wind energy association)*

Figure 6.1.3 represents the comparison between market growth of on-shore and off-shore, but in a different time scale. On-shore market had a big evolution between 1992 and 2004, but contrary the off-shore market is doing a huge increase from now (2009) until 2020.

6.2 Our customers

DanEnergy has an action area very clear and concentrated, that covers Northern Europe:

- England
- Denmark
- Scandinavian countries: Sweden, Finland and Norway



Each customer has its own demand of MW, and to provide them we have to study the best solution that fit with their own capabilities.

The first thing that we have to take into account is, although it seems obvious the wind characteristic, the speed and frequency. To help us in this point is easy to look in many wind maps.

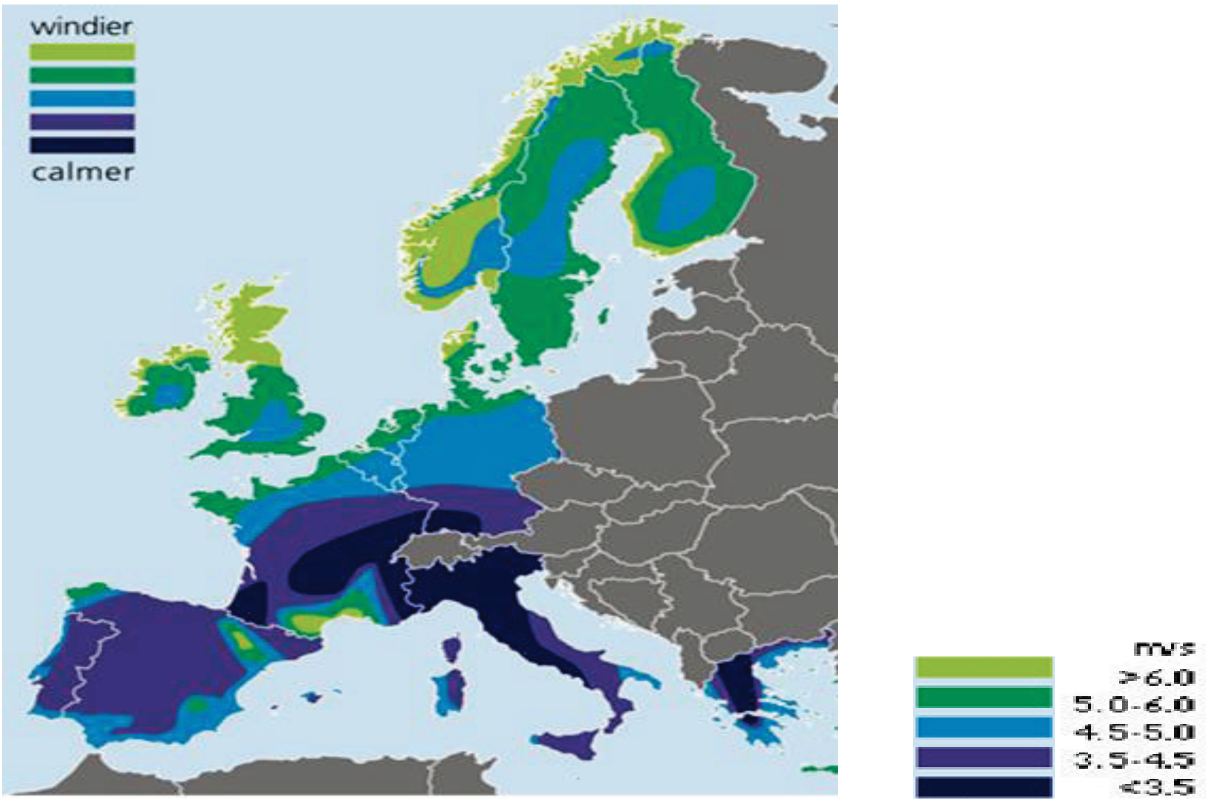


Figure 6.2: Wind map of Europe *(source: www.broadviewenergy.com)*

In this map of Europe, our clients are on the high zone in the scale, all around 5 or 6 m/s on the coast and 4.5-5 m/s on the centre of the countries.

To be more specific, in north part of England and Denmark the wind is very powerful as in all the coast of Norway, due to strong currents of the North Sea and as we move into the land the wind decrease a little but continues to maintain an average level.

So, in conclusion each one of our customers has many advantages when installing wind farms with either type of windmills, on-shore and off-shore.

In the next part we will focus in each country and develop other important factors when we choose the best product portfolio. These factors are:

- Characteristics of the geography.
- Amount of wind farm developed.
- Capacity of future development.

6.2.1 England

Geography

In relation with its size, English territory is very diverse. This large island can be divided into two zones: northern and western mountainous massifs composed of low-rise separated by flat areas that offer some of the jagged coastline of the European continent and other more plain to the southeast of England. The main mountainous region, the Pennines, forms the backbone of northern England, is formed by several mountain ranges. The highest point in England is the peak Scafell with only 978 m.

Amount of wind farm developed

The UK currently has four major offshore wind farms complete and a well-structured program developed which has resulted in a high number of projects due for construction in the future.

As we see in figure 6.2.1, in England the vast majority of wind farms correspond to the type of on-shore, specially concentrated in the northern region. Otherwise, only find a few of off-shore windmills in both sides of the country, on the southeast and southwest. This agrees with the windiest places in the wind map.

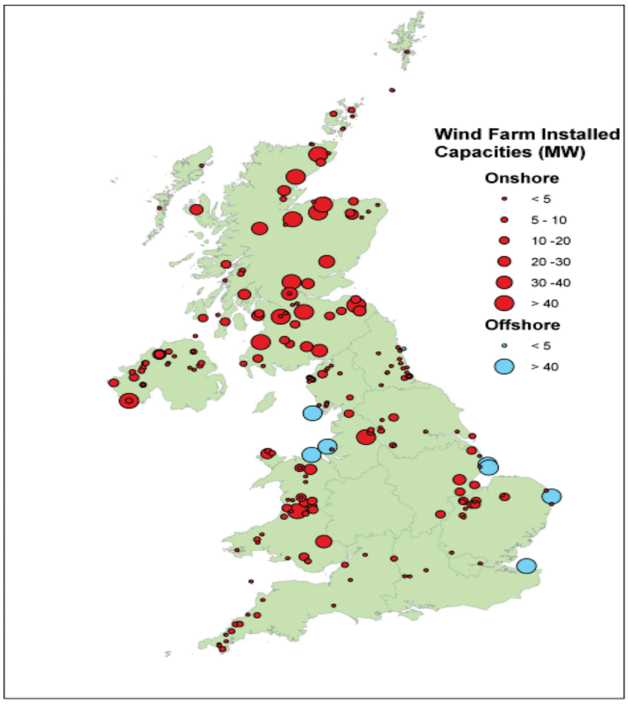


Figure 6.2.1: Wind Farm installed in England *(source: www.nce.co.uk)*

<u>Capacity of future development</u>

The England forecast is to be the world's largest offshore wind market this decade with up to 2.4 GW expected. A total of over 5 GW of offshore wind capacity is planned for the 2006-2010 period. In figure 6.2.2, the orange zones are future wind farms, so the off-shore market will be big in the coming years.

Figure 6.2.2: Future wind farms in England *(source: www.timesonline.co.uk)*

6.2.2 Denmark

Geography

Denmark, like all Nordic countries, has been interested in the elevation of the land as a result of the return of the ice. The territory of the country is mostly flat with mild hills; the highest peak is about 200 m. And the last point is the coast, there are many islands, so coastline is wide.

Amount of wind farm developed and future plans

Denmark has a big wind energy production due to its off-shore wind farms. In the next map (figure 6.2.3) and chart, shown the current and the future projects:

Figure 6.2.3: Current and future wind farms in Denmark *(source: Danish energy Agency)*

Planned offshore wind farms

10. Avedøre Holme (2009/2010)	3 turbines, 10-13 MW
11. Sprogø (2009)	7 turbines, 21 MW
12. Rødsand II (2010)	90 turbines, 207 MW
13. Anholt (2012)	400 MW

There are future project like we can see on the chart before and there are seven researched regions to install more offshore windmill until 2025.

6.2.3 Scandinavian countries

Sweden

The vast majority of the country is flat but to the west are the Scandinavian Mountains, which form a natural border with Norway. Most of the wind farms developed are onshore and some offshore. Markbygden Wind Farm is a series of wind farms that will be built by 2020, and will have a capacity of up to 4 GW.

Norway

Norway is characterized by high plateaus and mountains separated by valleys. The plains are small and scattered. The coast is so cut and with many fjords.
Norway has an excellent wind power potential. The country has further an interesting potential for offshore wind energy. Wind turbines might be located in shallow waters with very different soil conditions or floating in deep-water environment. They have many onshore wind farms, one of them set on the island of Smøla. The Nygårdsfjell 2 on shore wind farm represents yet another important step towards our ambition to triple our production of renewable energy by 2020.

Finland

Finland is very plain, besides the great Finnish part of the territory is below 200m above sea level. The Finnish coast is carved with bays and estuaries, and there are sections with various islands.

The Finnish Government gives tax incentives to promote wind energy and other renewable electricity. In the end of 2008 there were 118 wind turbines in Finland with a total capacity was 143 MW. They have the objective of 3000 MW wind power in 2020.

6.3 Capacity of the windmills

Since the first wind turbines in the 19th century until the modern current models has been a long way. Not only was challenged by its limited effectiveness and profitability, also by the visual impact of turbines, acoustic noise emissions and the risk to birds. But the development was a matter of time. Technological advances and new marine sites can afford, in good measure, the brakes on this energy has become one of the big bets for important countries.

The output has gained, and the size (rotor diameter, tower height) and the power have increased too, being a widespread phenomenon related to the evolution of technology and market. Most current installations of wind turbines are composed of unit size greater than 1 MW.

In today's market, most models used are those within the range of 2'5 and 5 MW, because the accessibility and logistics requirements in those sizes are already limiting.

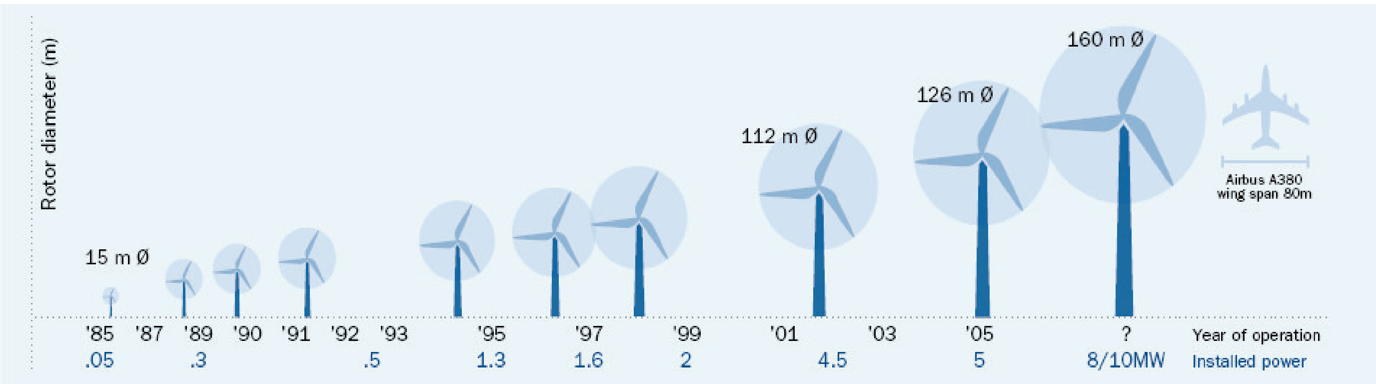
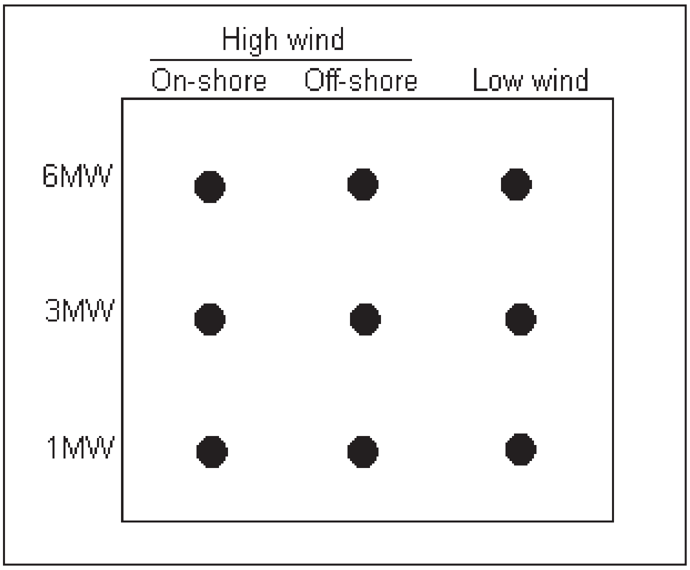


Figure 6.3: Size evolution of wind turbine over time *(source: EWEA, European wind energy association)*

To have a visual idea of the size evolution, use the figure 6.3 shown above realizing that the size of the last models is huge in comparison with the first model developed, around the double.

After this global vision of the main points to take into account to choose the best possible way, our product portfolio is going to stand out to offer a good variety of products. All of them, fit very well in to our customers' needs.

Summarizing, the next figure is our whole product portfolio, where we find nine different models of windmills, three models in relation to the power 1, 3 and 6 MW; and on the other hand depending of the wind, high and low.



7. Supply chain management of wind turbines

7.1 Markets and strategy

Supply chain managing in wind turbine production is not as easy as in the example of Dell Computers (chapter 4). The components are much heavier and bigger than computer parts. If there is a quality problem it is not easy to send the wind turbine back. It includes high costs of transportation back and back to installation side. Due to the size and weight of wind turbine components, transportation is expensive. For example, the cost to ship 120 Acciona wind turbines from Spain to the port in Duluth, Minnesota in 2007 was $13.7. This is an average cost of over $110,000 per turbine. According to GE, logistics can account for 20 percent of the cost of a wind turbine million (10 million euro). The supply network strategy has to be more precisely and sophisticated. The chosen methodology of operations strategy matrix allows us to have a good overview in making decisions to compete in the wind turbine market. Figure 6.1 shows the strategy with the performance objectives in relation with the supply network of DanEnergy.

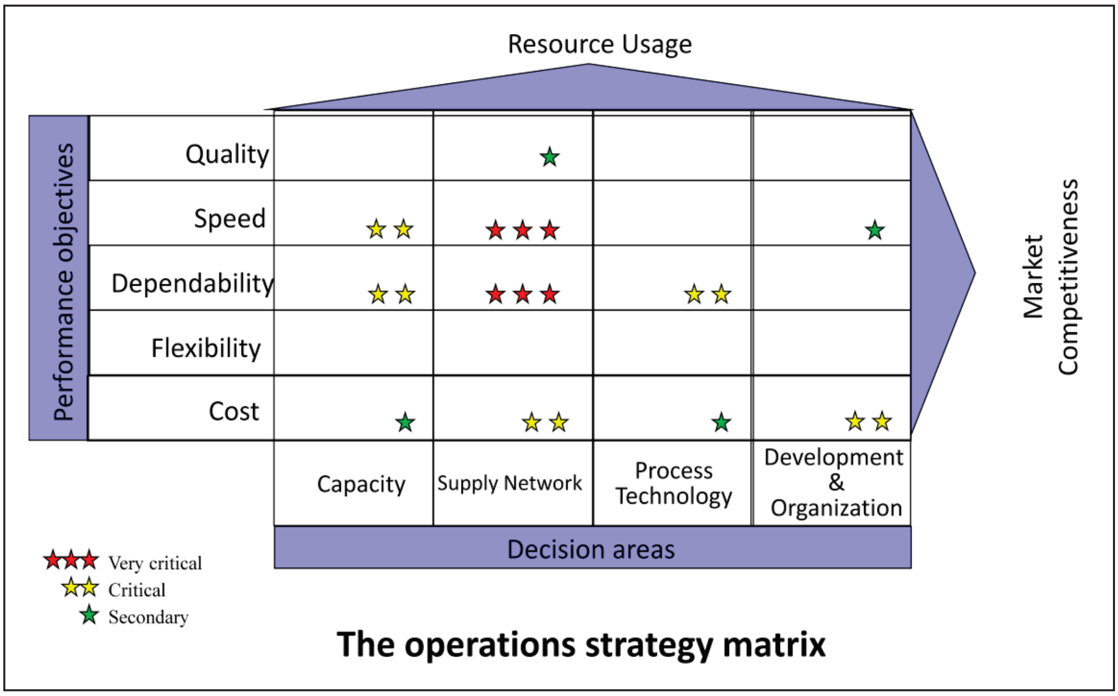


Figure 7.1: Operations Strategy Matrix *(source: operations strategy slack/lewis)*

In this matrix is shown that we want to perform in the wind turbine market with speed + dependability = availability and cost. Why we choose these factors? The wind turbine market is dominated by such big OEMs (Original Equipment Manufacturer) like Vestas or GE, who are now over 20 years operating efficiently in this area. They have already much market shares showed in figure 6.2.

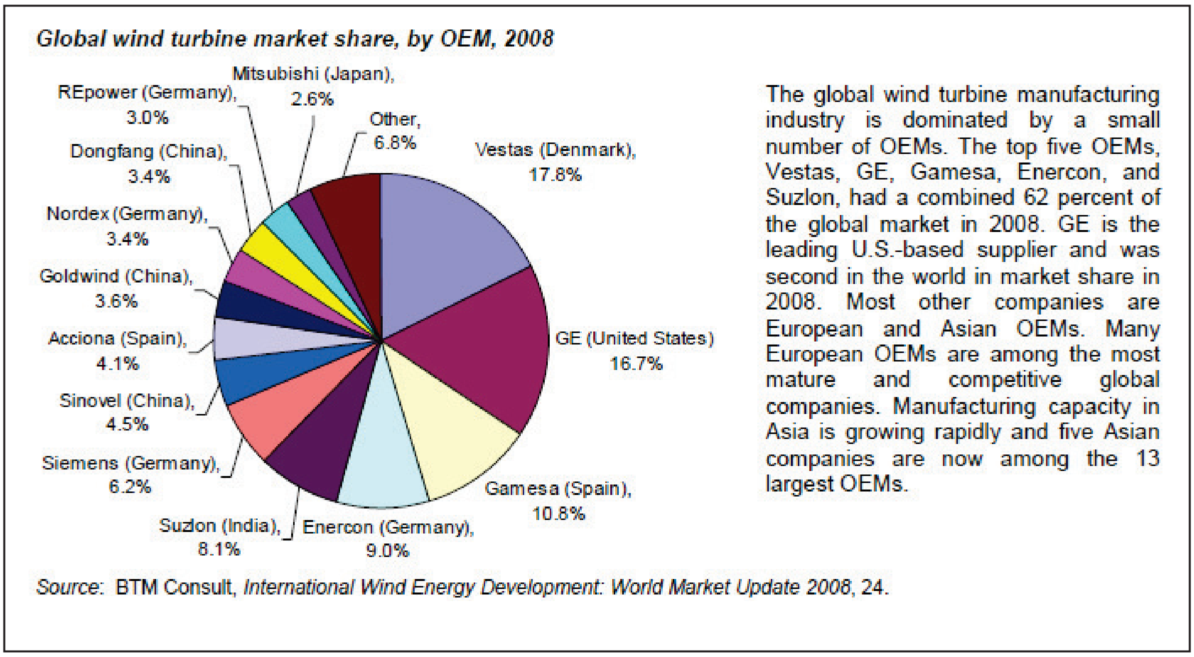


Figure 7.2: Market share 2008 *(source: BTM Consult)*

We are still beginning to produce the windmills and to enter into the market. The competitors have already an advantage of over 30 years now. So it has to make up a lot of time. To be the biggest in Northern Europe, it has to be made good and quick analyzes, has to be found dependable suppliers who delivers us with short lead times and coincident not to be more expensive. Certainly we do not lose sight of the quality, because compared to other products wind turbines have a longer lifetime of about 20 years. Therefore it is necessary to purchase from suppliers who conforms to our criteria.

7.2 Supply chain overview

The rapid growth in global demand in the last few years strained the wind turbine supply chain. In response, some OEMs expanded and diversified their supply chain while others enhanced in-house production capabilities through investments in new manufacturing facilities or purchases of major component suppliers. Different business models have led to different degrees of vertical integration (described later) by company and by component figure 7.3.

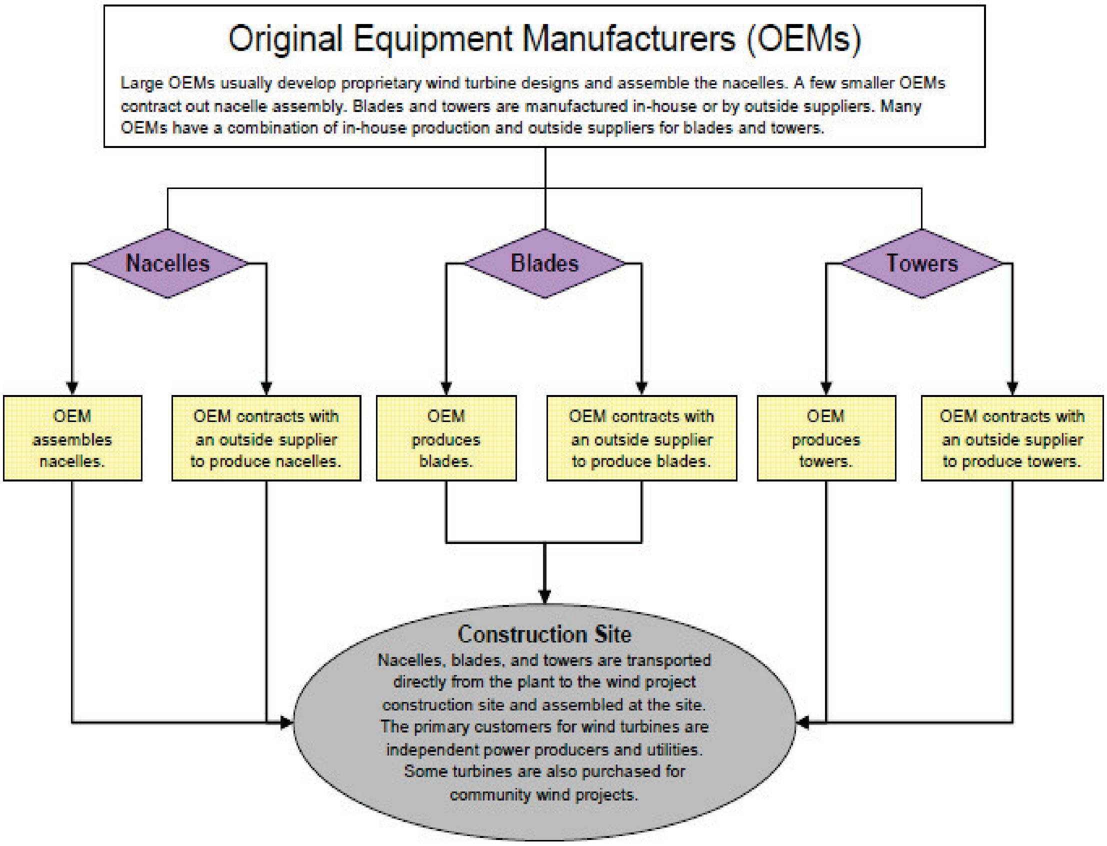


Figure 7.3 OEMs production strategy *(source: prepared by USITC staff)*

7.3 Supply chain characters in wind turbine

An outline of the structure of the wind industry is presented below. Note that there can be a great deal of blurring at the top of the chain between developers, owners and operators because some companies are active in two or three of these roles.

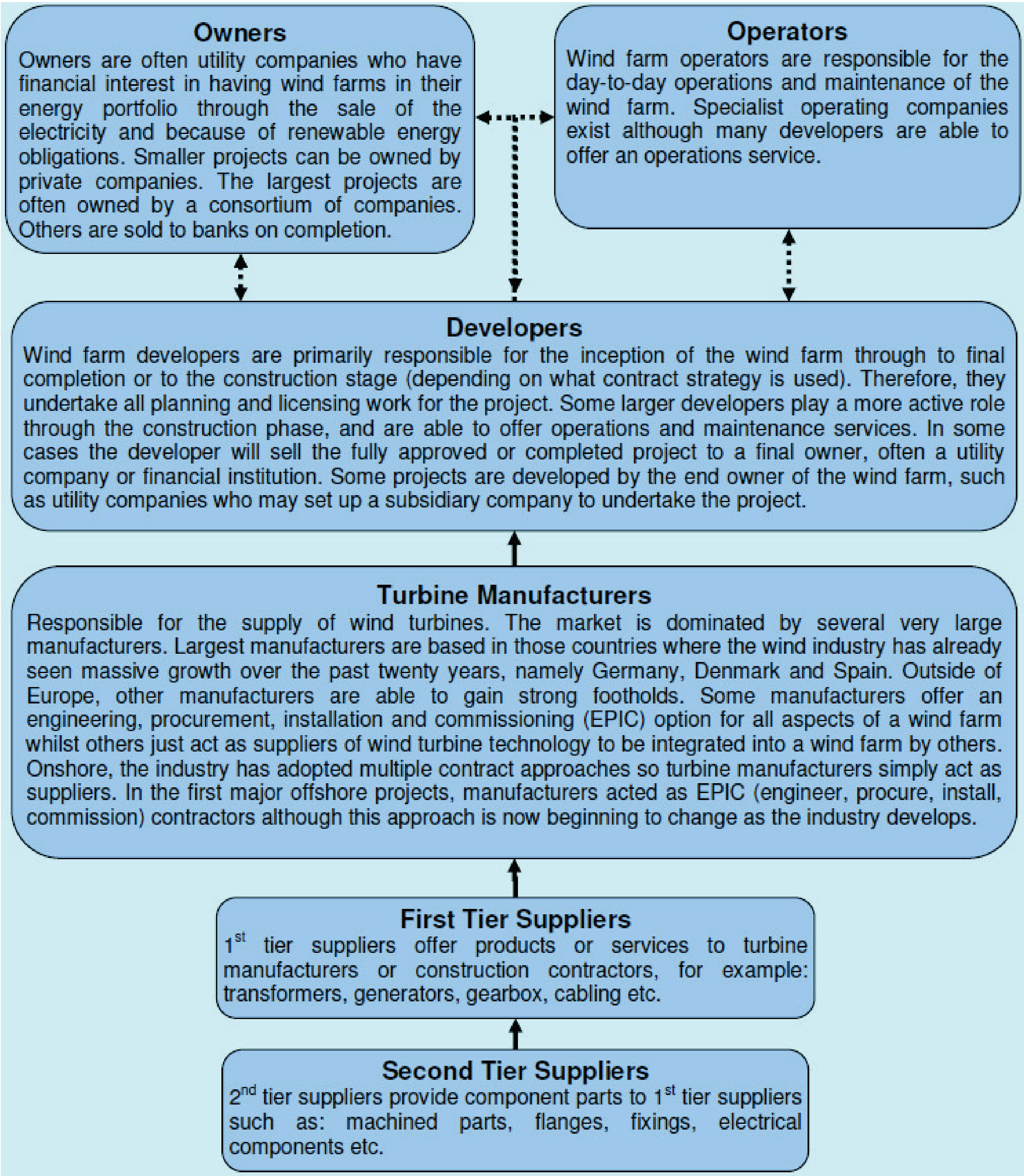


Figure 7.4 Supply Network of wind turbine *(source: BTM consult)*

These two factors can act as an advantage for companies looking to gain work with manufacturers. Due to the range of supply options available to customers, short lead times are common for manufacturers. Whilst larger turbine manufacturers are able to forecast likely demand for their products and build accordingly, this is not the case for smaller manufacturers who cannot always produce in advance of orders being placed.

The Structure that DanEnergy is using you can see in the following figure 7.5.

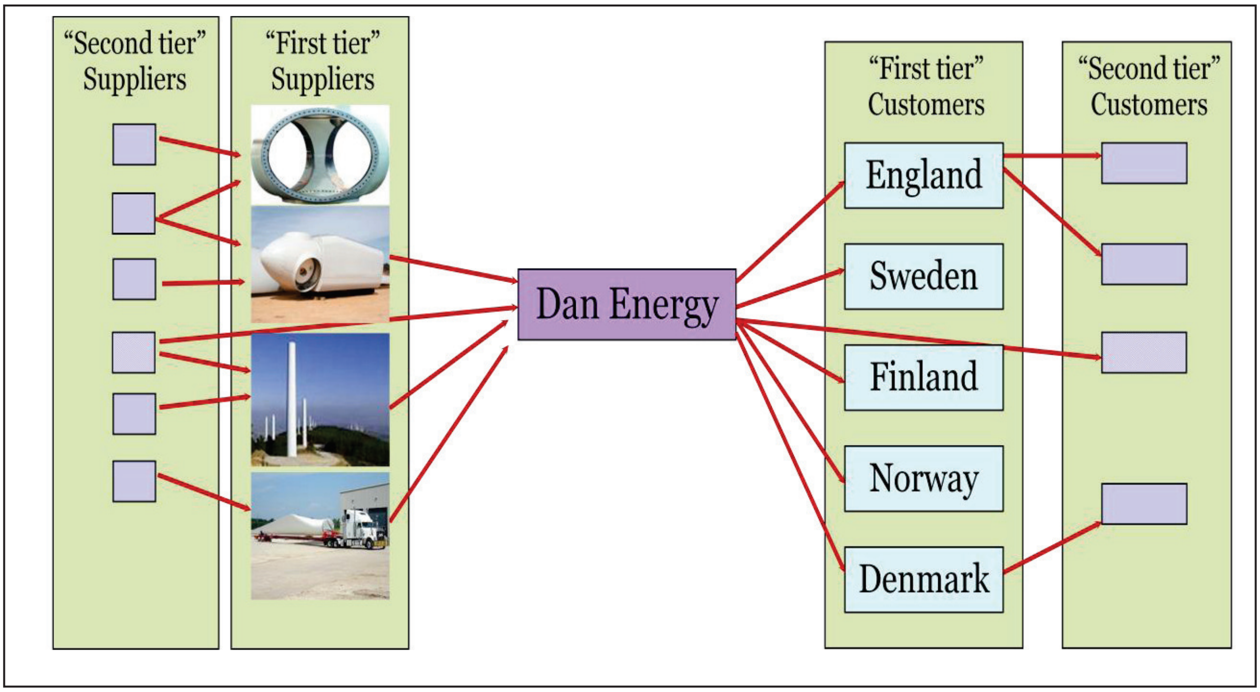


Figure 7.5 Supply structure of DanEnergy

DanEnergy is a company who is producing energy from coal and gas. So he has no experience in building wind turbines, installing wind parks, even less making the wind turbine parts from raw materials. Due lack of knowledge we decided to purchase all of the parts and just assemble the nacelle ourselves. The nacelle is the most complicated part in the wind turbine and there are many parts which we can purchase to reduce our costs. It houses the main components of the wind turbine, such as the controller, gearbox, generator and shafts. Here a detailed nacelle in figure 6.6:

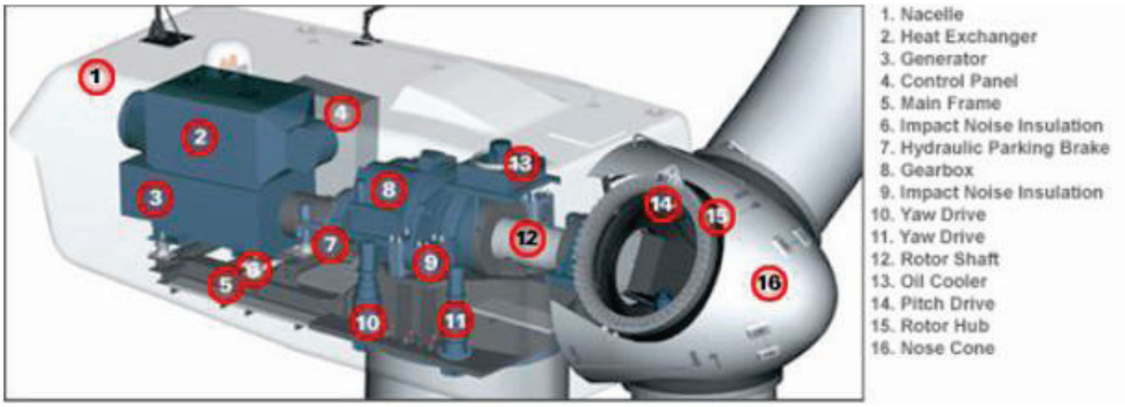


Figure 7.6: wind turbine nacelle *(source: BTM Consult)*

The yaw mechanism within the nacelle automatically turns the nacelle so that the rotor of the turbine is facing directly into the wind, allowing maximum power generation.

Components in the nacelle (in addition to those described below) include:

- Nacelle bed plate
- Main bearing (in most cases)
- Main shaft (in most cases)
- Brake calliper (typically spring-applied, hydraulic-release), gearbox slip rings
- High speed shaft
- Yaw bearing
- Yaw system (sensors, motors, gearboxes, pinions)
- Control and power panels
- Sensors, cabling
- Cooling systems
- Maintenance crane and tooling
- Nacelle cover

Our first tier suppliers are directly linked to us. They deliver us as you can see in figure 7.4 with for example nacelle parts or the rotor hub parts. The parts of the hub are going to be assembled in Poland, too. Tower and blades are directly delivered to the construction side, so we have less storage cost.

Main parts of the Rotor Hub:

Rotor Hub – The rotor and hub assembly of the turbine rotates in the region of 10-25 revolutions per minute depending on turbine size and design (constant or variable speed). The hub is generally attached to a low speed shaft which connects to the turbine’s gearbox. Wind turbines will typically start operating at a wind speed of 3-4 metres per second and have a cut-out wind speed of 25m/s.

Most modern turbine hubs contain a pitch system to adjust the angle of the blades by rotation of a bearing at the root of each blade in order to control power and slow the rotor, as required. This pitch system may provide hydraulic or electric actuation (market is split approx. 50:50).

Control of the power output from the blades is done by one of 2 basic methods:

- Pitch Control, where the angle of attack of the blades is decreased to limit power – this requires almost constant adjustment of the pitch angle at above rated wind speed. This type of control can be coupled with variable speed generator technology to give superior power output quality, lower operational loads and greater operational flexibility (eg. to reduce noise levels during particular conditions).
- Active Stall Control, where the angle of attack of the blades is increased to limit power – this requires only occasional adjustment of the pitch angle at above rated wind speed and but has to be coupled with simpler fixed-speed generator technology, providing a simpler solution but with reduced functionality compared to Pitch Control coupled with variable speed.

Older turbines work via passive stall control. In this case, the blades do not pitch and power limiting is achieved through natural stalling of the aerofoils as the windspeed increases. Such blades have tips that can pitch quickly through 90 degrees to allow the rotor to be slowed.

Components on the rotor (in addition to the blades):

- Blade Bearings
- Hub casting
- Electric pitch system (communications, control and power panels, batteries, sensors, motors, gearboxes, pinions)
- Hydraulic pitch system (communications, control and power panels, actuators, pumps, sensors, valves, hoses, filtration).
- Grease distribution system

7.4 Suppliers of wind turbine parts

Supply chain management is one of the key elements of the wind turbine supply. There are many factors that have to be considered. In the following chapters these factors will be discussed. To make any mistake first we look at other successful companies and their suppliers in figure 6.7. Here you can see that many companies are purchasing in different ways and have different suppliers. But on the other hand some turbine makers are purchasing their parts from the same supplier. Let´s pick out two companies and look at their strategy.

Major wind turbine manufacturers and their suppliers

Turbine maker	Rotor blades	Gearboxes	Generators	Towers	Controllers
Vestas	**Vestas**, LM	Bosch Rexroth, Hansen, Winergy, Moventas	**Weier**, Elin, ABB, LeroySomer	**Vestas**, NEG,DMI	**Cotas (Vestas)**, NEG (Dancontrol)
GE Energy	LM, Tecsis	Winergy, Bosch, Rexroth, Eickhoff, **GE**	Loher, **GE**	DMI, Omnical, SIAG	**GE**
Gamesa	**Gamesa**, LM	**Echesa (Gamesa)**, Winergy, Hansen	**Indar (Gamesa)**, Cantarey	**Gamesa**	**Ingelectric (Gamesa)**
Enercon	**Enercon**	Direct drive	**Enercon**	KGW, SAM	**Enercon**
Siemens Wind	**Siemens**, LM	**Winergy**	ABB	Roug, KGW	**Siemens**, KK Electronic
Suzlon	**Suzlon**	**Hansen**, Winergy	**Suzlon**, Siemens	**Suzlon**	**Suzlon**, Mita Teknik
REpower	LM	Winergy, Renk, Eickhoff	N/A	N/A	Mita Teknik, ReGuard
Nordex	**Nordex**	Winergy, Eickhoff, Maag	Loher	**Nordex**, Omnical	**Nordex**, Mita Teknik

Notes: 1. Towers are often produced locally to where projects are built.
2. Names in bold indicate in-house supply or ownership of supplier by turbine manufacturer.

Source: BTM Consult

Figure 7.7: Major wind turbine manufacturers and their suppliers *(source: BTM consult)*

Vestas Wind Systems A/S, Denmark

Company Profile

Vestas Wind Systems is the world leader in wind technology and a driving force in the development of the wind power industry. It has grown from a small Danish company manufacturing cranes. It started selling wind turbines in 1979 and to date has installed a total of 18,000MW in over 50 countries, worldwide. It currently employs around 10,000 people. Vestas acts solely as a manufacturer of wind turbine hardware, associated SCADA systems and as an EPC (Engineering, Procurement and Construction) contractor.

Top Selling Turbines

- Current products are V80-2MW (1.8MW in US) (transitioning to V90-3MW), V82-1.65MW and V52-850kW turbines.
- Next products are V100-2.75MW (small quantity production in 2006) and V120-4.5MW (prototype in 2006/7).

Markets

- Global

Key Relevant In-House Manufacturing Locations

- Rinkobing, DK (nacelles)
- Skagen, DK (hubs)
- Lem, DK (blades)
- Varde, DK (towers)
- LM Glasfiber and in-house (blades)
- Near construction side (nacelles, towers)

Purchasing Function

Vestas has a number of Production Business Units (PBUs) covering nacelles (inc. hubs), blades, towers & control systems. Each PBU has a Purchase and Logistics function. Individual local production units within each PBU also have purchasing capability.

Strategy

- Typically, key supplier selection and price/quantity negotiation is by the PBU, with local purchasing placing call-off orders for these components.
- Strategy is to work with as few large, global suppliers as possible, whilst keeping sufficient capability and flexibility.
- The Technology Business Unit is involved in key supplier and component approval, often involving an introduction plan, testing and first article inspections.

Gamesa Eólica S.A, Spain

Company Profile

Gamesa Eólica is one of the world's largest wind turbine manufacturers. In 2004, it ranked second worldwide. Gamesa Eólica produces a range of turbines from 850 kW to 2 MW. In 2003, Gamesa acquired the turbine manufacturer Made. Gamesa Eólica has its own extensive design and technological development capability. Through 21 manufacturing facilities it has a huge integral production capacity, comprising of the manufacturing of blades, gearboxes, generators, converters and towers. Gamesa is also active as a project developer and offers turnkey installation services. A large proportion of all Gamesa turbines are used directly in projects developed by the company. (*source: www.gamesa.es*)

Top Selling Turbines

- Current products are 850 kW (G52, G58), 2 MW (G80, G83, G87 & G90)
- Next product 4-5MW due in 2007

Markets

- Spain, Germany, Italy, France, Ireland and UK,
- US and China

Key Relevant In-House Manufacturing Locations

- 6 locations in Spain (nacelles and hubs)
- 7 locations in Spain (blades, blade parts and blade tooling)
- 2 locations in Spain (generators and converters)
- 2 locations in Spain (gearboxes)
- 2 locations in Spain (towers)
- US and China in 2006

Purchasing Function

- Central purchasing split nacelle/blades/tower. Nacelle group split mechanical / electrical / miscellaneous.
- Local purchasers in US and China fit into the above structure.

Strategy

- Vertical integration, enabling control of quality, cost, delivery time and technical feedback.
- Global purchasing, with long-term partners setting up manufacture where customers are.

7.5 How DanEnergy is purchasing?

Because of growing demand and booming wind turbine market it is more difficult to purchase all the parts easily with low cost, even less to find a dependable supplier. By analyzing the market of the needed parts of the wind turbine there are some bottlenecks.

Blades:
A crucial component requiring sophisticated production techniques, global supply is dominated by independent blade maker LM Glasfiber, which has about 27 % of the market. All the major turbine manufacturers apart from GE Energy and Repower produce most of their own blades. No shortage of supply at present. To cope with demand a number of new blade factories were either opened or announced in 2006 by Gamesa, Vestas, Siemens and LM Glasfiber in China, the US, Denmark, Spain, India and Canada.

BTM (Birger Tuemand Madsen) Consult says global production capacity should increase from 20 GW now to 25-30 GW by 2010. This should be enough to satisfy demand.

Gearboxes:
Most turbine manufacturers have traditionally outsourced their gearboxes to a shortlist of six or seven independent companies. This situation changed somewhat with the acquisition in 2005 of gearbox supplier Winergy by Siemens Wind and then in 2006, Hansen Transmissions by turbine maker Suzlon. Hansen has about 30 % of the global market for wind turbine gearboxes and Winergy about 40 %. Siemens specifically announced, however, that its acquisition was only part of a wider purchase of the parent company Flender and there would be no change in the relationship between Winergy and other turbine manufacturers.

Gearboxes are nonetheless the component for which most shortages of supply have occurred. Three reasons are given by BTM Consult for this: the limited number of production facilities tailored to the wind market, a shortage of large bearings and a bottleneck caused by unexpected repairs to operating gearboxes, including the replacement of bearings. BTM adds that although a number of gearbox manufacturers which normally supply other heavy industries have considered entering the wind market, they have often shied away because of uncertainty about the return they would achieve.

Keith Hays of EER (Energy Efficiency Ratio) says another important factor is that not enough of those gearbox manufacturers committed to the wind market have been able to ramp up their production lines quickly enough to cope with new multi-megawatt models. It can take several years to tool up and test for a new turbine size.

According to a recent report on gearbox supply by MAKE Consulting, however, most of the manufacturers are already in the process of expanding their capacity, with new production lines opening in both Europe and Asia. This should lead to a resolution of current delays by 2008.

BTM says global production capacity should increase from 15 GW now to 21-32 GW in 2010 – enough to satisfy demand.

Bearings:

There are particular shortages of large bearings used in gearboxes and the main shaft. BTM Consult says that the delivery time for large bearings can be 16-18 months where no framework (long term supply) agreement is in place. One reason for the shortage is that the boom in the wind industry has coincided with a generally increased level of activity across all heavy industry. For bearing manufacturers wind represents only a small fraction of their business.

Generators:

Supplied to the wind industry by a number of large companies such as ABB and Siemens, and dedicated suppliers like Indar (Gamesa). No signs of a shortage of supply.

Cast iron and forged components:

This includes the main frames used to support the rotor hub and nacelle, the hubs themselves and the main shaft which links the rotor to the gearbox. The market here has again been affected by the high level of activity in the heavy industry sector, with increased demand for both forged steel and cast iron.

BTM says that the lead time for supply of steel parts for gearboxes can be up to 40 weeks.

7.6 Strategy to solve bottleneck

One point to solve the bottleneck is global sourcing. Global sourcing means identifying, evaluating, negotiating and configuring supply across multiple geographies. Normally, even companies who exported their goods and services still sourced the majority of their suppliers locally. Nowadays companies are increasingly willing to look further afield for their suppliers, and for very good reasons. Most companies report 10 per cent to 35 per cent cost savings by sourcing from low-cost-country suppliers like china is.

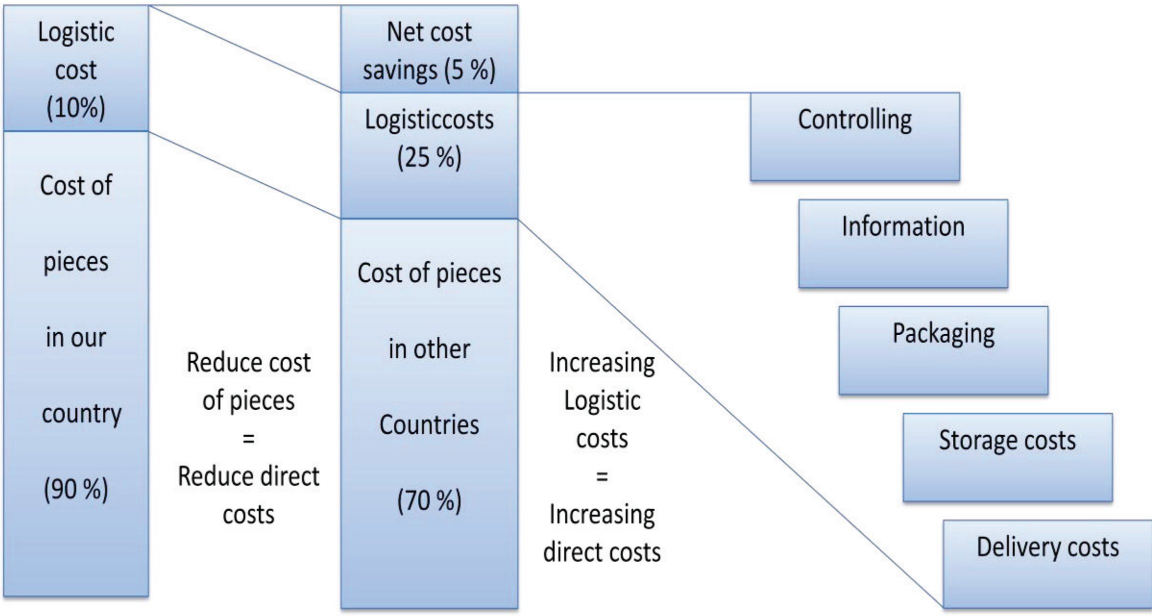


Figure 7.8: Global Sourcing advantage *(source Prof. Dr. Geisler)*

Also there are other factors promoting global sourcing. If a company looks for suppliers worldwide, other suppliers in the home market get pressure to make their parts and services cheaper. Also due the world competition the quality of the wares and services are getting significantly better. Furthermore the formation of trading blocs in different parts of the world (e.g. European Union, EU, the North American Free Trade Agreement, NAFTA, and the South American Trade Group, MERCOSUR) has lowered tariff barriers within the blocs. Also law system like the CISG (Convention of International Sale of Goods) and Incoterms have relieved to source global.

There are also, of course, some problems with global sourcing. The risk of increased complexity and increased distance need managing. The risks of delays and hold-ups can be greater than when sourcing locally. Also negotiating with suppliers whose native language is different from one´s own makes communication more difficult and can lead misunderstandings over contract times. Therefore, global sourcing decisions require business to balance cost, performance, service and risk, factors, not all of which are obvious. In figure 6.8 you can see some obstacles on the way to global sourcing.

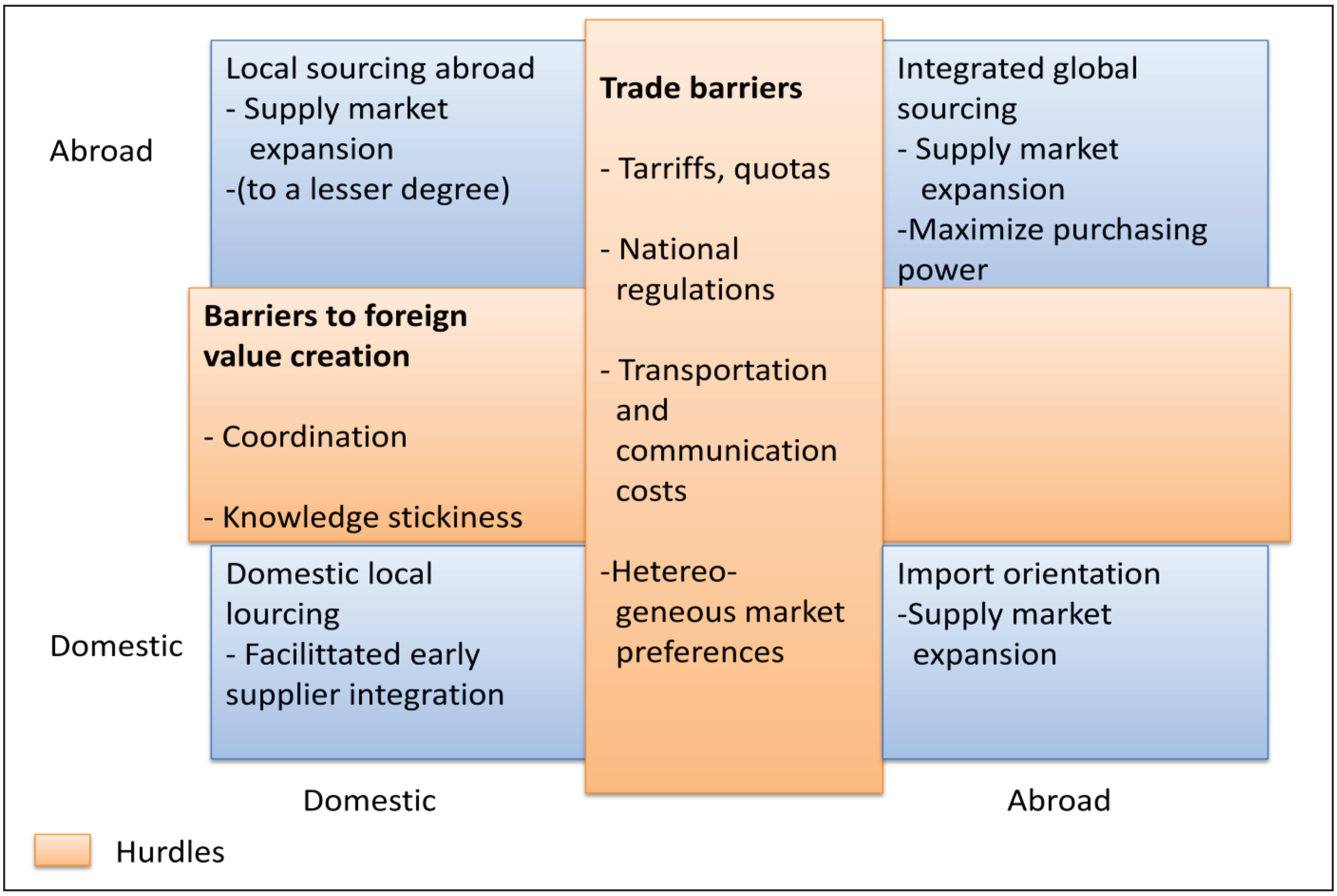


Figure 7.9: Location of own value creation to be supported by sourcing (*source: Kaufmann / Hedderich 2004*)

Once a company has chosen its suppliers, the next question is: Should we give single supplier all your business for particular or service? Or should we use multiple suppliers? You can see in figure 7.9 advantages and disadvantages of single supplier and multiple suppliers.

Advantage of One Supplier	Advantage of Multiple Suppliers
By using one supplier, quantity discounts may be achieved	Competition among suppliers provide better service and price
The supplier will be more responsive if it has all of your business for the item	Probability of assured supply is better. Multi sourcing spreads the risk
Contractual agreements may prohibit the splitting of an order	Eliminates a supplier´s dependence on the purchaser
Deliveries can be scheduled more easily	Provides a greater flexibility of volume
Supports just-in-time manufacturing	No single supplier may have sufficient capacity
Allows for better supplier relations	Allows for testing of new suppliers without jeopardizing the flow materials
The just-in-time philosophy can be better utilized	Government regulation may require multiple sources

Figure 7.10: Single sourcing vs. multiple sourcing *(source: operations management R.Danreid)*

Due choosing multi sourcing suppliers are reducing their risks of disrupted supply. That means if one supplier is not dependable or not delivering in time, other suppliers can pick up the slack. Furthermore, multi sourcing can more easily support changing quantity requirements. For example, if we need more parts of gearboxes than our supplier can supply, we can split the order between two or more suppliers. In fact of this we are flexible and dependable for our customers. Furthermore we have decided to make ABC-Analyze for each parts of the wind turbine to know which parts we have to make aggressive negotiations.

6.6.1 Outsourcing vs. Vertical integration

One of the first questions of each company is: Should we provide in-house by building a manufacturing plant or should we are provided by a manufacturer by other members of the supply chain? Vertical integration is a measure of how much of the supply chain is owned or operated by a manufacturer. Products or services provided by a manufacturer are insourced. Products or services not provided by a manufacturer are outsourced. Outsourcing means that a company pays a supplier to produce their processes or services, which trend increases in the last years. Figure 7.6.1 show some advantages and disadvantages.

Performance objectives	´Do it yourself´ In-house supply	´Buy it in´ Outsourced supply
Quality	Quality problems are easier to trace in-house , improvement can be more immediate	Supplier have specialized knowledge & more experience, but communication of quality problems
Speed	Closer synchronization of schedules which speeds up the throughput	Speed of response can be built into the supply contract → commercial pressure will encourage good performance, delivery problems
Dependability	Dependable delivery helps internal costumers to be informed about potential delays, but if the operation also has external costumers, internal may receive low priority	Late delivery penalties in the supply contract can encourage good delivery performance.
Flexibility	Closeness to real needs of business can alert the in-house operation that some kinds of change are required	Suppliers are larger and have wide capabilities than in-house suppliers → more able to respond to changes
Cost	Potential to share costs such as research and development, logistics, economics of scale	Main reason why buy! Suppliers can achieve economics of scale, they are in competition with market → reduce cost

Figure 7.6.1: outsourcing vs. insourcing *(source: operations strategy nigel/slack)*

Another choice is to integrate a supplier or costumer in your business. Then we talk about backward integration. Forward integration is company´s acquisition or control of its channels distribution.

We have decided to buy our all parts, because of having no experience in for example making blades or gearboxes. It would take many years to reach the “know-how” of others in this market. On the other hand there is an option to make a vertical integration of manufacturers who produce the parts for us called backward integration or buy some of our costumers called forward integration Figure 7.6.2.

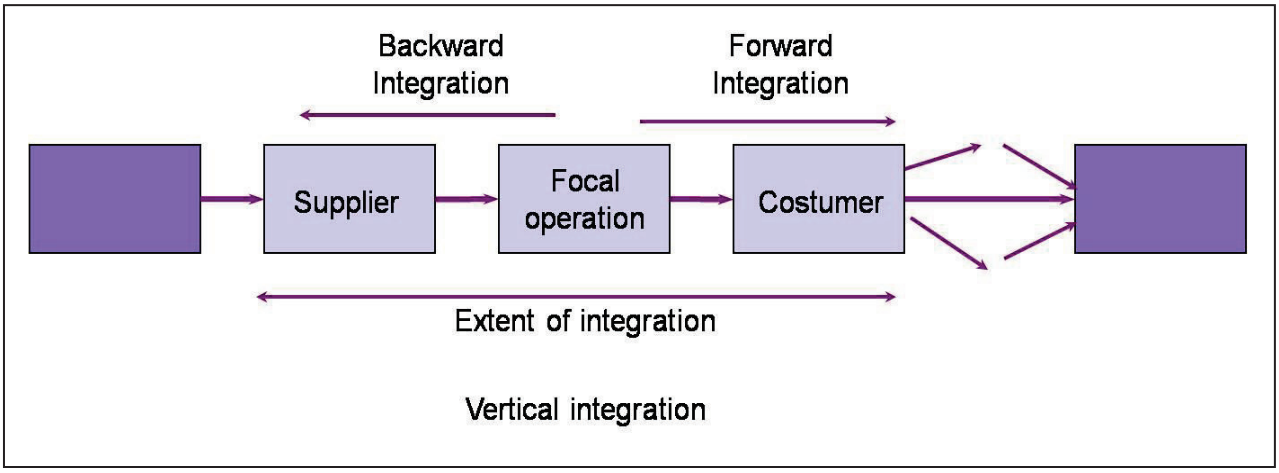


Figure 7.6.2: Vertical integration options *(source: operations strategy slack/lewis)*

The supply chain for nacelle components reflects the different sourcing strategies and levels of vertical integration of OEMs. Looking at the same three companies, Suzlon purchased major drive train and gearbox manufacturer Hansen in 2006 and is expanding in-house production of components such as control panels and generators. Siemens has bought Flenders and its drive system and generator manufacturing subsidiaries Winergy and Loher, but has not followed the same extent of vertical integration like Suzlon. GE outsourced a larger percentage of components, but does rely on a combination of inhouse production and outsourcing for some components (e.g., gearboxes and generators). Other companies demonstrate the same variation in the extent of vertical integration. For example, Acciona does not produce any gearboxes or generators inhouse, while Gamesa produces around half of each in-house in figure 7.6.3.

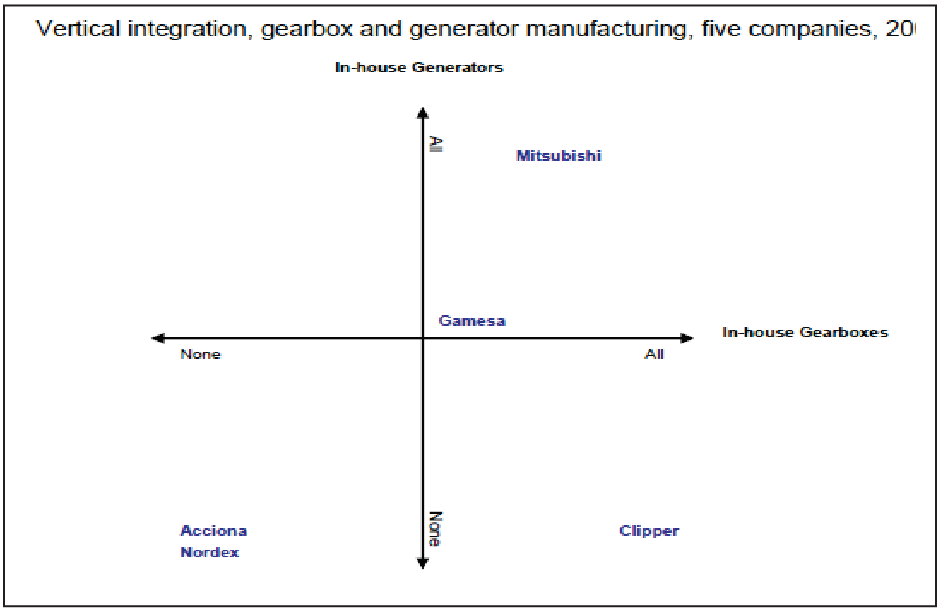


Figure 7.6.3: Vertical integration of five companies *(source: BTM consult)*

Dan Energy should follow the same strategy as Nordex or Acciona is doing in the first years, because of having no experience and knowledge. The strategy we are going to follow for all parts of our wind turbine.

Make or buy

First of one of every companies decision is, do we make the products or do we buy in the parts. These analyzes includes many counts in our case. We do have to know how many our fix costs are, including all kinds of employees like electrician, mechanical workers further salespeople and office costs.

Dan Energy is not going to make any of its parts of the wind turbine. We are following another strategy. We want to develop good relationships with our suppliers. We think that we can reduce some costs and solve some bottlenecks in fact of doing relationships.

7.6.2 Developing relationships

Doing business in an area where many competitors are operating many years now is a big challenge for Dan Energy. But where there's a will there's a way. Looking at our competitors and not to lose sight of our strategy to be the biggest in Northern Europe in using our performance objectives like dependability and speed, there are many ways to reach Rome. One way we can go is to develop relationships. But what type of relationship and with which supplier? In figure 7.6.4 you can see some types of relationships we can choose.

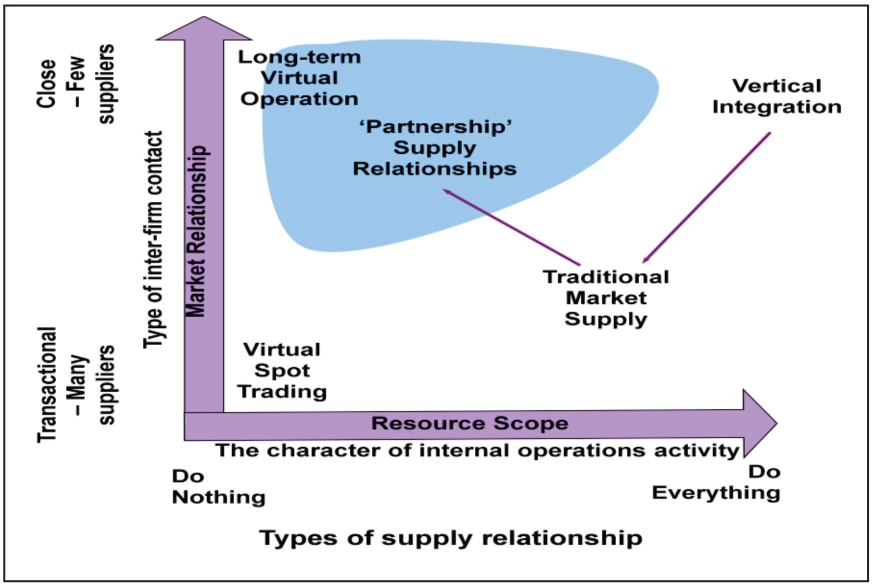


Figure 7.6.4: Types of supply relationships *(source: operations strategy slack/lewis)*

DanEnergy is going to make types of relationships like joint ventures and vertical integrations. Here are the advantages of joint ventures and why we choose to make it:

- Spreading risks and costs among the parties concerned
- Window on new technology
- Backup from existing resources

But one the main point of advantages is to be quick in comparison to our competitors. We get access to new technologies and can act like one company. Moreover we can reduce our costs concerning to logistic cost and dependability is increasing. According to a recent survey of turbine manufacturers, more than 40 percent of companies indicated that the best way to enter new markets is through joint ventures. Another 40 percent indicated that the best way is through a subsidiary, while less than ten percent prefer to export. As a reflection of this, large OEMs and blade manufacturers tend to produce in at least two of the major global markets, though tower manufacturers are less likely to produce outside their home region.

7.7 Conclusion

Aside from this, the most complicate part is the nacelle, because of the many different and varied parts that contains. So the key components that make up a complete nacelle are:

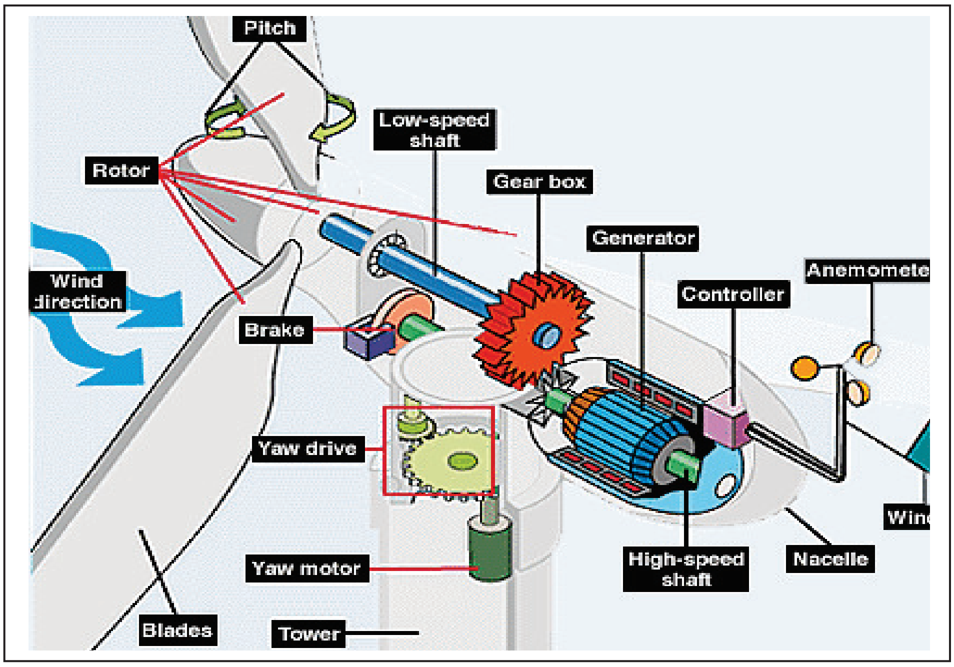


Figure 7.11: Main parts of the nacelle *(source: www.mywindpowersystem.com)*

Inside the whole wind turbine each part or piece has an importance that we have to take into account, to put more effort to find the best supplier with the relation quality-prize.

We are going to define with three diagrams, the contribution in percentage of the components respecting different parameters:

- Value and weight.
- Overall cost: main parts and components of the nacelle.

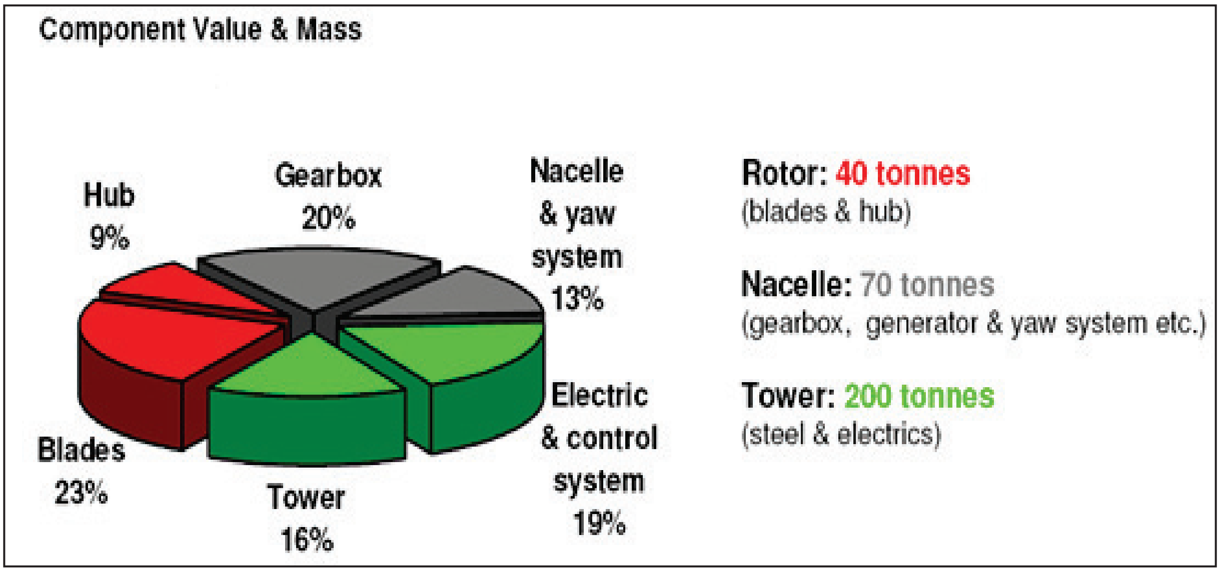


Figure 7.12: Component value & weight (source: BVG Associates)

It shows that the heaviest part is the tower with the electric and control system, following the whole nacelle and the rotor. It has sense because of the materials used in the construction, basically steal. The tower height, at least, will be from 40 to 60 m (like a building from 13 to 20 floors). This assessment is also reflected in the costs (figure 7.12), the tower is the most expensive part closely followed by the rotor (blades and hub), however the material is not steel but glass fiber.

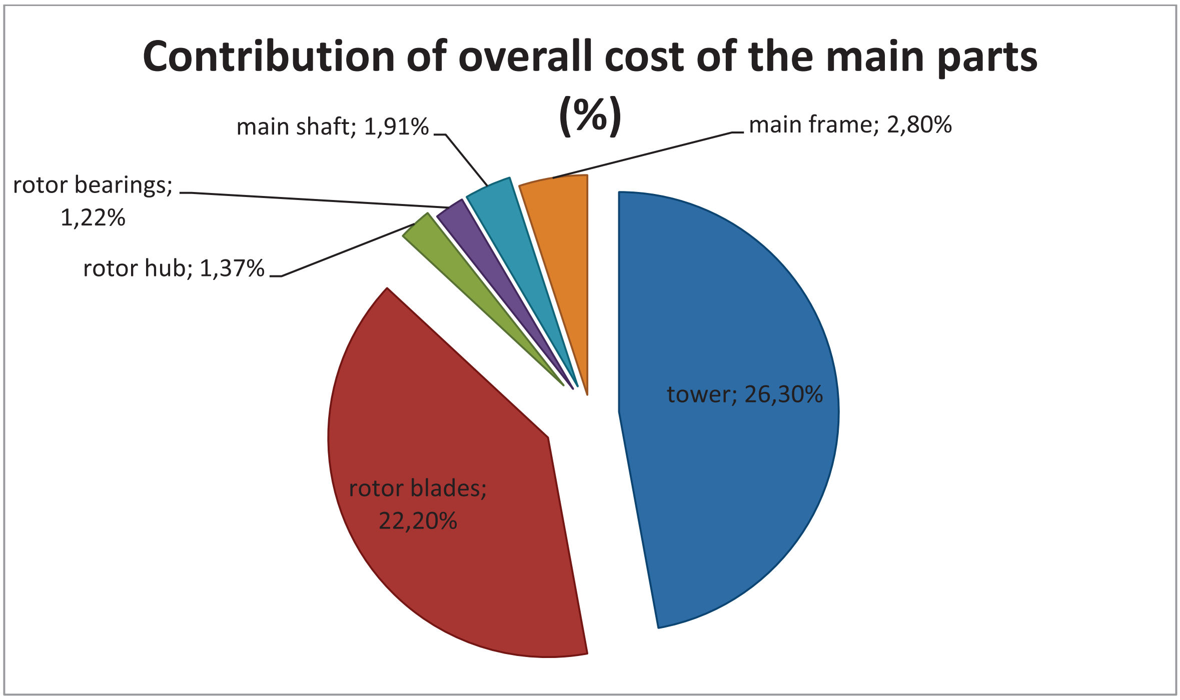


Figure 7.13: Overall costs of the main parts *(source: BTM consult)*

Focusing on the nacelle, we realize that inside it, not all the components have the same relevance, since the gearbox has the higher price and besides more weight.

Hence, when we have to choose our suppliers, we will pay special attention to them and demand concrete requirements to obtain guarantees because we handle significant amount of money.

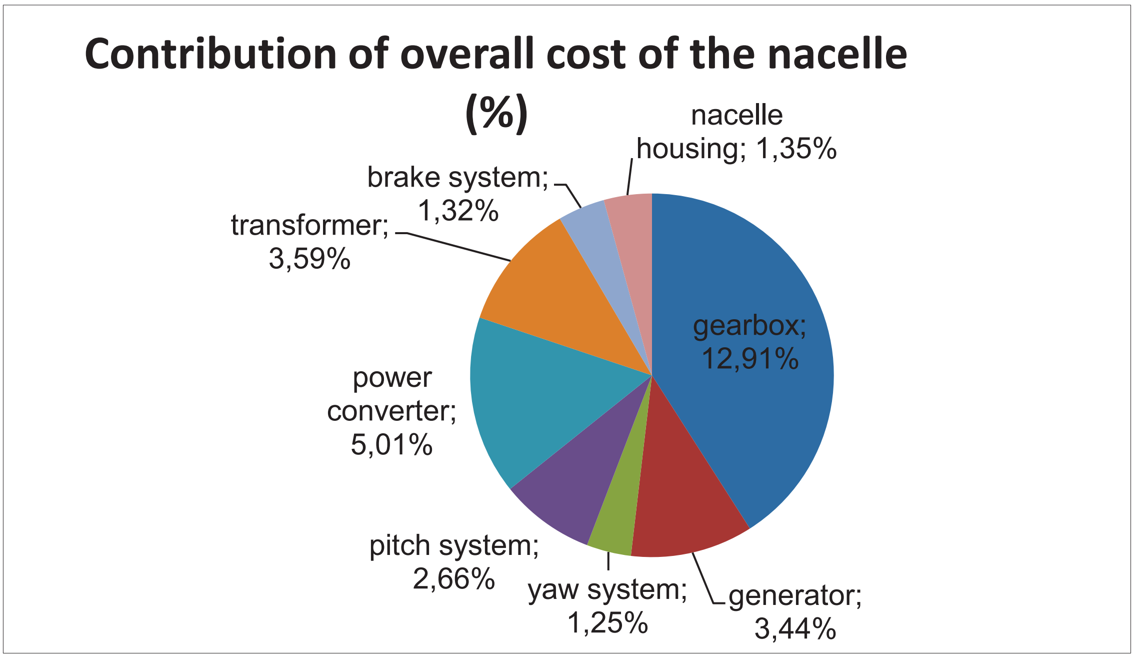


Figure 7.14: Overall costs of the main parts *(source: BTM consult)*

7.7.1 Selection of suppliers

The growth of the home wind turbine market is tremendous and many new suppliers are opening their doors. Before you make the decision what supplier to choose, it makes sense to do some research. We are going to follow the strategies of supply explained below: Single sourcing and Multi sourcing. We have two situations to study, because we have many separated parts of a wind turbine with different characteristics:

7.7.1.1 Supply towers and blades.

7.7.1.2 Supply parts of the nacelle.

Each one has different requirements that we have to know and try to satisfy the best possible way. Our requirements are going to be the same as our operation strategy criteria that we explained in the first pages of this report. Low cost, dependability and speed are the guidelines to get our target, so for this reason we want that our suppliers must also comply.

7.7.1.1 Supply towers and blades

First, we study about tower and then we finish with the blades because even they are important, both of them are going to have single sourcing.

A. Tower

Inside the whole wind turbine, the tower is the heaviest that we explained before, so this brings many problems about the logistic, transportation cost. Therefore we have thought about two different plans.

a) Choose the supplier near the customer. Look for a supplier in each different country. This offer the advantage to decrease the transportation and logistics cost, but is complicated to have contracts and relationship with many companies because they probably have different values.

b) Choose a general supplier installed in a good geographically location in the middle of all our clients. This option can be more expensive respecting the cost, but is going to result an easily deal.

In both cases, if some problem appears, we will be able to fix it. If we are in the case a), and the order of tower is not going to arrive on time, another supplier could provide, surely with an increase of the cost.

In our situation, we have found a general supplier that offers us the both cases in one. Timber tower is a company that produce towers made of wood, probably it sounds unthinkable, but it has big advantages.

- Cost of transportation. These towers are logistically easy to transport, because they can use 40ft normal containers instead of abnormal loads. The weight is less and they can move more, because don’t have limit diameter problems in comparison with the steel tower, that have a restriction of 4, 20 m to pass under the bridges.
- Price of the material. The continued rise in the steel price has done that the price of the tower increase too. So, this material change brings us the opportunity to reduce cost and be more competent in wind turbine market.
- Good maintenance. Wood can resist corrosion with a period of 20 years of development and save maintenance cost.
- The last thing that we propose is like this product is an innovation; we want to integrate in our operation strategy in near future to decrease more the cost.

B. Blades

This component is one of the most energetically important in a wind turbine. It has all the aerodynamic design, so we need to trust in the quality of our supplier. From an aerodynamic viewpoint, the perfect blade would be wide, thick and long. However, such a blade would put too much strain on the wind turbine and would also strike the tower during rotation. In other words, it would be too heavy without being rigid enough.

The supply strategy of this part is going to be similar than the tower, because blades need to stay near the customer however in this case there is a big benefit, the weight of the blades is not as large than the tower. Following the same argument we searched an important supplier that adduces to us strength and power to provide our clients. Lm Glassfiber has been our choice, because is the world's leading supplier of blades for wind turbines and one in every three wind turbine blades currently in operation is from them.

- Their clients are wind turbine manufactures, that don't produce their own blades, like DanEnergy. They do the normal blades or specific models.
- The blades have big quality, reliability and robust, and they even can provide us blades for our big model, 6MW wind turbine.

An important point that they offers us is a close cooperation that bring the opportunity to make and integrated blade development, thanks to their technological development capacity. Hence our project is probably not at the beginning, but probably on the 3rd year when we have more knowledge and economic stability. The future strategies will be explained in the next paragraph called Strategic Contracts.

7.7.1.2 Supply parts of the nacelle

This component need more attention and is so complicated because it has many pieces of different sizes and importance too. We are going to look for suppliers only for the main parts based on the ABC- Analyze. This analyze shows the economy weight, in our case inside the nacelle, based in figure 7.14. It is so useful because we can divide in three groups, the most important parts and the rest that don't worth to pay attention.

The next list of parts shows which one are the important with A and going down with B and C:

-Gearbox	A	-Brake system	B
-Generator	A	-Nacelle housing	B
-Yaw system	B	-Transformer	A
-Pitch system	A	-Power converter	A
-Cables	C	-Screws	C

To obtain the best results in this research first is to decide what strategy we are going to do. Multi sourcing is perfect for the main parts like the gearbox and the power converter due to the overall costs and on the other hand single sourcing is for the rest of the components.

In this case the main criteria are:

- Location-proximity to our assembly plant in Poland.
- Cost-reduce logistics and transportation cost.
- Speed- control delivery time.
- Dependability-have a close and personal relationship.

There are many options to evaluate and find the best supplier, one of this is:

- Scorecard.

We are going to do an example with the gearboxes in relation with three important suppliers: Bosh Rexroth, Winergy and GE.

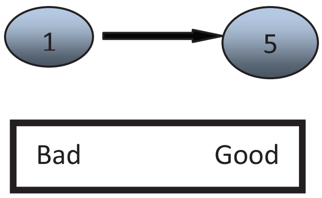
Scorecard

		Weight (%)	Winergy		GE		Bosch Rexroth	
		referred 100%	Points	Score	Points	Score	Points	Score
	Product quality	10	5	0,5	3	0,3	4	0,4
	Quality capability	10	4	0,4	3	0,3	4	0,4
	error-free products	3	1	0,03	1	0,03	2	0,06
Quality	Lower processing cost	3	2	0,06	2	0,06	2	0,06
	Financial situation	4	5	0,2	3	0,12	4	0,16
	Price of products	15	3	0,45	4	0,6	3	0,45
	Payments term	5	3	0,15	3	0,15	5	0,25
Cost	Discounts available	2	2	0,04	1	0,02	2	0,04
	Security of supply	15	4	0,6	3	0,45	5	0,75
	Kept informed of delivery dates	2	2	0,04	3	0,06	2	0,04
	Higher confidence in operation	2	3	0,06	4	0,08	2	0,04
Dependability	Internal stability	5	4	0,2	3	0,15	5	0,25
	Delivery time	15	4	0,6	2	0,3	4	0,6
	Development time	5	3	0,15	4	0,2	3	0,15
Speed	Fast response to request	4	4	0,16	2	0,08	3	0,12
	TOTAL	100		3,64		2,9		3,77

Scorecard is a useful tool that helps us to decide easily which the best supplier is. You have to decide what features are you going to highlight associated with the characteristics you want in a supplier.

The explanation of our scorecard is simple, our strategy is based in this four features: quality, cost, dependability and speed. So we want that the suppliers have a good level in these performance objectives. Inside the features we decide what concrete things we need in a supplier.

Then we attach the weight we want to have in percentage and finally decide the range of punctuation (from 1 to 5).



Now start the work research, we need the supplier information to evaluate with the range, then multiply by the importance percentage and finally get the score of each characteristic.

In the end, we add all the score and get the final punctuation to compare them.

To be clear, the calculations are here:

	Weight (%)	**Supplier 1**	
	referred 100%	Points	Score
Product quality	10	5	(10/100)*5=0,5

So in our case, between these three suppliers we have chosen Bosh Rexroth and Winergy because they have the higher punctuation and they have a location in Poland or near, like in Germany.

To continue with the dynamic followed now, the rest of the nacelle parts we are going to summarize in the chart. We can see the main parts of the nacelle and the hub and which the provider chosen.

	Nacelle					
	Gearbox	Generator	Yaw system	Pitch system	Power converter	Transformer
Supplier	Bosch Rexroth Winergy	ABB Winergy	Bosch Rexroth	Rothe Erde	ABB	ABB

	Nacelle					
	Brake system	Nacelle housing	Rotor hub	Rotor bearing	Main shaft	Main frame
Supplier	Bosch Rexroth	Suzlon	Suzlon	Rothe Erde	Suzlon	Suzlon

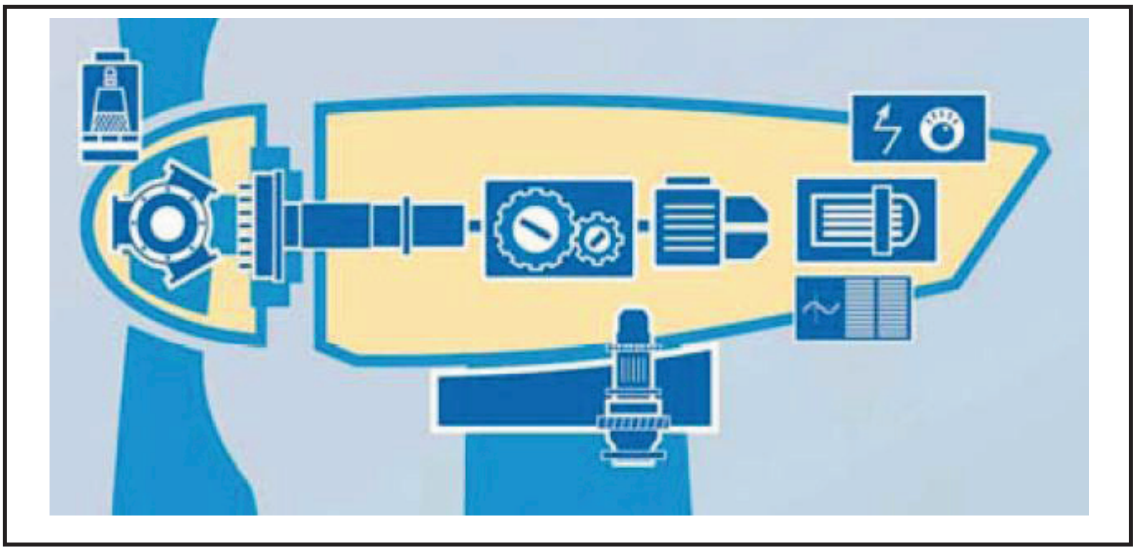


Figure 7.15: Picture of the wind turbine *(source: BTM consult)*

Furthermore, we have one thing more to decide about the rotor hub and the hydraulic system trailer inside. The hub is a heavy component, from 1mT to 50mT, for this reason the cost of transportation is increasing. This fact leads us to think of a good strategy to reduce the outgoings.

The solutions were:

- Make a contract between hydraulic system provider (Rothe Erde) and the hub provider. The first ones will be sent and installed inside the hub.
- The whole hub, since the own supplier will be leaded to our assembly plant to be tested and connected.

7.7.2 Strategic contracts

During the years of the project, the operation strategy followed won't be the same in the first year that we are going to develop in the last years.

Our first strategy, during the first two years 2011 and 2012, is based on the fact that DanEnergy doesn't have experience in the wind manufacturer market, so has to buy all the parts independently and later assemble. The tower and the blades go directly from our supplier to our clients, but the nacelle is mounted in our assembly plant and then sent to the customer.

After this period, in 2013 our company will grow both in capital and knowledge, therefore are going to establish a new contract. The best agreement is a Joint Venture with a manufacture company, this will be in our case only with blades and towers. We have chosen this contract due to offers us many advantages:

-Share costs and risks of the projects that need a large initial investment to start.

-Brings know-how, overcome trade barriers in a new market or to compete more effectively.

The terms of the contract will be that DanEnergy is going to design and the manufacturers like LMGlassfiber with blades and Timber Tower with the towers are going to build them. This is going to be easy, thanks to our suppliers that have a predisposition to integrate and do this kind of relationships.

In 2013 the value reaches the maximum of demand and then starts to decrease, but in our case we are going to continue producing to be able to export and introduce ourselves in other countries to develop new wind markets.

Due to the increase or the maintaining of the production on the last two years, we can maintain the same strategy or introduce a new one. This could be to find an external manufacturer to do a percentage of our production like other companies do, like Gamesa.

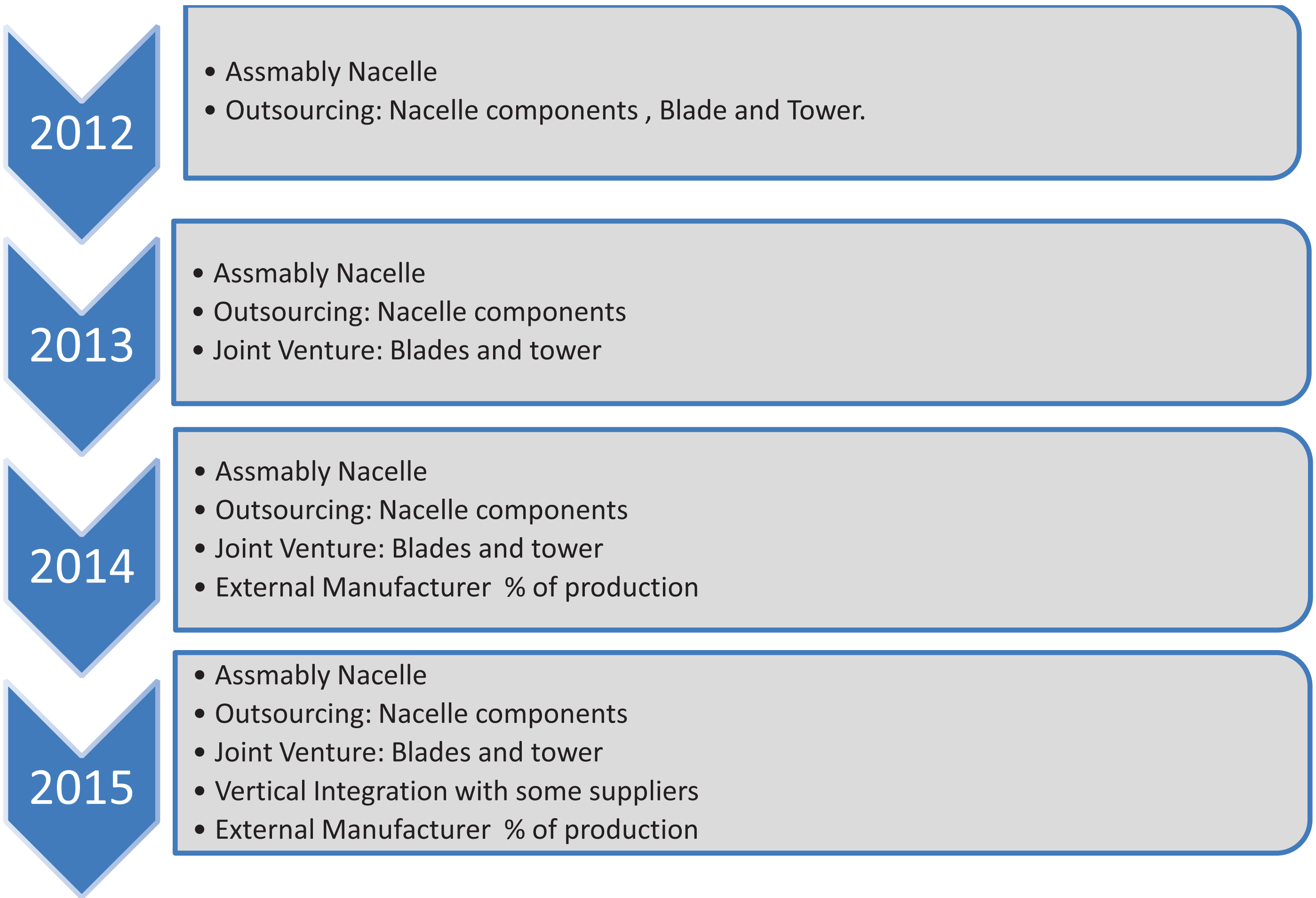


Figure 7.16: Strategy time line.

8. Capacity Strategy

8.1 Initiation of capacity

We are now thinking about capacity for our business. First we have decided if we are going to produce ourselves or not. We have all the money we want for our project but we have to be most competitive as we can. We think that the best way is to use suppliers but not for all the part of the wind turbine. The structure of a wind turbine is rather simple: a steel or concrete tower is equipped with a kind of machine house (called nacelle) on top, which is turning around a vertical axis in a way that the rotor (usually equipped with two or three blades) always faces the wind. Many turbine manufacturers make special efforts for the design of their turbines to allow them to blend well into the landscape. Most wind turbines have three blades, a more aesthetically appealing set-up than two-blade turbines, which are, however, lighter and easier to assemble and might, therefore, be preferred for offshore installations.

Figure 8.1: the different part of the wind turbine *(source: Vestas website)*

We are just mounting one of the main parts of the wind turbine which is the nacelle. But what is clearly the nacelle and it structure because it is important to know the body structure of the nacelle in order to find suppliers of the different in-part of the nacelle and also in order to improve the mounting chain.

***Nacelles*:**

The plants that produce nacelles are primarily assembly facilities. Nacelle components are produced in house to the specifications of the global original equipment manufacturers and then assembled at the nacelle plant. Generally, the assembly of a nacelle takes less than a week. With high demand in 2009, plants generally operated two to three shifts per day and five days per week. The nacelle houses the main components of the wind turbine, such as the controller, gearbox, generator, and shafts.

Capacity can be defined as the maximum output rate that can be achieved by a facility. The facility may be the entire organization, a division, or only one machine. Planning for capacity in a company is usually performed at two levels, each corresponding to either strategic or tactical decisions. The first level of capacity decisions is strategic and long-term in nature. This is where a company decides what investments in new facilities and equipment it should be. In fact, these decisions are strategic in nature. Also, they require large capital outgoings and will have a great impact on the company's ability to conduct business. The second level of capacity decisions is more tactical in nature, focusing on short-term issues that include planning of workforce, inventories, and day-to-day use of machines.

We already know from our suppliers that it takes about one week to produce a blade. Trucks are the most common method of transport but sometimes it is too complicated for big parts like blades or towers. So we can say that most of time, nacelles, blades, and towers are shipped directly from the manufacturing plant to the construction site. But sometimes we need trains or trucks for the final transportation when the wind farm is inside the land.

For example, the blades, the rotor and the tower are going to be directly delivered on the land by the suppliers where we want to put the wind farm. It will be better for us because we don't have to store all these parts and that will saved space in our manufactory.

Their transportation will be:

Figure 8.2: Different kind of transport

Figure 8.3**:** Mounting a wind turbine

A rotor is installed on a 3 MW wind turbine with a crane after transportation by ship and after by truck.

8.2 Locating capacity

Facility location is determining the best geographic location for a company's facility. Facility location decisions are particularly important for two reasons. First, they require long-term commitments in buildings and facilities, which means that we won't have to make mistake because it will be difficult to solve it. Second, these decisions require sizable financial investment and can have a large impact on operating costs and revenues. Poor location can result in high transportation costs, inadequate supplies of raw materials and labor, loss of competitive advantage, and financial loss. Businesses therefore have to think long and hard about where to locate a new facility.

In most cases, there is no one best location for a facility. Rather, there are a number of acceptable locations. One location may satisfy some factors whereas another location may be better for others. If a new location is being considered in order to provide more capacity, the company needs to consider options such as expanding the current facility if the current location is satisfactory. As you can see, there is a lot of things to consider.

8.2.1 But how can we choose the best facility location?

In most cases, there is no one best location for a facility. Rather, there are a number of acceptable locations. One location may satisfy some factors whereas another location may be better for others and we have to determine it.

During the amount of manufacturing capacity, the building is an important consideration for us, another equally important consideration is the location of our manufacturing facility. So we have decided to build only two assembly plants for nacelles and we have to determine the size of each one.

- Plant 1 – Produce 1MW, 3MW and 6MW wind turbines.
- Plant 2 –The same distribution as the Plant 1.

In order to be near from our customers, we decide to buy lands in Poland. That's why we have determined the cost of living in the different countries of Europe.

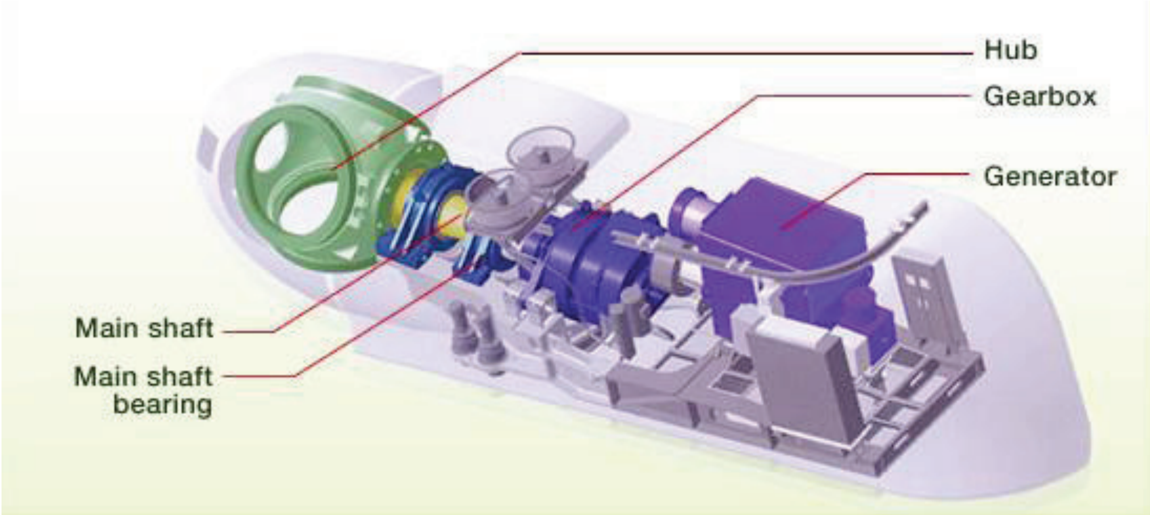


Figure 8.2.1: The nacelle we are going to manufacture *(source:www.thewindpowersystem.com)*

Many factors can affect locations decisions, including proximity to customers, transportation, source of labor, community attitude, proximity to suppliers, and many other factors. The nature of the firm's business will determine which factors should dominate the location decision. As already mentioned, service and manufacturing firms will focus on different factors. For us and in order to have profit, we have to tend to locate near the markets we are going to serve, whereas non-profit organizations generally focus on other criteria. We have decided to produce large manufacturing facilities tend to be less flexible and responsive to market changes.

We are introduced some issues which gave to us solutions for the choice of the location:

8.2.1.1 Proximity to Sources and Supply

Our firm needs to be located close to sources of supply that we need for our business. The best reason that we have to be near our business and near our suppliers is the cost of transportation. In order to reduce the cost, we have to locate closer in Europe near our customers and suppliers. So a reason to locate close to sources of supply is to avoid high transportation costs. Moreover, manufacturing of a product requires certain resources like energy, water basic infrastructure and so on. Hence, manufacturing organizations will try to locate their facilities in places where these basic resources are available and available cheaper compared to other places. Poland can offer to us:

- Economic growth is 2 to 3 times higher than in Denmark
- Electrical power for our buildings manufactory

- Good infrastructure in Poland: trains, autobahn, airport
- Good transportation companies like Universal Transport

"Wind Energy is a booming industry, and Universal Transport is part of this industry - with tailored transport solutions. Wind parks are erected worldwide - a development that we at Universal Transport support from the beginning on. As partner of leading European manufacturers for wind farms we have specialized in this market segment. Such transcontinental special transports require highest experience and intense preparation especially in the planning phase. Typical for Universal Transport, the answer to this logistical challenge was specializing with suitable fleet and equipment - without any compromise." (Source: website of Universal Transport).

8.2.1.2 Proximity to Customers

We need to be accessible to their customers in order to share more information with us. For this reason, we have to choose a land which offers convenient access. Large companies like us often locate in a central area of the market they serve. Also, items such as heavy nacelles for wind turbine need to be produced close to the market because the costs of transportation of these materials are higher.

Figure 8.2.2: Map Europe with our factory and some suppliers

We have made a choice to be close to our suppliers and to our customers in order to reduce costs.

8.2.1.3 Presence of appropriate labor

The location of a manufacturing facility is dependent on the skill set required for doing the work and availability of personnel with those skill set. It may be found that some regions are having an abundance of appropriate labor while others have none at all. The availability of appropriate and low cost labor is a very important element in being competitive. Therefore, it plays an important role in the location of the manufacturing facility. Other factors that could consider are local wage rates, the presence of local unions, and attitudes of local workers. Work ethics and attitudes toward work can vary greatly in different parts of the country and between urban to rural workers. Attitudes toward factors such as absenteeism, tardiness, and turnover can greatly affect a company's productivity. Some good explications help us for the choice of Poland:

- There is a large, young, dynamic and highly educated population of 40 million people in Poland. 50% is under 35 years.
- Low Income tax of 19%.
- Facility with laws
- Young market in wind turbine, high level of wind near Russia and East countries (export)
- The most attractive city in Europe in salary fees and cost of living
- Ranked 2nd European country in Foreign Investment Confidence Index (AT Kearney).
- Poland will be part of the Euro-zone as from 2012. This will be an extra boost for real estate value.
- The Baltic coast area has currently the highest potential for real estate value increase in the near future.

(sources: http://www.polish-realestate-fund.com/)

We have also studied the cost of living in different countries and compared it. The next investigation shows us the classification of the most expensive capital in the world. In this inquiry, Warsaw in Poland is the 65th of the list so is in the middle and is profitable for us. Poland is the best location we have chosen because we would like to be most lucrative as we can.

Continuing with the part of the best location for our factory we have here the: Mercer Cost of Living Survey – Worldwide Rankings, 2008 (table 8.2.1.3):

(Including rental accommodation costs)

The indices are based on Mercer's cost of living database and are modified to include rental accommodation costs and to reflect constant weighting and basket items. They are based on the cost of living of the city New York (indice 100). We do not recommend that expatriates use the figures represented here to compare their own compensation packages

- Possible choice for the mounting manufactory land:
- Our choice for the mounting manufactory land:

Ranking (March 2008)	city	Countries	cost of living index
1	Moscow	Russia	142.4
2	Tokyo	Japan	127.0
3	London	UK	125.0
4	Oslo	Norway	118.3
5	Seoul	South Korea	117.7
6	Hong Kong	China	117.6
7	Copenhagen	Denmark	117.2
8	Geneva	Switzerland	115.8
9	Zurich	Switzerland	112.7
10	Milan	Italy	111.3
11	Osoka	Japan	110.0
12	Paris	France	109.4
13	Singapore	Singapore	109.1
14	Tel Aviv	Israel	105.0
15	Sydney	Australia	104.1
…	…	…	…
22	New York	US	100 (base)
…	…	…	…
25	Amsterdam	Netherlands	97.0
26	São Paulo	Brazil	97.0
…	…	…	…
31	Stockholm	Sweden	95.2
…	…	…	…
37	Munich	Germany	93.1

38	Berlin	Germany	93.0
39	Brussels	Belgium	92.9
40	Frankfurt	Germany	92.5
…	…	…	…
42	Kiev	Ukraine	91.7
…	…	…	…
45	Bratislava	Slovakia	90.6
46	Düsseldorf	Germany	90.4
47	Hamburg	Germany	89.9
…	…	…	…
65	Warsaw	Poland	85.7
…	…	…	…
85	Vilnius	Lithuania	80.2
…	…	…	…
123	Tianjin	China	67.9
…	…	…	…
138	Buenos Aires	Argentina	62.7
139	San José	Costa Rica	60.6
140	Johannesburg	South Africa	60.4
141	Karachi	Pakistan	54.7
142	Quito	Ecuador	54.6
143	Asunción	Paraguay	52.5

Table 8.2.1.3: Ranking of cost of living *(source: Mercer Cost of Living Survey – Worldwide Rankings, 2008)*

7.2.1.4 Skills for helping us in location's choice

Furthermore, we have decided a number of procedures that can help us in evaluating location alternatives. There are decisions-support tools that help structure the decision-making process. Some of them had helped us such as quality of products and others can help us with qualitative factors that can be measured like distance. We have to remember that the location decision is one thing very important for our company because we are going to invest a lot of money and we have to live there for a long time in order to make profit.

Factor rating can be used for our decisions in order to evaluate multiple alternatives based on a number of selected factors. It is valuable because it helps decision maker's structure their opinions relative to the factors identified as important.

The following steps are used to develop a factor rating:

- ***Step 1:*** we had identify dominant factors: proximity to market, quality, appropriate labor, cost, transports, size of storage because for heavy industries and with the help of the operations strategy Matrix.
- ***Step2:*** we assigned weights to factors reflecting the importance of each factor relative to the other factors. The sum of these weights must be 100;
- ***Step 3:*** We select a scale by which to evaluate each location relative to each factor. A commonly used scale is a 5-point scale, with 1 being poor and 5 excellent.
- ***Step 4:*** We evaluate each alternative relative each factor, using the scale selected in Step 3. For example, if you chose to use a 5-point scale, a location that was excellent based on quality of life might get a 5 for the factor.
- ***Step 5:*** For each factor and each location, we multiply the weight of the factor by the score for that factor and sum the results for each alternative by EXCEL. This will give us a score for each alternative based on how you have rated the factors and how we have weighted each of the factors at each location.
- ***Step 6 :*** We selected the alternative with the highest score

Factor Scores (1-5 scale)

Factor	**Copenhagen (Danemark)**	**Hambourg (Germany)**	**Szczecin (Poland)**	**Factor Weight**
Proximity to market	5	4	4	15
quality	4	5	3	20
Appropriate labour	4	4	3	10
cost	1	2	5	30
transports	2	5	4	15
size of storage	1	2	5	10
			TOTAL	100

Compute weighted Factor Scores

Weighted Factor Scores

Factor	**Copenhagen (Danemark)**	**Hambourg (Germany)**	**Szczecin (Poland)**
Proximity to market	75	60	60
quality	80	100	60
Appropriate labour	40	40	30
cost	30	60	150
transports	30	75	60
size of storage	10	20	50
TOTALS	265	355	410

Best Total Score	410
Best Location	Szczecin (Poland)

Figure 8.2.1.4: Evaluation of the best land

Figure 8.2.1.5: Zone of the best land for location

8.2.2 Land

We have to settle down near the border of Germany in the North West of Poland. This region is really dynamic in Poland and we have the proximity of the Germany (50km)

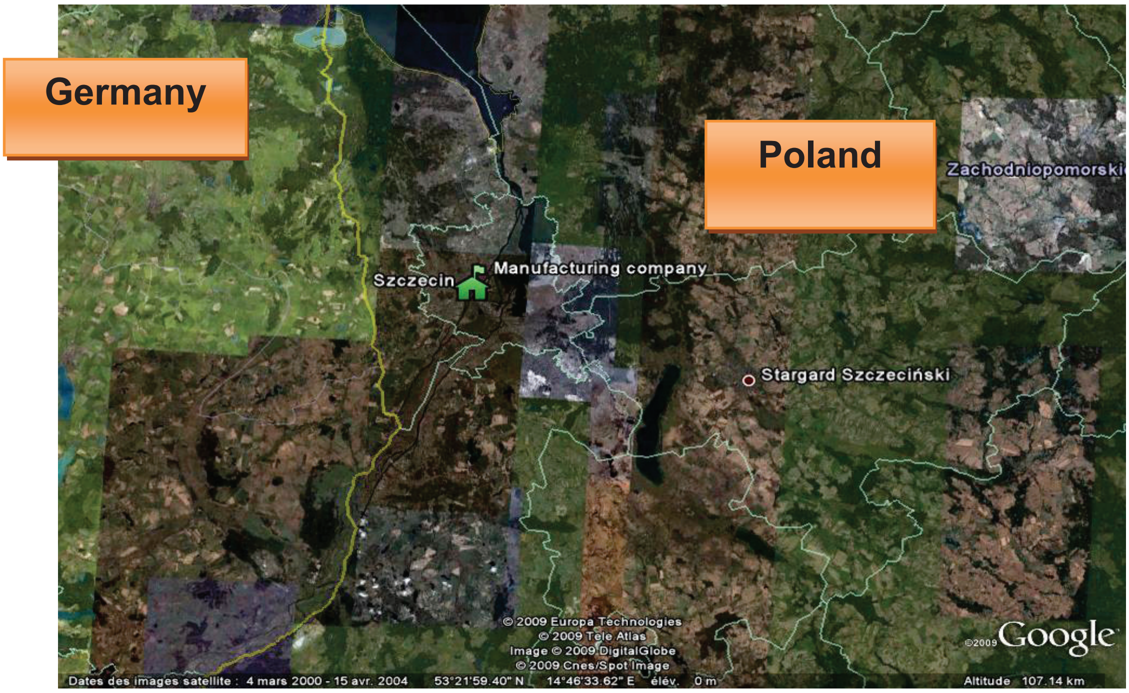


Figure 8.2.3: Map of Poland border *(source: Google Maps)*

Figure 8.2.4: Sczecin and Infrastructures

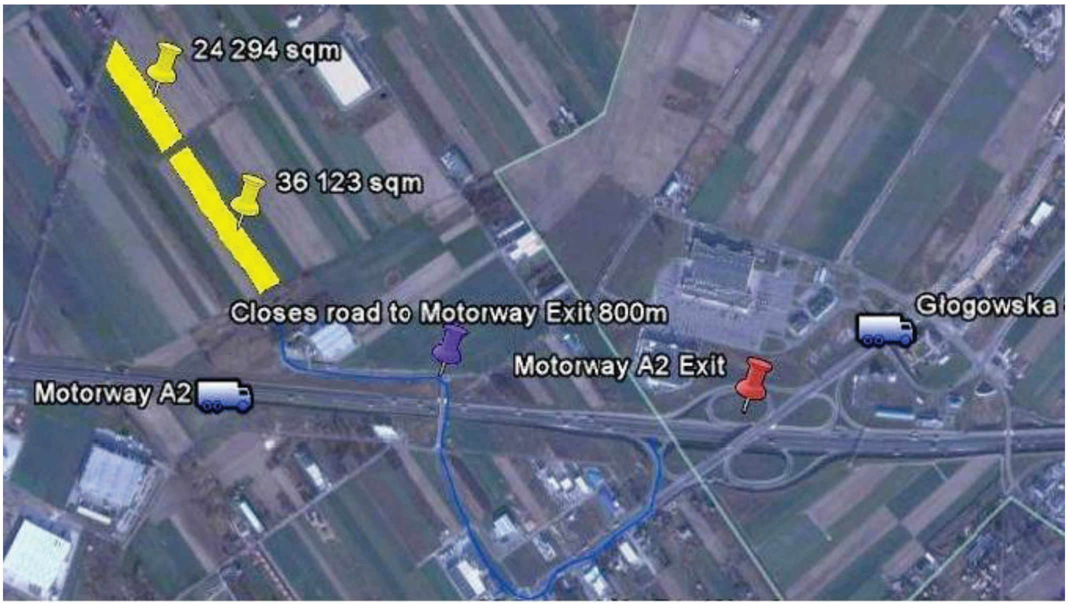


Figure 8.2.5: Sczecin and Infrastructures

We would like to put our manufacturing in Szczecin – western Poland biggest city. Sczecin is one of most dynamic grow city with 600 000 citizens and strategic location between Berlin – Warsaw – Moscow (motorway A2). Our land is located 800m from motorway A2 exit in Sczecin so is perfect place for logistic and industries company.

Figure 8.2.6: Motorway A2 and at left the land

Figure 8.2.7: Photos of the land with the electrical lines

There are also really good connections with center of Sczecin (10 km to rail way station- center) by train only 4 km to Szcecin Airport.

Figure 8.2.8: The commercial port of Sczecin (10 km from our company)

Figure 8.2.9: More photos of the port of Sczecin

As we can see on the last photo we have the possibility to store before shipping the different parts of the wind turbine as our suppliers can do also. In fact, when we are going to charge the cargo, it will be better to charge all the ship very quickly and in its maximum capacity. As a consequence, the transportation costs will decrease. We know that we have already storage in our company land but this storage in the port is only used for the shipping transportation for a little time by the shipping's company.

Figure 8.2.10: The central station of Sczecin (10 KM from the station near of our company, 2km)

Figure 8.2.11: The airport of Sczecin (4km by train)

The proximity is really important because there is a good visibility for customer and transportation access. Furthermore, around the land there is no habitation and we have no zoning restrictions, soil restrictions. Szczecin is 3rd biggest University City in Poland so is no any problems to get well educate people. Our business will bring pollution in recycling and the noise will be tested for an improvement of the quality of life and working. Both fields are 80m wide and they are separate by planned and extruded but still not build road. This land is fully planed and dedicated for heavy industrial activity, stocks and logistics warehouse. Water, gas and power are located in road. Lot A is partly cover by high voltage line 2x110kV. Under line can be stock, parking and roads.

There is an opportunity to buy neighbor's lot and expand area by 200m wide field (located from south side if we don't have enough storage).

We have an area of 60'417 meters square, shared for two lots:

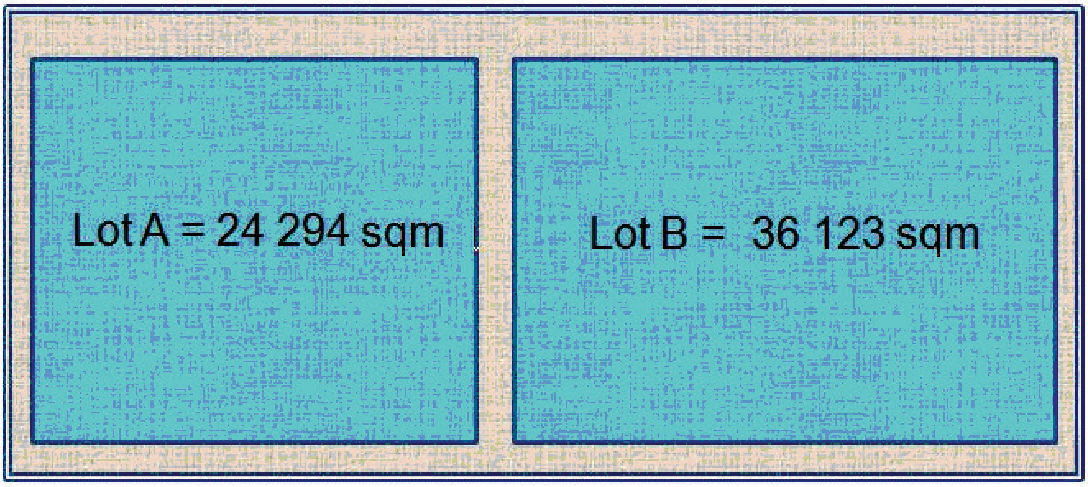


Figure 8.2.12: The allocation of the assembly chain will be like this.

8.3 Assembly plant

In this point we are going to make a detailed description about all the assembly plant, since the sizes and storage until the different capacities strategies, mounting lines and detailed information of the capacity plan selected.

8.3.1 Plant

We are going to build the plant in Szczecin (Poland) as is explained detailed in the last points. But in reality is not only one, it will be two factories. At the beginning (2011) we will start the production of the first factory and in the peak of the production we will start to produce in the second factory to satisfy the demand (figure 8.3.1).

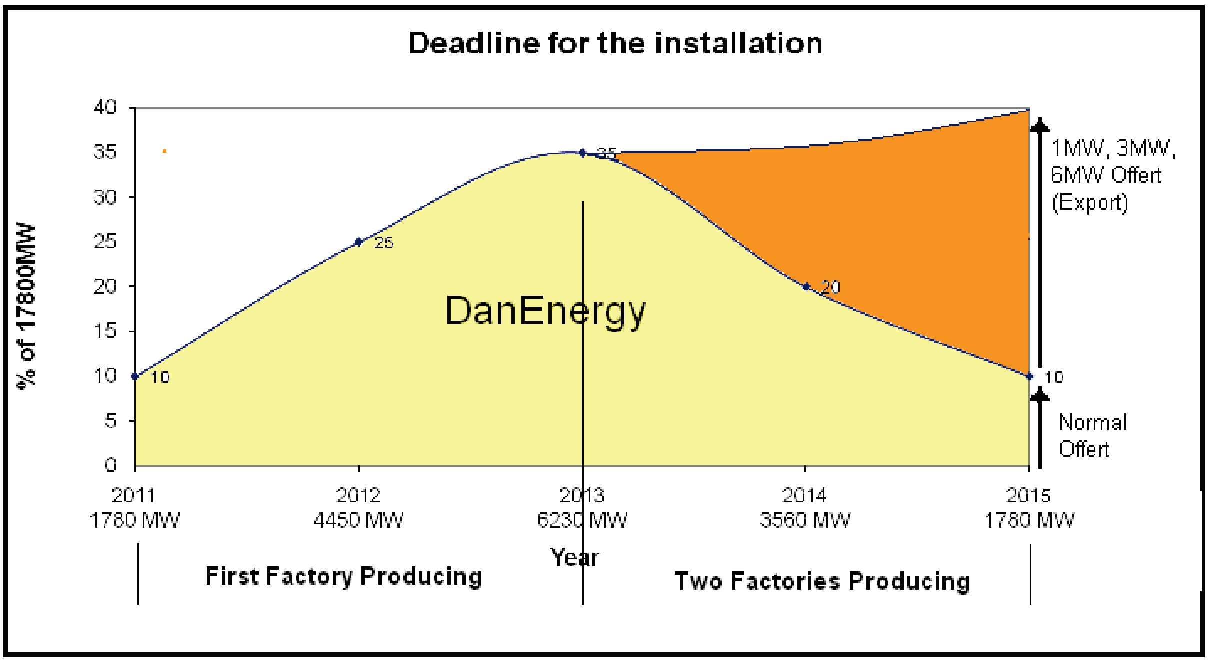


Figure 8.3.1: Deadline for the installation related with the production factories

We are building two factories not one, because we made a specific strategic capacity plan called Leading strategy that will be explained in point 7.3.3 more specifically. The storage of our plant is divided in two parts: the outside storage and the inside. The outside storage is for mounting nacelles and hubs, and the nacelle cover ready for assemble, it will be just in front of the factory, also inside the factory we will have space for storage other pieces necessaries for assemble the hole nacelle. The heavy pieces like yaw bearing, generator or gearbox will be stored in the floor and the lighter like yaw brake or cabling and sensor in a rows, thus we will use better the inside space.

8.3.2 Sizes

We made a complete research about the sizes that a big factory like this has to be. We looked in other big companies like Gamesa or Enercon how their factories are, how many nacelles be produced each year, how many employees, what type of turbines they produce or witch capacity they have, to make a concrete size for our factories according their sizes. Our first factory is the bigger, because have more mounting lines and will be settled in the bigger half of our place, and its 36.000 m^2. And the second one, the smaller, because have less mounting lines, will be settled in the second half, and it's 24.000 m^2.

The outside storage is just in front of the factory and it's really big because it has to storage a great quantity of complete nacelles, that each one it perfectly occupy 50m^2. At the beginning of our production we will have a lot more production than our demand as you have read in the case description. That means the storage will be at 100% of his capacity. Making calculations and taking into account the space between nacelles and the cranes needed to move this nacelles we can say that the storage exactly will be 40.000m^2 and can store about 750 nacelles already mounted (figure 8.3.2).

The last 3 years of our production plan we have about the same production and demand. That means that the storage decrease respect the first two years, thus we remake the calculation about our new storage and now it will be 25.000m^2 for store approx. for 500 complete nacelles. This 15.000m^{2}not used storage can be used perfectly to place the second factory that has to start producing these last years.

Figure 8.3.2: Storage Place (Red cross) *(source: Google Earth)*

The internal storage of our plant will be inside obviously and between each line (figure 8.3.3). Each piece will be in the correct position of the mounting line for an easy and fast utilization. A correct organization of this storage can be really productive for our factory.

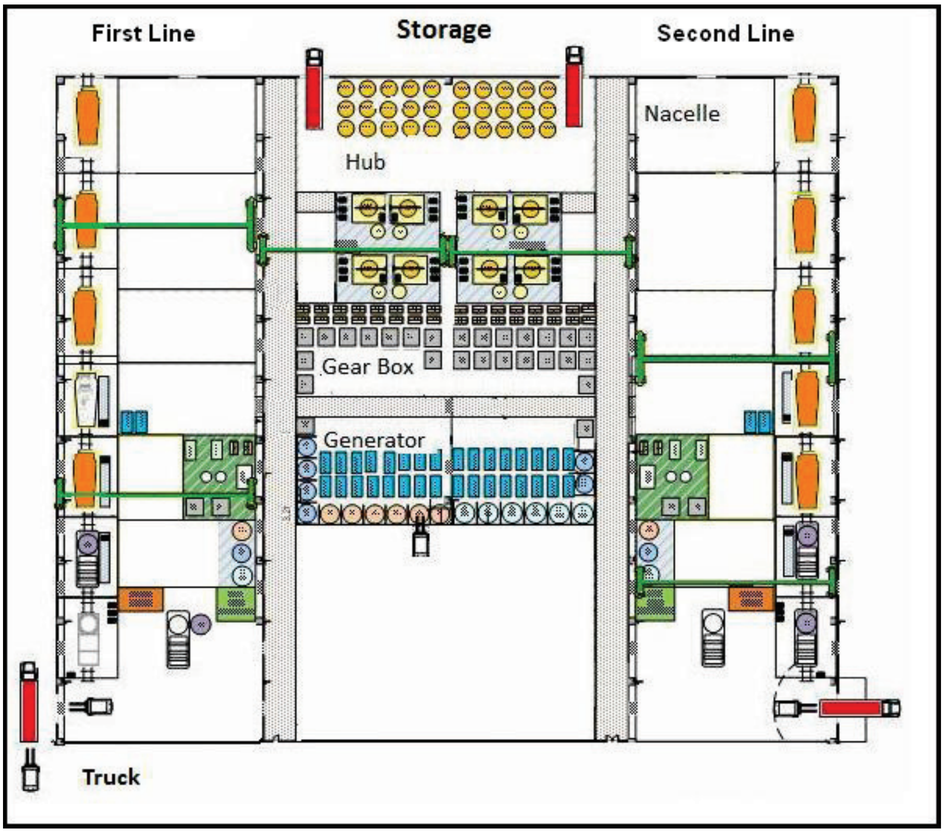


Figure 8.3.3: Drawing of factory distribution

Also apart from the storage we have to count the space that we need for our cranes and his space to move, that is not a little space.

8.3.3 The Capacities Strategic Plans

This is the one of the most important decisions of our project, how we want to manage the production of our factory. We have different options that we are going to explain now.

The capacity strategic decision is really complicate and complex, and we will explain very accurate our decision and the different options. First we are going to see in figure 8.3.4, a summary of the two principal ways to go in the decision of capacity:

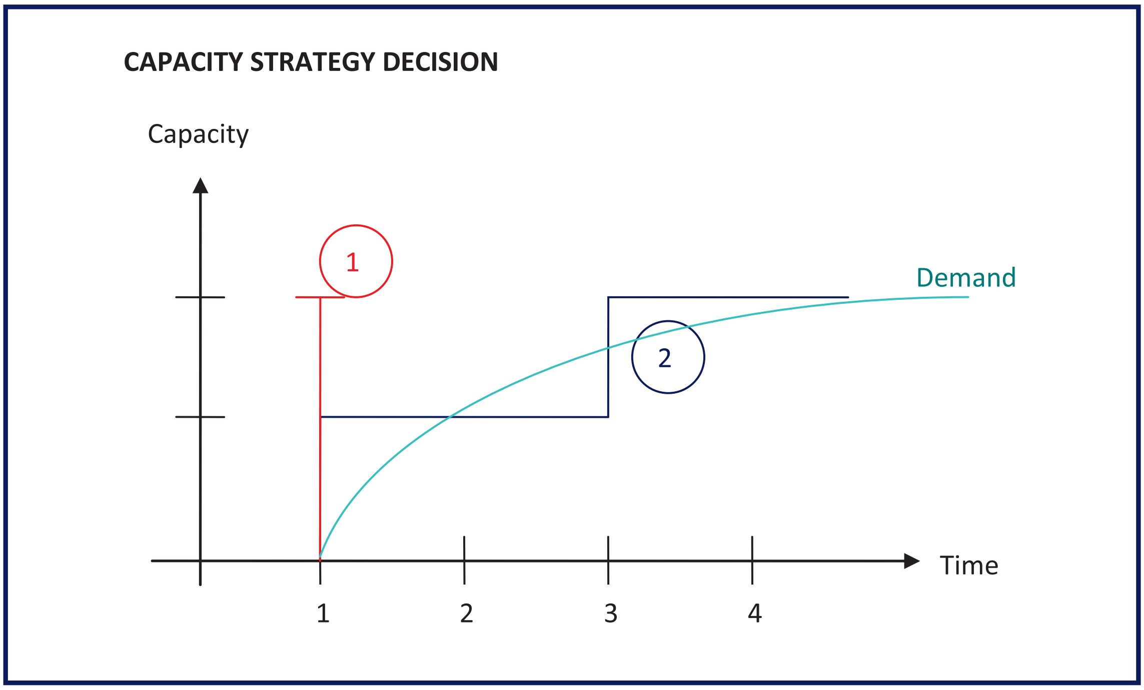


Figure 8.3.4: Summary of the strategic capacity

We can see in this figure the Capacity against the Time and three different lines, the red, the first choice of the capacity decision, it means to build all the capacity the first year ignoring all the demand, then you have useless place at the beginning and a lots of storage, and the second one, the blue, is following the line of demand and consist to build extra building during the increase demand.

But we are going to see more detailed this capacity strategy decision in the next four graphs:

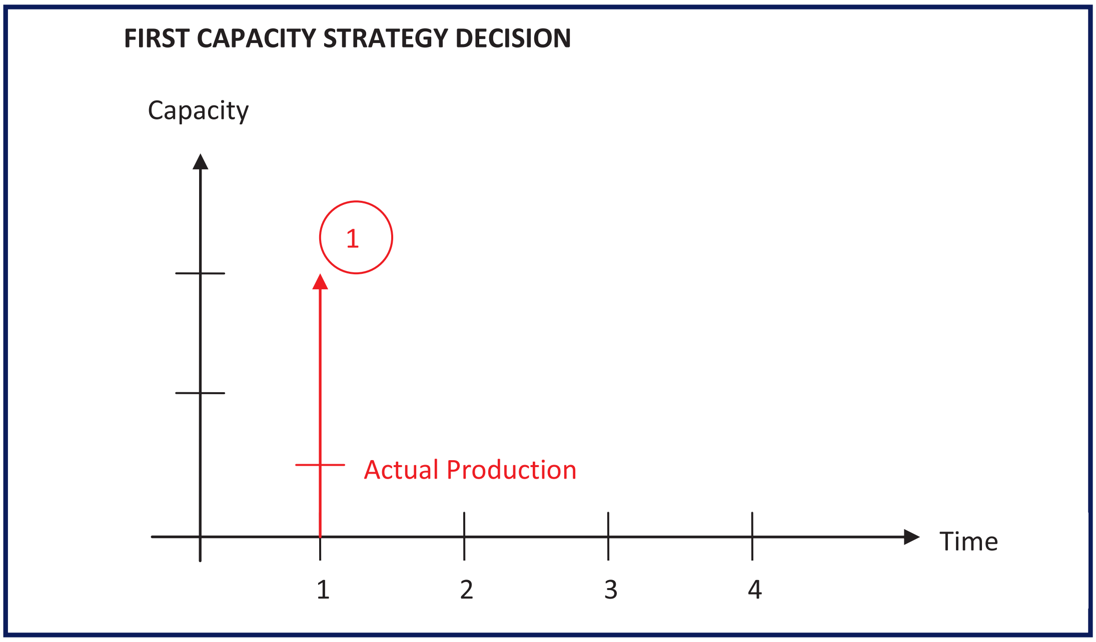


Figure 8.3.5: First Capacity strategy decision

The first capacity decision showed in the figure 8.3.5 consists in build the entire factory the first year, but don't produce at 100%. It's not the correct choice for our capacity decision because you have some advantages but the mostly part are disadvantages like the storage, lots of cost at the beginning, useless space at beginning or low utilization.

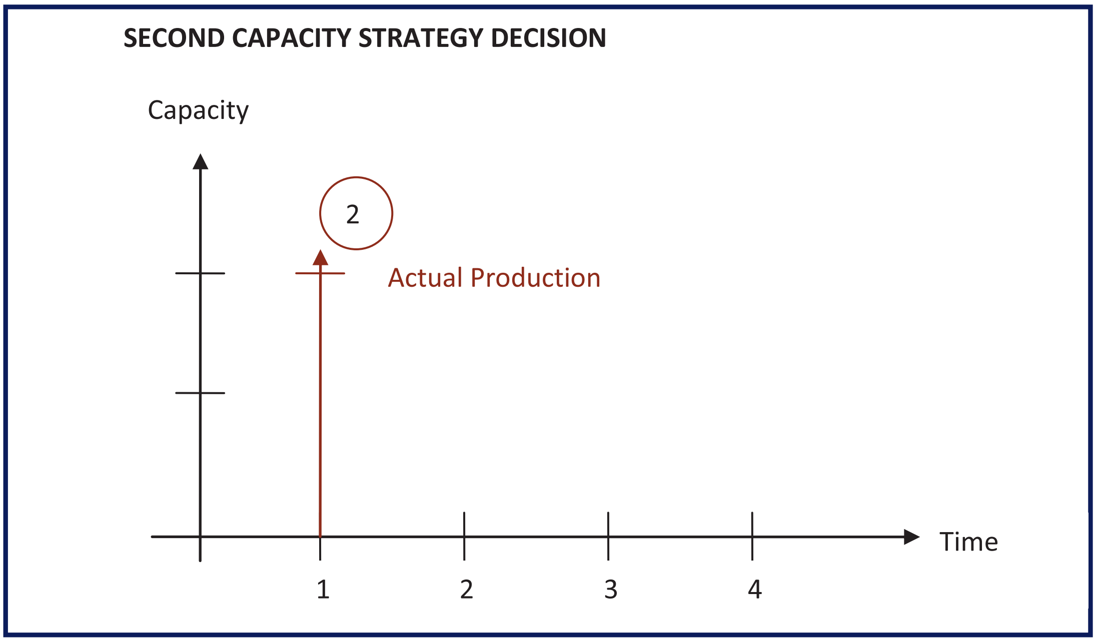


Figure 8.3.6: Second capacity strategy decision

The second capacity decision showed in figure 8.3.6, it's similar than the first but is producing at 100%. Like the first it has too many disadvantages or maybe more for the inventory cost because the high productivity since the beginning and it should not be our choice.

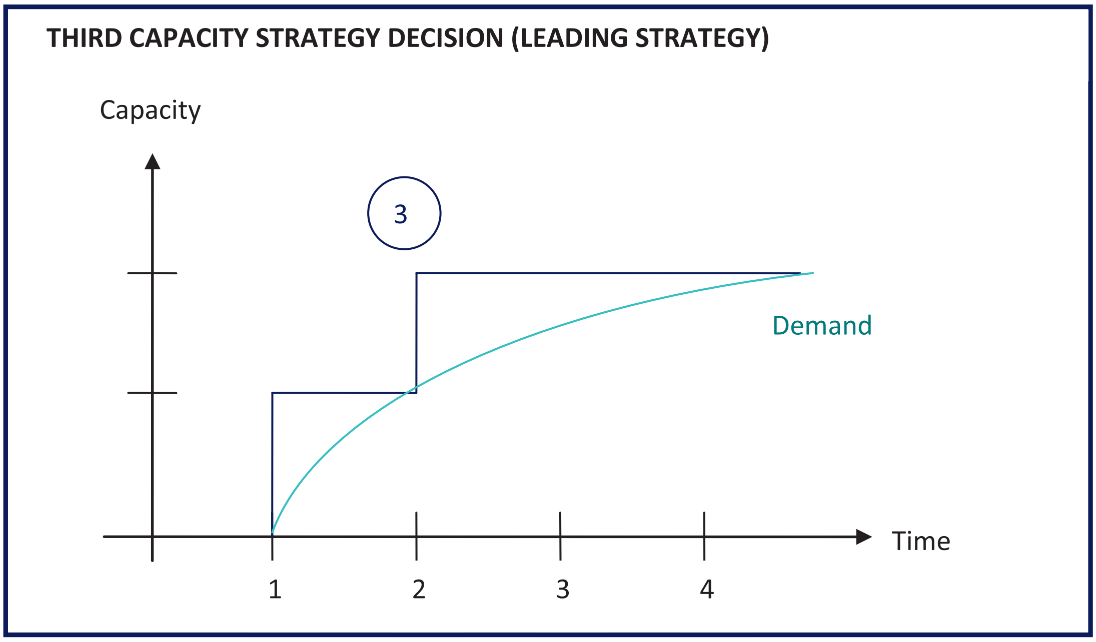


Figure 8.3.7: Third capacity strategy decision (leading strategy)

This one, the third capacity strategy is one of the best choices for capacity strategy, you have an extra building cost but a lot less storage than the before options. You are building the factory following the demand, later can be cheaper to expand the factory because we invest in it.

This third option is the choice that we have selected. We have a high capacity build up and lower storage but enough for safety, otherwise we haven't a lots of cost in the beginning like the first options, neither useless space in the beginning or low utilization, always we will produce around the 95% of capacity in our factory.

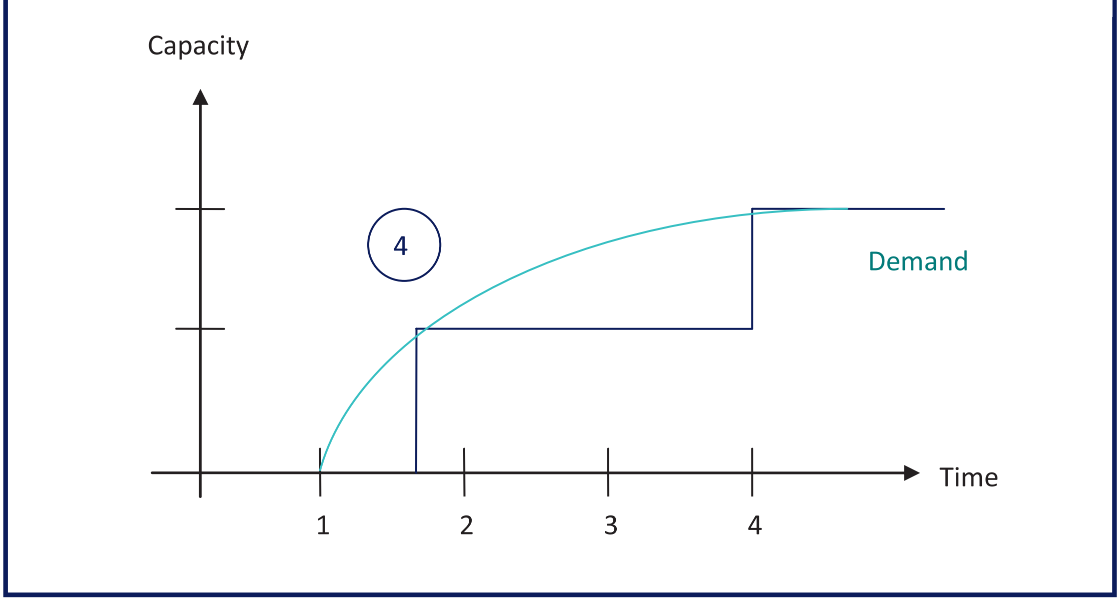


Fig 8.3.8: Fourth capacity strategy decision (lagging strategy)

This option, the fourth capacity strategy decision from figure 8.3.8 is the last strategy for capacity. It is not a bad option as well, but your production is under the demand, in consequence you don't have any storage (bad thing) and normally you have always a lag on the production. That's why we don't choose this option; we want to be dependable with the delivery for our customers.

8.3.4 Summary production strategy plan

We have chosen the leading strategy as I said, and we will make the second factory in the third year, following the demand. The first three years we will produce around 95%, it's around 4500 MW of energy produced or around 1400 wind turbines. And the two last years with the increase of the production with the second factory it's about 7000 MW or 2400 wind turbines. In the following figure 7.3.9 we can see this numbers.

The hubs that we store inside our factories from our hubs suppliers as we can see in figure 8.3.3, will be mounted at the end of each line and stored after outside, ready to transport to our customers. As we can see in the same figure, the production of our factory will be distributed like a series production for each mounting line. Following step by step all the steps needed to mount a nacelle and then the hub together.

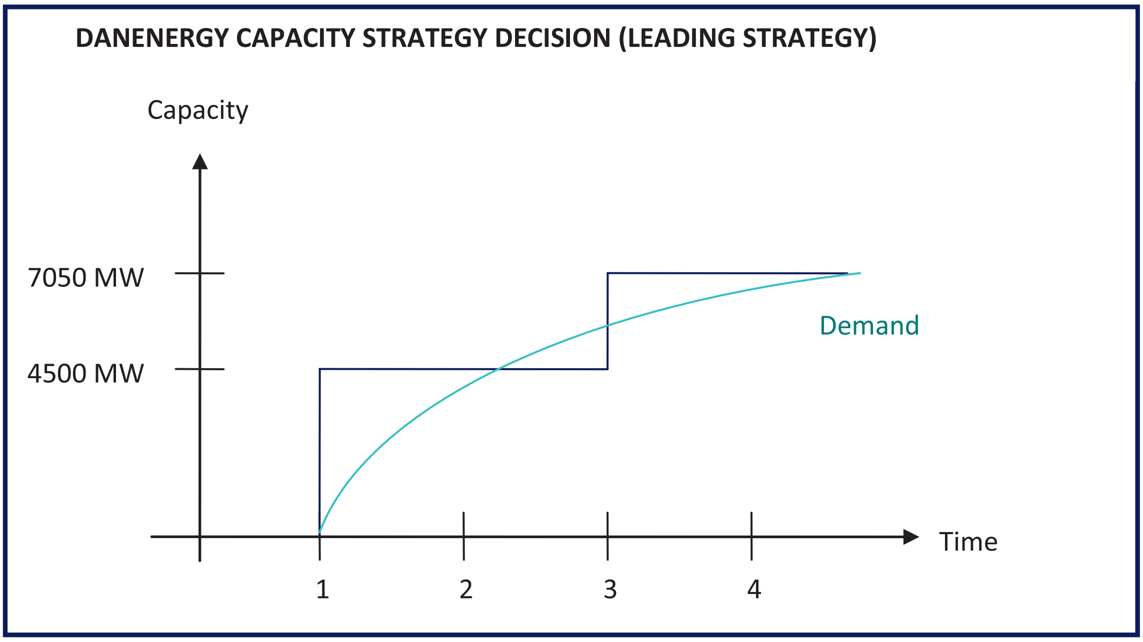


Figure 8.3.9: DanEnergy capacity strategy decision

We have made all the calculation needed for our plan, that is explained later accurately, and we have chosen to work in two shifts in the plant to reach the desired demand of production. Also we have made the calculation of mounting lines, explained accurately later, and the first factory will have five mounting lines, one of 1 MW, two of 3 MW and 2 of 6 MW. And the second factory, starting in the third year, will have three mounting lines, one of each one, one of 1 MW, one of 3 MW and one of 6 MW.

8.3.5 DanEnergy capacity strategic plan

First of all we are going to speak about the hours to make each windmill, the working hours per year and the ideal case of the factory if it's working at 100%. Later we will speak about the detailed and real production year per year.

MW	**1**	**3**	**6**
Hours	**8**	**15**	**20**

Figure 8.3.10: Hours to produce one windmill for each line

We have chosen 3 types of windmills, already explained in product portfolio, and we made an extend research to know how many hours each windmill can spend to complete the assembly. We have looked in Vestas, Gamesa and other big companies and with the next reasons we calculate this numbers of figure 8.3.10.

- Flow production system (each employee is responsible for producing his or her own sub-assembly just when is needed).
- Everything in the production factory runs like a clockwork, reducing the total number of person-hours needed to assemble each nacelle.
- Give employees more responsibility for their own activities at every step, improving the quality.
- Local suppliers (Explained in the supply network part), cutting the delivery times and reducing value of its warehouse inventory.

Shift	1	2
Hours/year	2080	4160

Figure 8.3.11: Working hours per year per shift

This figure 8.3.11 is simply a working hours of our company. In a year we have 260 working days, a normal number for lots of companies. And a shift consists of 8 hours of work, then we have that if we are going to work in two shifts (16h) for 260 days, we have 4160 hours producing complete nacelles in our factory. This is an important number for the next calculations:

Total First 3 years at 100%				
MW	1	3	6	
Lines	1	2	2	Total Production
	520	555	416	4680 MW

Figure 8.3.12: Production of our plant the first 3 years if it works at 100%

Total Last 2 years at 100% (2 factories)				
MW	1	3	6	
Lines	2	3	3	Total Production
	1040	832	624	7280 MW

Figure 8.3.13: Production of our plant the last 2 years if it works at 100%

The numbers of the figure 8.3.12 and 8.3.13 are calculated only for the ideal case, not the real, we all know that a real factory have sometimes breakdowns and the corresponding maintenances that never allow to produce at the ideal 100%.

In figure 8.3.12 we can see, like we will see in the next graphs about production each year, the quantity of the nacelles and hubs assembled that we will do for each type of wind turbines in a year. At the end of the total production, if you multiply for the MW of each turbine we can see the total number of MW produced for one year. In the same in figure 8.3.13 you can see the quantity of complete nacelles assembled a year and the total production.

8.3.6 Detailed production of the plants year by year

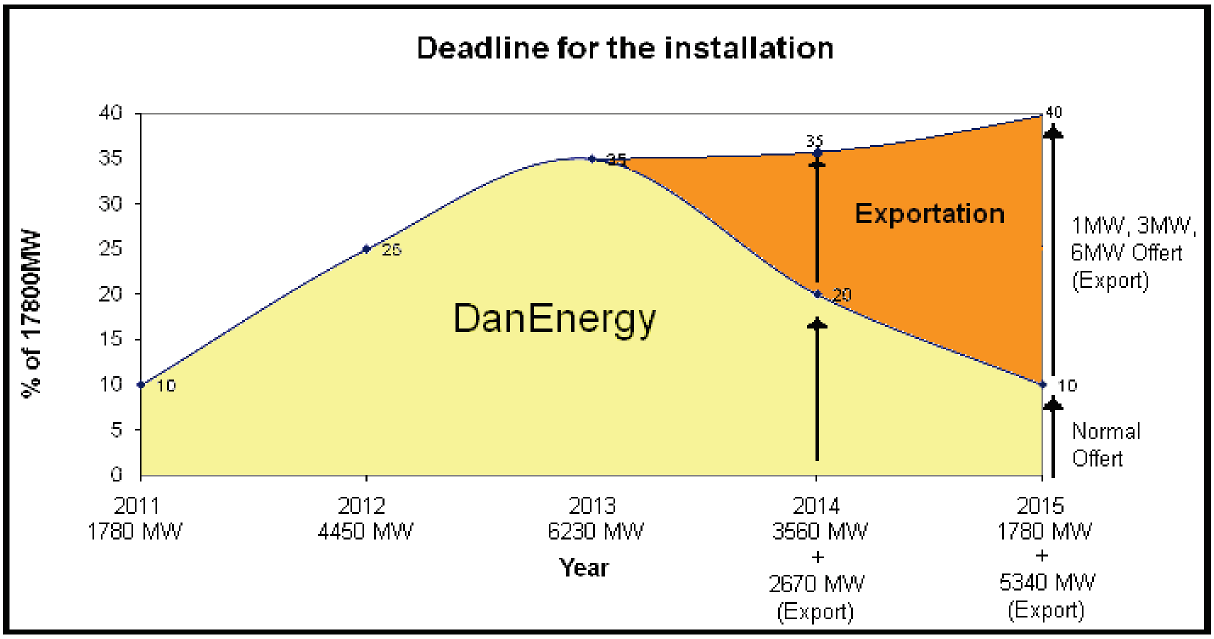


Figure 8.3.14: Production needed each year for our customers and exportation.

This figure 8.3.14 is really useful to help explaining the production of each year. We can see the five years of our production and the quantity needed every year to our customers and exportation.

- **2010 to 2011:**

Year	2011		Needed	Have	Storage	% Storage		
Shift	2		1780	4030	2250	100		
		MW	**1**	**3**	**6**			
		Lines	1	2	2		Total Production	
% production:	86,11		448	478	358	=	4030	MW

Figure 8.3.15: Complete information about the production of 2011

The first year of our production, 2010 to 2011, we need to produce for our customers the quantity of 1780 MW (Needed (Figure 8.3.15) and also in figure 8.3.14). Then if we always work in two shifts and we have one line of 1MW, two of 3MW and two of 6MW we can make a calculation for each type of nacelle to know the quantity of each nacelle that we produce. If we look the figure 7.3.15 again we see that we produce 448 complete nacelles of 1MW, 478 of 3MW and 358 of 6MW.

Then if we multiply for the quantity of MW that each nacelle have we can know the total production, in this year is 4030 MW.

In the same figure 8.3.15 we have a summary of the production, how many we have (production), how much storage we have (production – needed) and the percentage the storage use. Also we can know the percentage of production in the plant in this year (actual production * 100 / max. production), in this case is 86.11%.

This total production is not 95% or 96% like normally because the storage is complete, an option is to make big the storage and produce always at almost 100% but the cost of a bigger storage only for the first year is expensive. And we are already producing a lot more than we need (storage 100%).

This production is like this because we are following the figure 8.3.9, the leading strategy, we have much storage at the beginning and later we increase (3 third year) the production to follow the demand.

- **2011 to 2012:**

Year	2012		Needed	Have	Storage	% Storage		
Shift	2		4450	6700	2250	100		
		MW	1	3	6			
		Lines	1	2	2		Total Production	
% production:	95,09		494	527	396	=	4450	MW

Figure 8.3.16: Complete information about the production of 2012

Following the same instructions from the last year in the figure 8.3.16 we can see as well the quantity that our customers need (4450 MW), then this quantity is the amount that we are going to sell them. We are working with the same capacity, because we didn't build the second factory yet.

This year we are producing a little bit more than the last year (4450 MW), because now our production is around 95% because our customers need more MW now, and we can see the increase of produced nacelles, 494 for 1MW, 527 for 3MW and 396 for 6MW.

If we take a look now in the figure 8.3.16 again in the top part we can see that we have 6700 MW (2250 MW from the last year (storage) + 4450 MW produced this year). Then we sell to our customers the amount quantity of 4450 MW and we have again 2250 MW in the storage, this means the 100%.

- **2012 to 2013:**

Year	2013		Needed	Have	Storage	% Storage		
Shift	2		6230	6750	520	23,11		
		MW	1	3	6			
		Lines	1	2	2		Total Production	
% production:	96,15		500	533	400	=	4500	MW

Figure 8.3.17: Complete information about the production of 2013

The second year we are going to build the new assembly plant.

Then if we look the figure 8.3.17 we can see the numbers of the production of this year, they are very similar than the year before but we need to produce a lot more for our customers, but this is the reason why we have a good amount of storage. The exactly quantity is 6230 MW, but we only produce 4500MW. If we count the quantity of we produce and the storage we have 6750 MW. This means that we have 520 MW of storage, and the storage is at 23.11%

We still have the same shift and the same mounting lines (this year). We produce at 96.15% of the total productivity and we make 500 complete nacelles of 1MW, 533 of 3MW and 400 of 6MW.

- **2013 to 2014:**

Year	2014		Needed	Have	Storage	% Storage		
Shift	2		6230	7570	1340	59,56		
		MW	**1**	**3**	**6**			
		Lines	2	3	3		Total Production	
% production:	96,84		1007	806	604	=	7050	MW

Fig 8.3.18: Complete information about the production of 2014

The year 2014 is an important year because we just increase our production by building the second factory. Now we have one mounting line more of 1 MW, another of 3MW and other of 6MW.

We increased the production up to 7260MW if it's working at 100%, but is not working at 100% because of the same reasons explained before (breakdowns and maintenances), it's working at 96.84% if we look at the figure 8.3.18, this means we produce a quantity of 7050MW.

We still working with two shift and the same hours per nacelle. If we make the calculation again counting the new mounting lines we can say that the production of the hole company is 1007 complete nacelles of 1MW, 806 complete nacelles of 3MW and 604 complete nacelles of 6MW.

Like the last year, we need to sell an amount quantity of 6230MW (35% of 17800MW, figure 8.3.14) Then if we discount this number from 7570MW (Total produced + last storage) we have a new storage of 1340MW, this is about 60% of his capacity.

- **2014 to 2015:**

Year	2015		Needed	Have	Storage	% Storage		
Shift	2		7120	8390	1270	56,44		
		MW	1	3	6			
		Lines	2	3	3		Total Production	
% production:	96,84		1007	806	604	=	7050	MW

Figure 8.3.19: Complete information about the production of 2015

This is the last year of production in our project. We don't have to think about the next years, because this is out of our project. In 2015 our demand will increase about 5% respect the last year. We sell less to our first customers (Scandinavian countries and England) and we export a lot more, it's totally possible because we have a huge product portfolio.

In figure 8.3.19 we continue producing the same of the last year, 7050MW, and means approx. an 96.84% of the production respect the production at 100%, about 1007 complete nacelles of 1MW, 806 complete nacelles of 3MW and 604 of 6MW.

If we count the total production and the storage of the last year we have 8390MW in total, but we sell 7120MW (needed) and then we safe 1270MW in storage, about 56.4% of his capacity.

Finally, to conclude the part of production of our plant, we have shown the quantity of nacelles and hubs mounted and ready to sell for our customers. The hubs it will be also ready for mount in the wind farm. Also we demonstrate that we follow the leading strategy explained in figure 8.3.9, we have increased the production in the last year, 2014, following the demand line of our customers.

8.3.7 Pictures of our plant

The figure 8.3.19 is only a simple layout about our first factory (5 mounting lines). That describes a few how has to be inside the factory, about the approximate place of the lines and the storages. As I explain before the inside storage is between two lines, and as you can see is organized be places, to be more efficient.

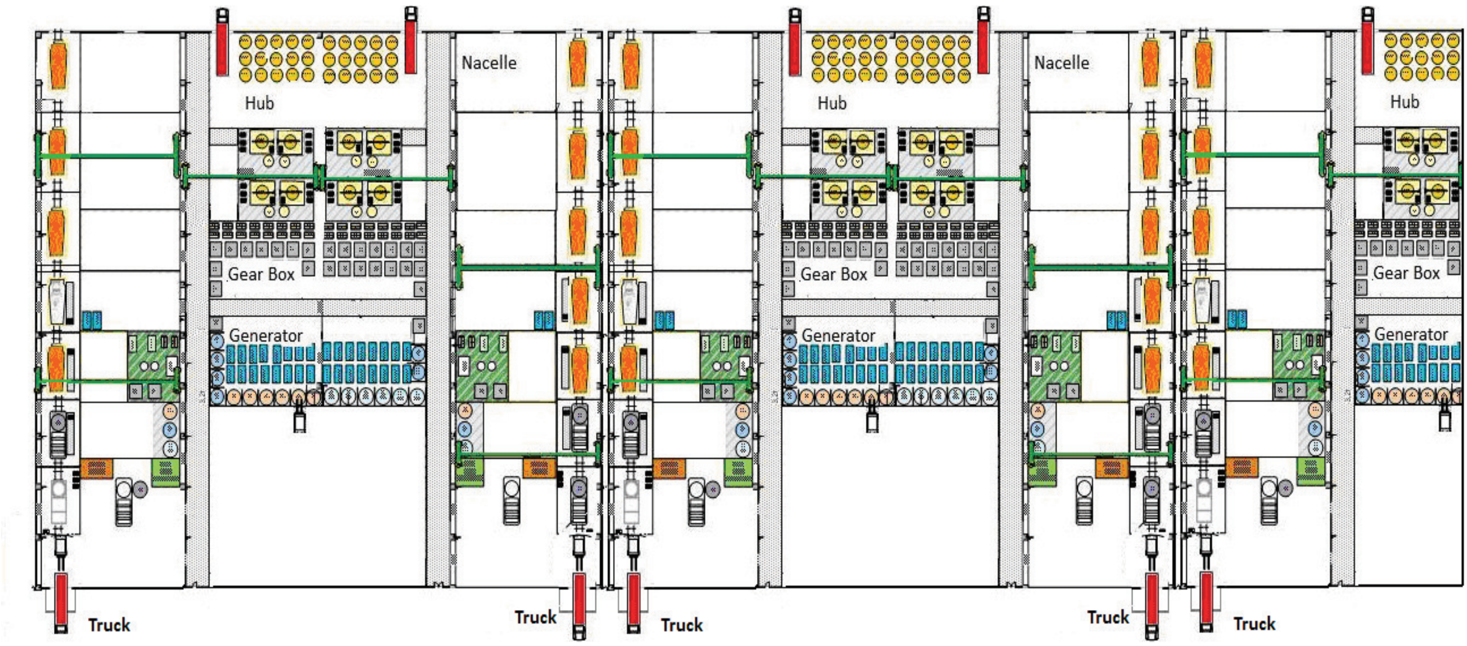


Figure 8.3.20: DanEnergy assembly factory draft

The second factory follow the same layout of this one, but only with 3 mounting lines, will have the same storage inside (organized) and the same outside.

8.4 Capacity conclusion

We made an extend work about capacity. To find the better location for our plants we did a great work of research and we have presented the potential of Poland (with maps and statistics costs), compared with other EU countries, which already have developed wind manufactories in a very high level. Poland is twice cheaper than Germany or France.

The resources like water, electricity, transport, are important in Poland and will offers to us good conditions for working. We also can develop our company in the future as we want because lands are really cheap and there is a lot of choice on the housing market.

Also the capacity strategic plan was really complex, at least 10 times we had to recalculate the numbers of the factory, every time that we change some number all the capacity strategy change.

We leant a lot in this part of capacity. This kind of complex of research in relation to the real life and related to a “real” company makes us to discuss a lot for all the options that we had, so in conclusion this part was one of the most difficult parts of our project and as a consequence we leant a lot.

9. Financial part

9.1 Target Costs

Before we start to analyze the net present value, we want to decide how much the price of our wind turbine should be cost including all other costs, for example installation, service and warranty. For this reason we are going to use a tool called “Target Costing”.

Target costing is a pricing method used by firms. It is defined as "a cost management tool for reducing the overall cost of a product over its entire life-cycle with the help of production, engineering, research and design". A target cost is the maximum amount of cost that can be incurred on a product and with it the firm can still earn the required profit margin from that product at a particular selling price.

Target costing involves setting a target cost by subtracting a desired profit margin from a competitive market price. To compete efficiently in the wind turbine market, we need to know how many margin we want to have and how much the wind turbine should cost, of course we try to be cheaper than our competitors. Usually we need a market research from our marketing department how much our customers would pay for the wind turbines including questions for example, do you need more quality or dependability. In fact of don´t having the numbers we are going to estimate these.

- But what is our target cost?
- And how does target costing work?

To install a 1,5 MW wind turbine, the cost is about 1.687.000 € as you can see in the figure below. We know the building costs without profit for the wind turbine.

The production cost for a 1 MW, 3 MW, 6 MW wind turbine will be shown with this estimation. We put a little more for the 3MW and the 6MW (so it is not totally a linear progression). So our estimation costs will be like this in the financial part:

1 MW = 1000000 €.

Component	Mass kg	Specific Costs €/kg	Costs €
Blades (Glass/Epoxid)	3 x 5.600	14	235.200
Hub, processed	10.000	2,5	25.000
Bearing	3 x 1200	8,0	28.800
Bladeadjustment	1.500	-	45.000
Sundries, fixture, spinner	1.000	5,0	5.000
Rotor, total	32.900	-	339.000
Top of rotorbearing incl. cover	2.500	6,0	13.200
Rotorshaft	7.000	2,5	17.500
Gearbox	16.000	8,0	128.000
Nacelleframe	11.000	2,5	27.500
Nacellecover	3.000	5,0	15.000
Yaw drive incl. bearing	4.500	10,0	45.000
Other (Brakes, coupling, generatorshaft, Hydraulic, Cooling)	2.000	-	20.000
Assembly			15.000
Mech. Drivetrain und Nacelle	46.000	-	281.200
Generator	7.500	35 €/kW	52.500
Inverter, ca. ½ rated power (in the tower)		80 €/kW	60.000
Switchgear and controlgear	1.000	-	7.000
Control system	-		15.000
Transformer, 20 kV (in the tower)	-	18 €/kW	27.000
Electrical system	8.500		161.500
Tower incl. foundation	150.000	1,8	270.000
Cabling (Power cable)	1.000	-	20.000
Other equipment	5.000	-	20.000
Tower, total	156.000	-	310.000
Cost of component	-	-	1.091.700
Generalcosts, 50 % of Componentcosts	-	-	595.300
Sales price, imputed	-	-	**1.687.000**

Table 9.1: Cost of installation for 1,5 MW wind turbine (source: *Erich Hau: Wind turbines*)

	Target Price	1.600.000 €
-	Target Margin (profit)	100.000 €
=	Allowable Costs	1.500.000 €
	Target Costs	**1.550.000 €**
	Allowable Costs	1.500.000 €
	Target Gap	187.000€
	Drifting Costs	1.687.000 €

How much should the product cost?

Depends on market researches

Allowable costs are not always achievable. This number our max cost

Usually production cost

After this calculation we know how much our wind turbine should cost. It is about 1.550.000€. Now we can make the net present value analyze.

	2010	2011	2012	2013	2014	2015
buying	-	1780	4450	6230	6230	7120
Price of 1MW product	-	1 000 000 €	970 000 €	950 000 €	930 000 €	920 000 €
total costs of sales without TVA	-	1 780 000 000 €	4 316 500 000 €	5 918 500 000 €	5 793 900 000 €	6 550 400 000 €
TVA 19%	-	338 200 000 €	820 135 000 €	1 124 515 000 €	1 100 841 000 €	1 244 576 000 €
total costs of sales with TVA	-	2 118 200 000 €	5 136 635 000 €	7 043 015 000 €	6 894 741 000 €	7 794 976 000 €

Figure 9.2: Incomings

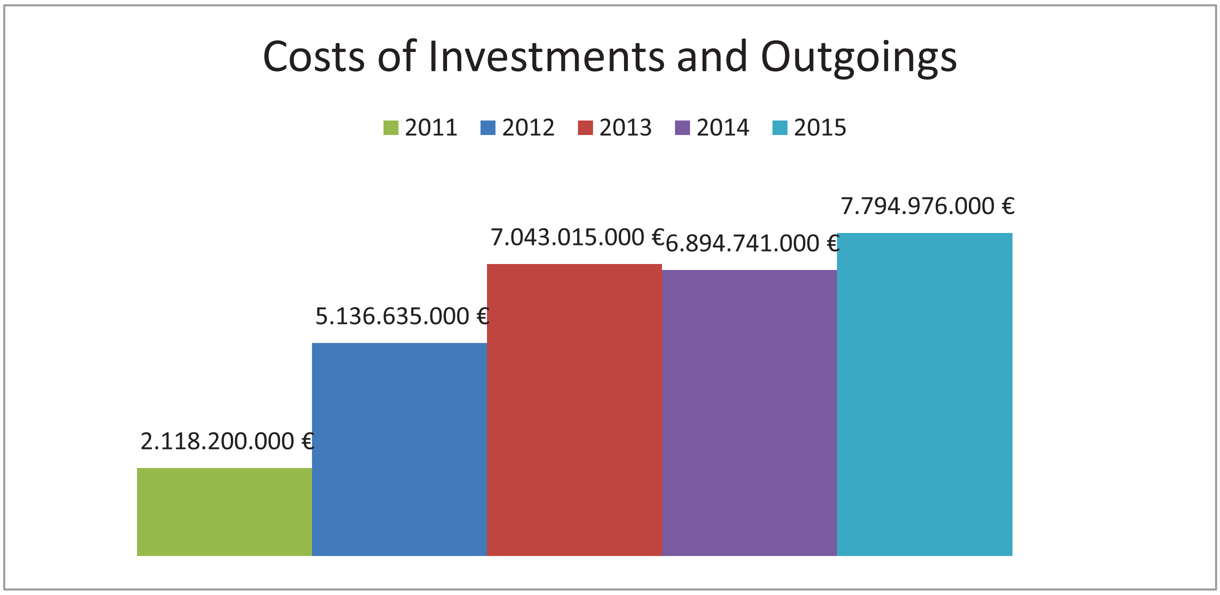


Figure 9.3: Costs of Investments and Outgoings

First of all, we are getting money from our company DanEnergy. The first year, we have to buy a land in Poland and also we have to build the first part of the building (5/8 of the total final size of the building) in 2010. We also need to buy cranes (24 because we need 4 cranes per shift).

Estimated costs for manufactory

lands cost	3 600 000,00 €
Total manufactory building cost	54 000 000,00 €
cranes	84 000 000,00 €
one travel lift (150T)	800 000,00 €
TOTAL	142 400 000,00 €

That is the explication of the building construction estimates with the average price of building manufactory in Poland. (*source: www.paiz.gov.pl*)

superficy (sqm)	60 000
prices per m² (euros)	900,00 €
TOTAL	54 000 000,00 €

number of cranes	24
prices of each crain	3 500 000,00 €
TOTAL	84 000 000,00 €

In fact, we have determined the price of each crane with the second hand website of industrial engines. *(source: www.equipmenttraderonline.com)*

Figure 9.4 : a travel lift for parking nacelle

That is all the cost for our business like electricity which is very expensive and also we are going to buy in 2010 the land. Further we are going to build five mounting lines of the total manufactory and two years later the rest of the building, so we have in total eight mounting lines. In the Appendix III you can see our outgoings each month.

Our production will be like this and we are going to decreasing the prices of wind turbines only in 2015.

9.2 Net present value

Net present value (NPV) or net present worth (NPW) is defined as the total present value (PV) of a time series of cash flows. It is a standard method for using the time value of money to appraise long-term projects. Used for capital budgeting, and widely throughout economics, it measures the excess or shortfall of cash flows, in present value terms, once financing charges are met

First we want to say that we have estimated the costs for our wind turbines by reference to Erich Haus` calculation. Furthermore there are many reasons to think about the calculation again after our strategy begins, because we are going to build another plant for compensation the demand on the market.

We estimated employees for each shifts for each plant:

Mechanican	640
Electrician	136
Fitter	24
Warehouser	80
Administration	64
Maintanance	32
Total	976

We have about 1000 employees and their salaries are about 1500 gross

Each month = 1000 X 1500 € = 1.500.000 €

Each Year = 12 month X 1.500.000 € = 18.000.000 €

	2010	2011	2012	2013	2014	2015
Main labor costs	- €	18 000 000 €	18 000 000 €	25 000 000 €	25 000 000 €	25 000 000 €
Prime costs	- €	2 118 200 000 €	5 136 635 000 €	7 043 015 000 €	6 894 741 000 €	7 794 976 000 €
general costs	92 600 000 €	4 435 200 €	68 900 048 €	5 359 998 €	5 431 398 €	5 431 398 €
turnover		2 095 000 000 €	5 238 000 000 €	7 332 800 000 €	7 332 800 000 €	7 923 750 000 €
net result	- 92 600 000 €	- 45 635 200 €	14 464 952 €	259 425 002 €	407 627 602 €	98 342 602 €
net cumulated result	- 92 600 000 €	- 138 235 200 €	- 123 770 248 €	135 654 754 €	543 282 356 €	641 624 958 €
company funding	150 000 000 €	- €	- €	- €	- €	- €
cash flow	57 400 000 €	11 764 800 €	26 229 752 €	285 654 754 €	693 282 356 €	791 624 958 €
valorization	- 74 080 000 €	- 36 508 160 €	- 27 250 591 €	105 575 010 €	272 539 276 €	304 764 180 €

Table 9.2: Net Present Value

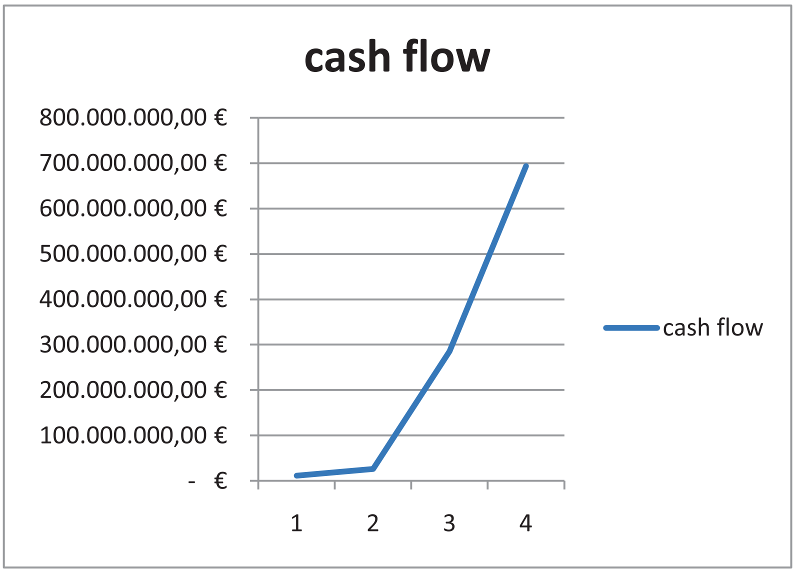


Figure 9.5: Cash Flow

10. Final Conclusion

In conclusion to this project we have build up a new strategy for DanEnergy to find a way to break into this dominated market aggressively. We have tried to make an analyze about the general market and looked for companies who are over many years now in this market how they did. Due looking to other successful companies, how they build up their strategy, we were able to see the lacks to make no mistakes in ours. Many companies have made too late vertical integration of suppliers, even less making joint ventures and now some have bottleneck in purchasing some parts. In using our strategy and following the points we have discussed, sure DanEnergy will have success, but has to manage its business carefully, especially in this tough time caused by the economic crisis.

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12. Appendices

Appendices

2. Appendix II - Calculations of turn over

2011	capacity power (MW)	number of sales	amount	turnover
wind turbine 1MW	199	199	1 100 000 €	218 900 000 €
wind turbine 3MW	633	211	3 500 000 €	738 500 000 €
wind turbine 6MW	948	158	7 200 000 €	1 137 600 000 €
Total	**1780**	**568**		**2 095 000 000 €**

2012	capacity power (MW)	number of sales	amount	turnover
wind turbine 1MW	493	493	1 100 000 €	542 300 000 €
wind turbine 3MW	1581	527	3 500 000 €	1 844 500 000 €
wind turbine 6MW	2376	396	7 200 000 €	2 851 200 000 €
Total	**4450**	**1416**		**5 238 000 000 €**

2013	capacity power (MW)	number of sales	amount	turnover
wind turbine 1MW	695	695	1 100 000 €	764 500 000 €
wind turbine 3MW	2211	737	3 500 000 €	2 579 500 000 €
wind turbine 6MW	3324	554	7 200 000 €	3 988 800 000 €
Total	**6230**	**1986**		**7 332 800 000 €**

2014	capacity power (MW)	number of sales	amount	turnover
wind turbine 1MW	695	695	1 100 000 €	764 500 000 €
wind turbine 3MW	2211	737	3 500 000 €	2 579 500 000 €
wind turbine 6MW	3324	554	7 200 000 €	3 988 800 000 €
Total	**6230**	**1986**		**7 332 800 000 €**

2015	capacity power (MW)	number of sales	amount	turnover
wind turbine 1MW	1015	1015	1 050 000 €	1 065 750 000 €
wind turbine 3MW	2445	815	3 400 000 €	2 771 000 000 €
wind turbine 6MW	3660	610	6 700 000 €	4 087 000 000 €
Total	**7120**	**2440**		**7 923 750 000 €**

3. Appendix III - Outgoings

Information	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
water and electricity	-	3 600 000 €	3 600 000 €	3 600 000 €	3 600 000 €	3 600 000 €
provision of maintenance	-	50 000 €	50 000 €	50 000 €	50 000 €	50 000 €
office supplies	-	5 000 €	5 000 €	10 000 €	10 000 €	10 000 €
postage	-	2 000 €	4 000 €	4 000 €	4 000 €	4 000 €
maintenance of premises	-	300 000 €	300 000 €	300 000 €	300 000 €	300 000 €
insurances	-	180 000 €	180 000 €	180 000 €	180 000 €	180 000 €
telephone & internet	-	7 200 €	7 200 €	7 200 €	7 200 €	7 200 €
rental car	-	180 000 €	200 000 €	200 000 €	200 000 €	200 000 €
Honorary Accountant	-	6 000 €	18 000 €	18 000 €	18 000 €	18 000 €
Advertising and Exhibition	-	50 000 €	50 000 €	50 000 €	50 000 €	50 000 €
displacement	-	30 000 €	60 000 €	60 000 €	120 000 €	120 000 €
buying lands	3 600 000 €	-	-	-	-	-
buying manufactory	89 000 000 €	-	53 400 000 €	-	-	-
Banking	-	25 000 €	25 000 €	25 000 €	25 000 €	25 000 €
Total Other purchases	-	4 435 200 €	57 899 200 €	4 504 200 €	4 564 200 €	4 564 200 €
T.V.A (19%)	-		11 000 848 €	855 798 €	867 198 €	867 198 €
Total external charges (TVA)	**92 600 000 €**	**4 435 200 €**	**68 900 048 €**	**5 359 998 €**	**5 431 398 €**	**5 431 398 €**

4. Appendix III - Responsibility Matrix and Gantt chart

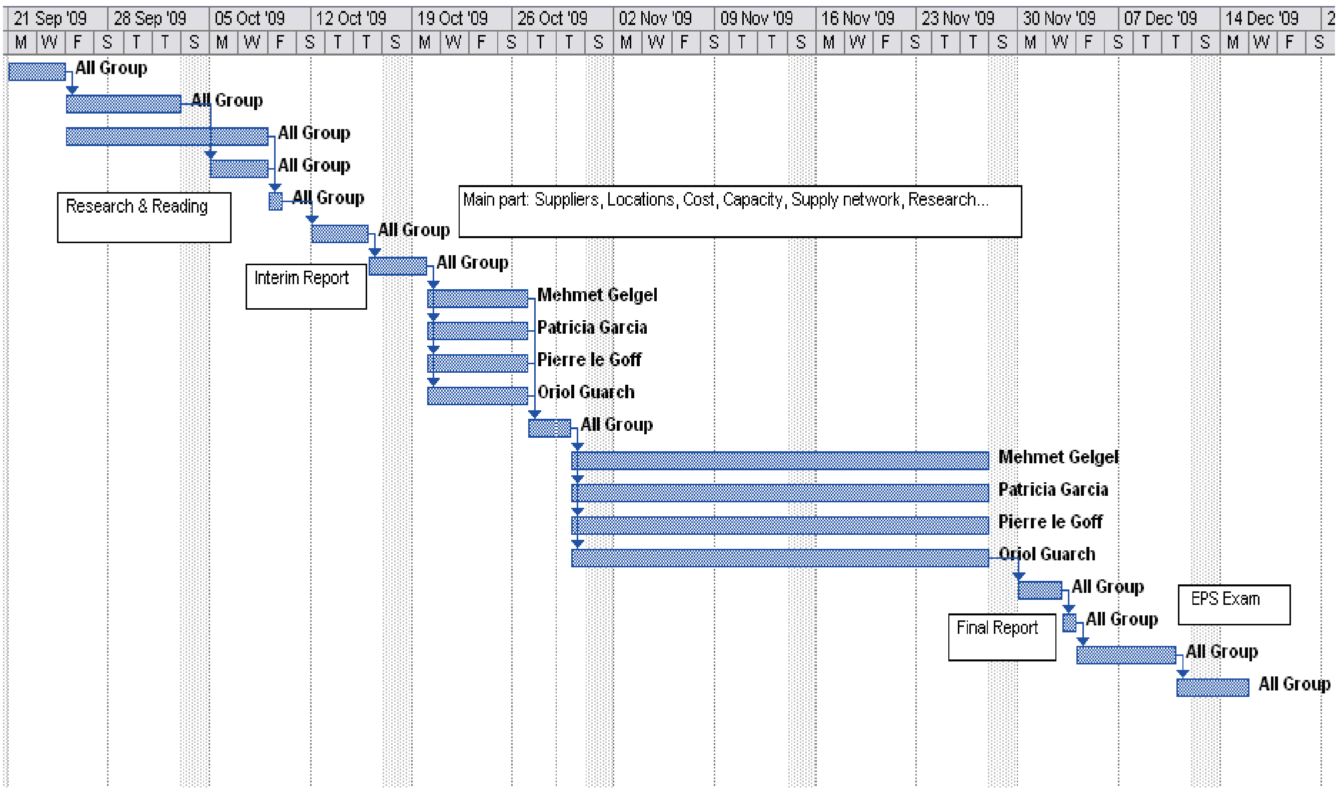
<u>Responsibility Matrix</u>

OBS / WBS	Mehmet Gelget	Patricia Garcia	Pierre Le Goff	Oriol Guarch	Comments
Follow operations strategy matrix	R	R	R	R	Help with the book
Best location		R		S	Good place for after transportation by ship
suppliers	R				Find on internet
Proximity from our suppliers	S		R		Getting information and professional friendship
Economics relationships	R		S		Getting some information in internet
Development manufacturing strategy	R	R	R	R	Help with the book

capacity			R		Determine which capacity for each wind turbine (1, 3, 6 MW)
Suppliers networks			R	S	Define our suppliers precisely
Cots all production		S		R	Information on internet
Reduce suppliers for having better costs	S	R			Just a few suppliers for our project
Ours factories		S		R	Choose technology: materials...

Gantt Chart

ID		Task Name	Duration	Start	Finish
1		Prepare Presentation	4 days	Mon 21/09/09	Thu 24/09/09
2		Develop Operacional Strategy Matrix	6 days	Fri 25/09/09	Fri 02/10/09
3		Read Book Operations Strategy	10 days	Fri 25/09/09	Thu 08/10/09
4		Prepare Interim Report	4 days	Mon 05/10/09	Thu 08/10/09
5		Deliver Report	1 day	Fri 09/10/09	Fri 09/10/09
6		Follow Operational Strategic Matrix	4 days	Mon 12/10/09	Thu 15/10/09
7		Interim Report	2 days	Fri 16/10/09	Mon 19/10/09
8		Suppliers & Cost	5 days	Tue 20/10/09	Mon 26/10/09
9		Location & Cost	5 days	Tue 20/10/09	Mon 26/10/09
10		Suppliers, Capacity & Suppliers Netw	5 days	Tue 20/10/09	Mon 26/10/09
11		Suppliers Network & Cost	5 days	Tue 20/10/09	Mon 26/10/09
12		Project Review 2	3 days	Tue 27/10/09	Thu 29/10/09
13		Suppliers & Cost	21 days	Fri 30/10/09	Fri 27/11/09
14		Location & Cost	21 days	Fri 30/10/09	Fri 27/11/09
15		Suppliers, Capacity & Suppliers Netw	21 days	Fri 30/10/09	Fri 27/11/09
16		Suppliers Network & Cost	21 days	Fri 30/10/09	Fri 27/11/09
17		Prepare Final Report	3 days	Mon 30/11/09	Wed 02/12/09
18		Deliver final report	1 day	Thu 03/12/09	Thu 03/12/09
19		Exam Preparation	5 days	Fri 04/12/09	Thu 10/12/09
20		Final Exam	3 days	Fri 11/12/09	Tue 15/12/09



W-1000/S I

1000 KW Wind Turbine

Robust design for reliable

A breath of fresh air

DAN ENERGY

Wind energy

W-1000/S Wind Turbine

Robust design for reliable performance.

- Sturdy electro-mechanical construction = **Longer operating life.**
- Adaptability to project site and competitive pricing = **Lower cost per kWh.**
- Pole-changing generator = **Optimized cut-in speed.**
- Remote control system = **Increased efficiency and control.**
- Germanischer Lloyd certified = **High standard achievement.**

General information

- The W 1000/S wind turbine is a stall controlled three-bladed, horizontal axis wind turbine which was particularly developed for an efficient utilization of wind energy on complex terrain.

- The W 1000/S wind turbine features a robust gearbox construction with integrated main shaft and main bearing allowing more reliability.

- This stall turbine is specifically suited for wind farms with difficult weather conditions and requiring a robust design.

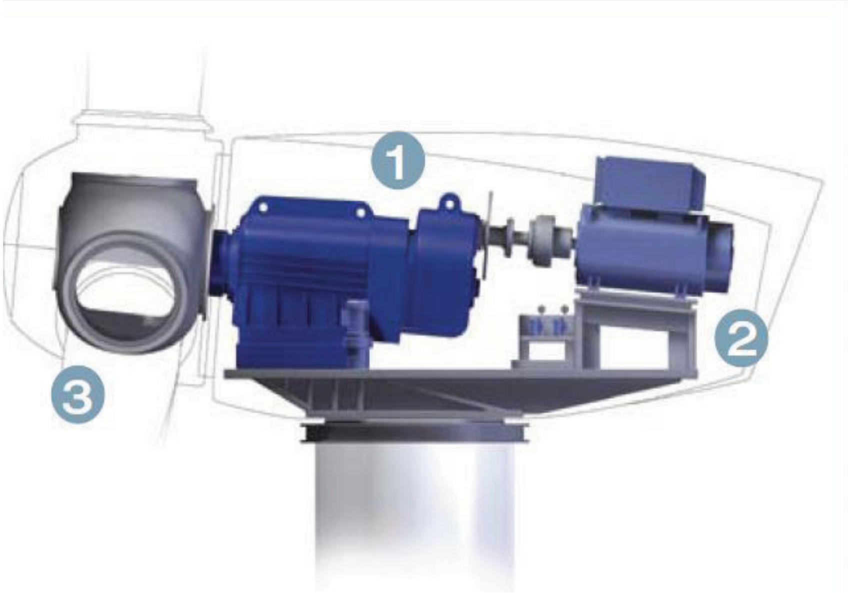
Technical description*

Rotor	
Diameter, m	54
Swept area, m^2	2290
Rotational speed, rpm	15 / 22
Wind class	II
Number of rotor blades	3
Power regulation	Stall
Brake System	
Primary braking system	Blade tip feathering
Service / Emergency brake	Disk brake
Tower	
Hub Height, m	70, 82
Generator	
Type of generator	Asynchronous / 2 stages
Rated power, kW	200 / 1000
Rated voltage, V	690
Frequency, Hz	50 or 60
Rated power Output, kVA	230 / 1087
Power factor (cos ø)	0.97
Gearbox	
Type of gearbox	Planetary & Helical
Control System	
Type of construction	Micro Controller
Yaw System	
Type of bearing	4-Point contact bearing
Type of drive	Gear motor
Number of drive units	2

*All specifications subject to change without notice. Please contact Dan Energy for complete and latest technical specification.

W-1000/S: A Powerful Wind Turbine!

Wind Turbine mechanical scheme



1

Durable gearbox with integrated main shaft for more operational safety

2

Powerful pole-changing generator with water cooling system

3

Slotted hub for precise and simple blade adjustment ensures optimal output

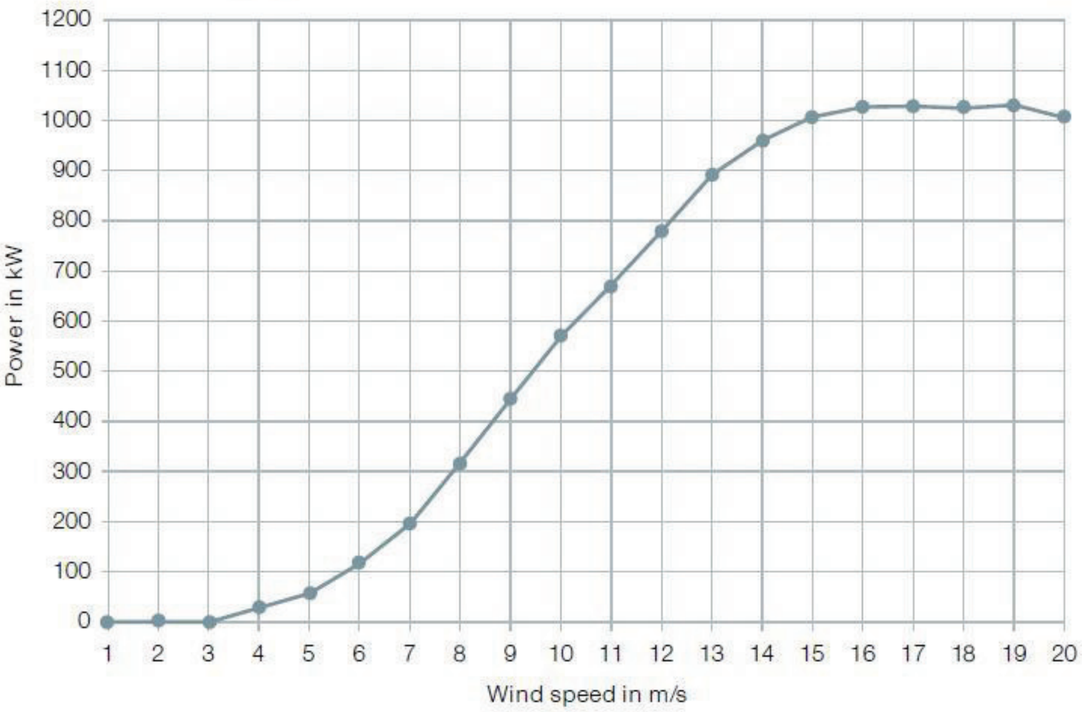
V[m/s]	W-1000/S
1	0
2	0
3	0
4	24
5	64
6	111
7	197
8	314
9	454
10	582
11	686
12	783
13	891
14	966
15	1010
16	1037
17*	1030
18*	1035
19*	1032
20*	1009
Cut-in	3.0 m/s
Cut-out	20.0 m/s

* interpolated

Power curve W-1000/S

Rotor: 54 m

Air-density : 1,225 kg/m^3



Mesured power curve. All data according to our best knowledge and subject to change.

W-3000/S

3000 KW Wind Turbine

Robust design for reliable

A breath of fresh air

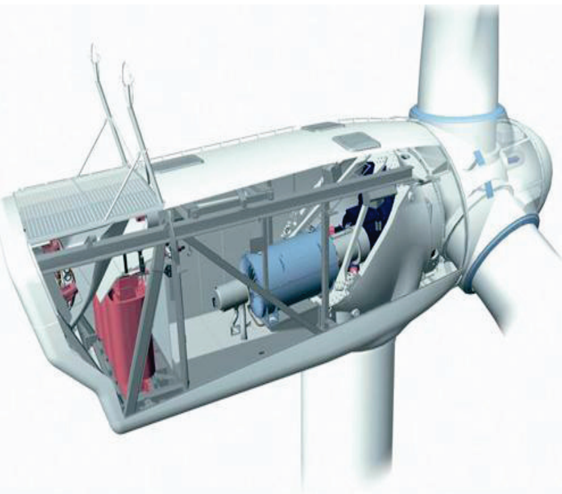
DAN ENERGY

Wind energy

W-3000/S Wind Turbine

Robust design for reliable performance.

- Sturdy electro-mechanical construction = **Longer operating life.**
- Adaptability to project site and competitive pricing = **Lower cost per kWh.**
- Pole-changing generator = **Optimized cut-in speed.**
- Remote control system = **Increased efficiency and control.**
- Germanischer Lloyd certified = **High standard achievement.**



General information

- The W 3000/S wind turbine is a stall controlled three-bladed, horizontal axis wind turbine which was particularly developed for an efficient utilization of wind energy on complex terrain.
- The W 3000/S wind turbine features a robust gearbox construction with integrated main shaft and main bearing allowing more reliability.
- This stall turbine is specifically suited for wind farms with difficult weather conditions and requiring a robust design.

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Wind energy

Power regulation	pitch regulated with variable speed

Operating data

Rated power	3,000 kW
Cut-in wind speed	3.5 m/s
Rated wind speed	15 m/s
Cut-out wind speed	25 m/s
Wind Class - IEC	IEC IA (high wind) and IEC IIA (medium wind)
Operating temperature range	standard range -20°C to 40°C. low temperature option: -30°C to 40°C

Sound power
(10 m above ground, hub height 80 m, standard air density 1,225 kg/m³)

4 m/s	97.9 dB(A)
5 m/s	100.9 dB(A)
6 m/s	104.2 dB(A)
7 m/s	106.1 dB(A)
8 m/s	107 dB(A)
9 m/s	106.9 dB(A)

Rotor

Rotor diameter	90 m
Swept area	6,362 m²
Nominal revolutions	16.1 rpm
Operational interval	8.6 - 18.4 rpm
Air brake	full blade feathering with three pitch cylinders

Tower

Type	tubular steel tower
Hub heights	80 m and 90 m (IEC IA) 105 m (IEC IIA)

Electrical

Frequency	50 Hz
Generator type	4-pole asynchronous with variable speed

Gearbox

Type	two planetary stages and one helical stage

Main dimensions

Blade

Length	44 m
Max. chord	3.5 m
Weight	6,700 kg

Nacelle

Height for transport	4 m
Length	9.65 m
Width	3.65 m (3.85 m installed
Weight	70 metric tonnes

Hub incl. nose cone

Diameter	3.6 m
Max. width	4.2 m
Length	4.4 m
Weight	22 metric tonnes

Tower

80 m

Weight	145 metric tonnes

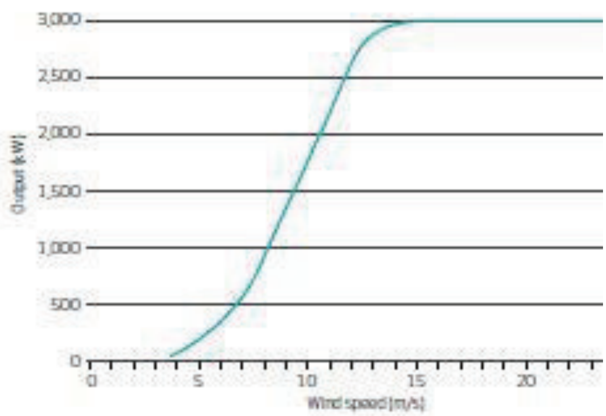
90 m

Weight	205 metric tonnes

105 m

Weight	255 metric tonnes
Offshore	site specific towers

Power curve 3.0 MW
Noise reduced sound power modes are available.



W-6000/S I

6000 KW Wind Turbine

Robust design for reliable

A breath of fresh air

DAN ENERGY

Wind energy

W-6000/S Wind Turbine

Robust design for reliable performance.

- Sturdy electro-mechanical construction = **Longer operating life.**
- Adaptability to project site and competitive pricing = **Lower cost per kWh.**
- Pole-changing generator = **Optimized cut-in speed.**
- Remote control system = **Increased efficiency and control.**
- Germanischer Lloyd certified = **High standard achievement.**

The 5-megawatt power plant
with 126 metre rotor diameter

General information

- The W 6000/S wind turbine is a stall controlled three-bladed, horizontal axis wind turbine which was particularly developed for an efficient utilization of wind energy on complex terrain.
- The W 6000/S wind turbine features a robust gearbox construction with integrated main shaft and main bearing allowing more reliability.
- This stall turbine is specifically suited for wind farms with difficult weather conditions and requiring a robust design.

DAN ENERGY

Wind energy

Proven technology in a new dimension

The W-6000/S takes our internationally renowned technology to a new dimension.. With a rated power of 6 megawatt and a rotor diameter of 126 meters, the W-6000/S is one of the largest and most powerful wind turbines in the world. The W-6000/S sets new standards for the economic viability of wind farms, especially in offshore installations. Wind farms with turbines of this size achieve outputs similar to conventional power plants. This in turn puts high demands on the control and regulation system because optimized integration into the power grid is essential. The W-6000/S can be easily integrated into the grid, just like any other power plant of its size.

Due to its modular structure and logistical flexibility, the W-6000/S is suitable for onshore and offshore installation. The offshore version is specifically designed to withstand extreme environmental conditions. This includes, for example, redundancy of key components to guarantee maximum availability, effective protection against corrosion and a permanent monitoring system.

Powerful, economical, reliable

By choosing Dan Energy turbines, you are selecting power plant technology of the highest quality. To ensure that your investment retains its value, we offer comprehensive after-sales service.

Our permanent system monitors your power plants 24 hours a day, 365 days a year ensuring the quickest possible response times of our local service teams. We also offer integrated service packages (ISP-onshore and OSP-offshore) that allow you to calculate your long-term operating costs.

We are constantly upgrading our services to meet the increasingly stringent requirements of monitoring, documenting and optimizing the operational behavior of wind farms. We offer a comprehensive modular wind farm management system that can be flexibly configured to suit local factors, ensuring efficient operation of your plant at all times. For more information, please refer to our brochures or contact our sales team.

Technical description

Rotor

Diameter, m	126.0m
Swept area, m²	12,469m2
Rotational speed, rpm	6.9 /12.1 (+15.0 %)
Wind class	I
Number of rotor blades	3
Power regulation	stall

Brake System

Type externally geared four-point bearing

Drive system Gear motors with multi-disc brakes

Stabilization Disc brake with hydraulically operated brake shoes

Tower

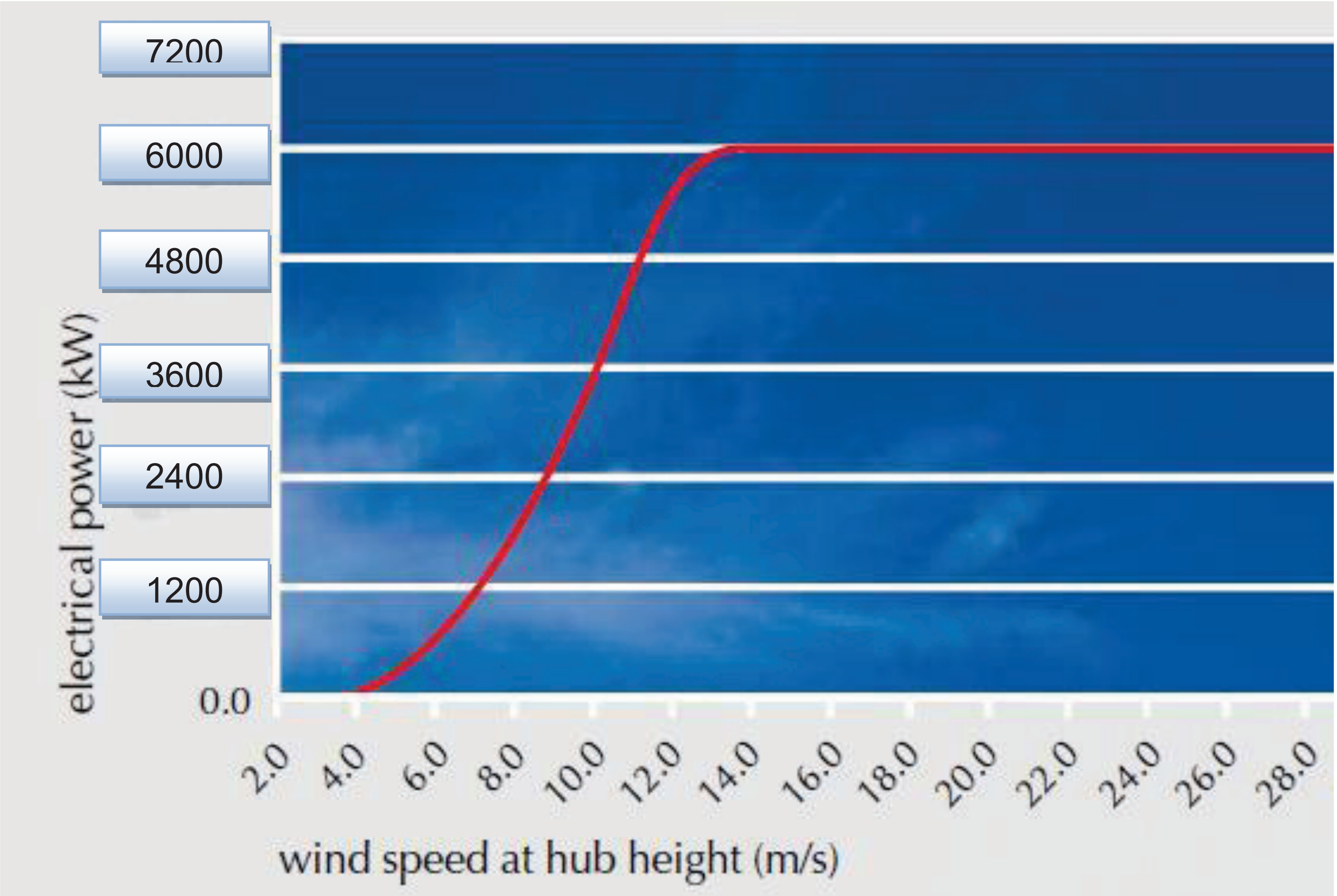
Hub height, m	117, onshore, 85– 95m offshore (depending on site conditions)

Generator

Type of generator	two helical planetary stage and one spur gear stage double-fed asynchronous generator, 6-pole
Rated power, Kw	800/6000
Rated rotor voltage, V	660
Rated stator voltage,V	950
Rated speed, rpm	670 –1,170 (+15.0 %)
Power factor (cos α)	0.97
Generator protection class	IP 54

Gear Box

Type of gearbox	Planetary & Helical


7200
6000
4800
3600
2400
1200
0.0
electrical power (kW)
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
wind speed at hub height (m/s)