VIA UNIVERSITY COLLEGE

GREEN MOBILITY

Mechanical Engineering &
Global Business Engineering

Federico Sassi 164198
Laura Brevini 164117
Laura Rondanini 164196
Nikolaos Felessakis 163537
Tobias Meyer 164175

Supervisor: Poul Sørensen, Jens Eybye

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The Global Business Engineering Programme
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Tobias Meyer 164175

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1. Chapter

1.1. Introduction

1.1.1. Problem description

In these modern times mobility became one of the most important aspects in the people's daily life. It not only became more important on big scale like travelling long distances to work, mobility always was and still is an important issue of small local city life. Therefore a good infrastructure for public transportation becomes inevitable. The main problem which is going hand in hand with a dense public transportation system is the danger of inefficiency. Frequently, big busses are driving through cities with only a hand full of passengers. After the busses are consuming big amounts of gasoline, which is made from fossil fuel, the environmental impact of a dense public transportation system is not a matter to be underestimated. Nowadays, the problem of unnecessary and inefficient fuel consumption stepped into public focus, not at least due to the global warming and the shrinking amount of fossil fuel. Therefore, the project team set the goal to develop a system, which provides green and individual mobility to people.

1.1.2. Purpose and goals

The purpose of the project was to solve the mobility problem in the city and around it. Therefore, in this project renting stations with electric bicycles, recharged by eco-energy, shall be introduced in the market. The business mission was to provide a quality product to people who are sensitive to the environmental problems. The product minimizes the impact on the environment and saves money thanks to renewable energy sources.

In this project, the intention was to launch a new mobility concept. The goal is to introduce an innovative transportation system in the people's daily life.

Key principles:

- The business shall respect the environment
- Provide a good value to the customer (quality/price)
- Reduce the traffic jam

1.1.3. The Project (Federico, Laura B., Laura R.)

The project is divided in eight chapters.

The first one is about the general description of Denmark: Political Factors, Environmental Factors, Economical Factors, Social Factors and Technological Factors. These studies were done with the PEEST Analysis.

The second chapter is about the analysis of generic concept about the renting station and the renewable energies. These two parts are important to study the final product and the part of its components.

In fact, in the third chapter the market research was inserted in order to choose all the components, which are necessary for the station and their prices. In the same chapter the places in Horsens are selected where will be placed the renting points.

The fourth chapter is about the possible stakeholders and competitors who will be found on the market in which the project's team wants to enter. Last but not least, the SWOT analysis was made to know the strength and weakness of the project.

The fifth chapter regard the design of the product, in detail the design of canopy and charging column as well as all their components. All these parts are fundamental to decide the strategy to use on the market.

In chapter six the strategy analysis, the channel distribution and the advertising are included.

The seventh chapter is about the security, which can not be underestimated for its importance.

At the end, in the eighth chapter, done two different business plans were done.

Despite the report was divided in several subchapters. All the different subchapters and their contents are connected with each other. This is visualized in the following pages:

Adjacency matrix: in the columns and in the lines there are the parts of the project. The link is represented by a "X"

Chart: This part explains better how the project has developed during planning and execution. Therefore, the flow of information has been visualized.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		X											X	X											
2								X	X					X											
3													X	X											
4					X									X											
5						X	X							X			X								
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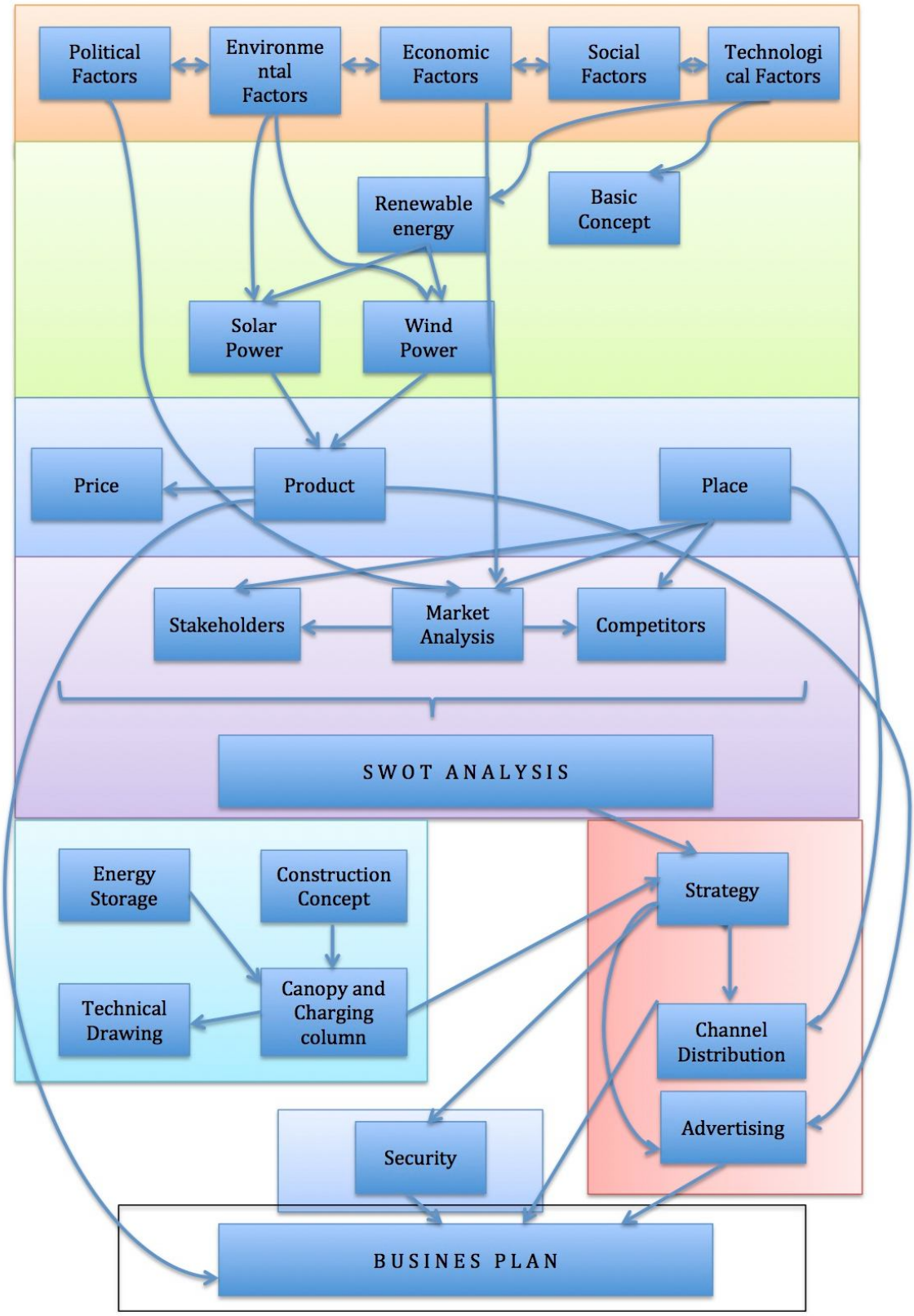
23																									X
24																									X
25																									

Table 1: Adjacency Matrix

1: Political Factors	14: Stakeholders
2: Environmental Factors	15: Competitors
3: Economic Factors	16: SWOT
4: Social Factors	17: Energy storage
5: Technological Factors	18: Construction concepts
6: Basic Concepts	19: Canopy and charging column
7: Renewable energies	20: Technical drawings
8: Solar power	21: Strategy
9: Wind power	22: Channel distribution
10: Products	23: Advertising
11: Price	24: Security
12: Place	25: Business plan
13: Market analysis	


Political Factors
Environmental Factors
Economic Factors
Social Factors
Technological Factors
Renewable energy
Basic Concept
Solar Power
Wind Power
Price
Product
Place
Stakeholders
Market Analysis
Competitors
SWOT ANALYSIS
Energy Storage
Construction Concept
Technical Drawing
Canopy and Charging column
Strategy
Channel Distribution
Advertising
Security
BUSINES PLAN

1.1.4. Team

The project team consists out of five exchange students from three different countries. The business part of the project was handled by three students from Italy who are enlisted as Global Business Engineers at the VIA University College. In particular, these students are Federico Sassi, Laura Brevini and Laura Rondanini. They where responsible for all business related issues like for example market research and cost analysis. The Web-Site was created by Federico Sassi and he was responsible for it. The mechanical part of the project was done by an exchange student from Greece who is enlisted as a Mechanical Engineer and another exchange student from Germany who is enlisted as Global Business Engineer. In particular these students are Nikolaos Felessakis from Greece and Tobias Meyer from Germany. They were responsible for technical research and construction. The final assembly including layout was done by Tobias Meyer. This multicultural team worked close together on this semester project. The persons were involved with the following ECTS points:

Federico Sassi (GBE):	15 ECTS
Laura Brevini (GBE):	15 ECTS
Laura Rondanini (GBE):	15 ECTS
Nikolaos Felessakis (ME):	15 ECTS
Tobias Meyer (GBE):	14 ECTS

2. Chapter

2.1. PEEST ANALYSIS

2.1.1. Introduction

PEEST analysis was stands for "Political, Economic, Environmental, Social and Technological analysis" and describes macro analysis. The research was focused in Denmark because it was decided to offer the product in this country and in particular in Horsens. The team investigated that these information are the most important to know for propose a new product in a new country.

2.1.2. Political factors (Laura B)

Denmark has been a strong supporter of renewable since the early days, seen as the initial trailblazer of the wind power industry and always willing to look at alternative sources of energy.

The basis of environmental policy in Denmark is to ensure that people, nature and environmental interests of Denmark and other countries are protected against pollution, and that development is conducted on a sustainable basis. The responsibility of enforcement and administration of environmental law lies with several authorities. The Danish Ministry of Environment is the superior authority administering environmental policy in Denmark and is responsible for the drafting of environmental law. The Danish Ministry of Environment has two agencies under its administration. The agency is also responsible for carrying out national climate adjustment strategies. A number of institutions are affiliated with the Energy Agency, including the Danish Energy Savings Trust, the Energy Technology Development and Demonstration Programme (EUDP) and the Danish Portal for Adaptation to Climate Change. Members of the Energy Agency administration also sit on the secretariat of the Danish Commission on Climate Change Policy[1]. The Environmental Protection Act is based on a principle of decentralisation, so actions should be taken and problems be handled as close to the people as possible.

[1] http://www.vanderbilt.edu/econ/candidates/papers/plr/ereh06.pdf

For this reason, it is the municipalities that administer and enforce most of the legislation, which is issued centrally. The courts of Denmark are, to a certain degree, involved in enforcing environmental law – both in criminal and civil cases. A broad variety of non-governmental organisations (especially "green" organisations) have an important role to play in ensuring the protection of the environment administers a large number of laws and regulations. The central law is the Environmental Protection Act, which lays down the fundamental objectives, the means with which to meet these objectives, and the administrative principles by which the Agency works. The Act is a framework Act and the framework of the Act is therefore to be supplemented with guidelines and regulations issued by the Ministry of Environment and the Danish Environmental Protection Agency under the authority of the Act. The Agency also administers a number of other laws such as the Chemical Substances and Products Act and the Contaminated Soil Act. The Nature Agency is the other important agency ensuring the protection of the Danish nature and the environment. This Agency manages the protection of waters and landscapes, aiming at ensuring biodiversity of animals and plants and clean water. Another important task of the agency is the planning of cities and landscapes. The Agency administers the Nature Protection Act, the Planning Act and other legislations on environmental aspects, e.g. environmental aspects of agricultural production, which is central to the Danish environmental protection as Denmark has a very extensive livestock production. Denmark also has a Ministry of Climate and Energy. This ministry is, among other things, responsible for national and international efforts to prevent climate change, primarily focusing on promoting and developing technologies of renewable energy. The Danish Energy Agency that is an agency under the Ministry of Climate and Energy administers the responsibilities in relation to the production, supply, transport and consumption of energy, including energy efficiency and savings efforts, as well as domestic CO2 targets and efforts to reduce greenhouse gas emissions. The agency is also responsible for carrying out national climate adjustment strategies. A number of institutions are affiliated with the Energy Agency, including the Danish Energy Savings Trust, the Energy Technology Development and Demonstration Programme (EUDP) and the Danish Portal for Adaptation to Climate Change[2]. Members of the Energy Agency administration also sit on the secretariat of the Danish Commission on Climate Change Policy. The Environmental Protection Act is based on a

[2] http://www.state.gov/r/pa/ei/bgn/3167.htm

principle of decentralization, so actions should be taken and problems be handled as close to the people as possible. For this reason, it is the municipalities that administer and enforce most of the legislation, which is issued centrally. The courts of Denmark are, to a certain degree, involved in enforcing environmental law – both in criminal and civil cases. A broad variety of non-governmental organizations (especially "green" organizations) have an important role to play in ensuring the protection of the environment[3].

Denmark, in recent years, offers a fair amount of support for the renewable industry[4]:

- A tax on the use of fossil fuels;
- A tendering procedure is being used for the two new large offshore wind installations mentioned. Operators will receive a spot price and initially a settling price in addition;
- A spot price, an environmental premium (€13/MWh) and an additional compensation for balancing costs (€3/MWh) for 20 years are available for new onshore wind farms;
- Fixed feed-in tariffs exist for solid biomass and biogas under certain conditions, and subsidies are available for CHP plants based on natural gas and waste (biomass, being CO2 neutral, is exempt from CO2 duty).

Solar heating plants are exempt from both energy and CO2 taxes. The Executive Order Solar heating obligations in new buildings outside the district heating areas which was adopted in 2001 – but has not yet come into force – will require the introduction of solar heating from owners of new buildings (excluding the domestic sector). Solar thermal installations are eligible for subsidies; Tax for landfill usage of €50 per tone and waste incineration is taxed at €44 per tone.

[3] http://www.nationsencyclopedia.com/Europe/Denmark-POLITICAL-PARTIES.html#b
[4] http://www.ens.dk/da-dk/klimaogco2/co2kvoter/documents/danish%20energy%20authority

2.1.3. Economic factors (Laura B)

Denmark is characterized for mixed economy features above average European living standards and high amount of free trade. Denmark ranks 16th in the world in terms of GDP (Gross domestic product) at PPP (Purchasing power parity) per capita and ranks 5th in nominal GDP per capita[5].

According to World Bank Group, Denmark has the most flexible labour market in Europe. Denmark has a labour force of about 2.9 million. Denmark has the fourth highest ratio of tertiary degree holders in the world. GDP per hour worked was the 13th highest in 2009. Denmark has the world's lowest level of income inequality, according to the UN, and the world's highest minimum wage, according to the IMF. As of June 2010 the unemployment rate is at 6.6%, which is below the EU average of 9.6%[6].

Denmark is one of the most competitive economies in the world. Denmark has the most free financial markets and also one of the most free product markets.

Denmark has a company tax rate of 25% and a special time limited tax regime for expatriates. The Danish taxation system is broad based, with a 25% VAT, in addition to excise taxes, income taxes and other fees.

Denmark is known for the Danish cooperative movement within among others farming, the food industry (Danish Crown), dairy production (Arla Foods), retailing (Brugsen), wind turbine cooperatives and co-housing associations.

Denmark has the 9th highest export per capita in the world. Main exports include: machinery, animals and foodstuffs, chemicals and oil and gas. Denmark is a net exporter of food and energy.

Denmark has ranked as the world's 11th most free economy, of 162 countries, in an index created by the Wall Street Journal and Heritage Foundation, the Index of Economic Freedom 2008[7]. The Index has been categorized as using inappropriately weighted indicators for economic freedom, leading to wealthy and/or conservative countries with barriers to trade placing high on the list, while poor and/or socialist countries with fewer restrictions on trade place low.

[5] http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx
[6] http://en.wikipedia.org/wiki/International_Monetary_Fund
[7] http://www.traveldocs.com/dk/economy.htm

2.1.3.1. Energy in Denmark

Denmark has considerable sources of oil and natural gas in the North Sea and ranks as number 32 in the world among net exporters of crude oil. Most electricity is produced from coal, but Denmark also has a share of wind power. Wind turbines produce 16–19% of electricity demand. Denmark is connected by transmission lines to other European countries.

Denmark is a long time leader in wind energy, and as of May 2011 Denmark derives 3.1 percent of its Gross Domestic Product from renewable (Clean) energy technology and energy efficiency, or around €6.5 billion[8].

2.1.3.2. Transport in Denmark

Significant investment has been made in building road and rail links between regions in Denmark. Private vehicles are increasingly used as a means of transport. Because of the high registration tax (180%), VAT (25%), and the world's highest income tax rate, new cars are very expensive. The purpose of the tax is to discourage car ownership. The car fleet has increased by 45% over the last 30 years. In 2007 an attempt was made by the government to favour environmentally-friendly cars by slightly reducing taxes on high mileage vehicles. However, this has had little effect, and in 2008 Denmark experienced an increase in the import of fuel inefficient old cars (mostly older than 10 years), primarily from Germany, as the cost for older cars—including taxes—keeps them within the budget of many Danes[9].

Bicycling in Denmark is a common form of transportation, particularly for the young and for city dwellers. With a network of bicycle routes extending more than 12,000 km and an estimated 7,000 km of segregated dedicated bicycle paths and lanes, Denmark has a solid bicycle infrastructure.

Denmark has integrated fluctuating and unpredictable energy sources such as wind power into the grid. Denmark now aims to focus on intelligent battery systems (V2G) and plug-in vehicles in the transport sector.

[8] http://www.cepos.dk
[9] http://www.visitdenmark.com

2.1.4. Environmental Factor (Laura R.)

Denmark has historically taken a progressive stance on environmental preservation. In 1971 established a Ministry of Environment and was the first country in the world to implement an environmental law in 1973. This Denmark's most basic environmental legislation is called Environmental Protection Act, which entrusts the Ministry of the Environment, in conjunction with local authorities, with antipollution responsibilities. The basic principle is that the polluter must pay the cost of adapting facilities to environmental requirements. The specifications relating to this law are analysed in the "political factors" part.

The Danish Government has signed different international agreements to improve environmental degradation and global warming, which are: Antarctic Treaty; Kyoto Protocol about climate change; Endangered Species Act which was designed to protect critically imperilled species from extinction. These agreements have helped in the reduction in CO_2 emissions by Denmark. In fact, the environmental problems include air pollution, especially from automobile emissions; excessive noise, notably in the major cities; and the pollution of rivers, lakes, and open sea by raw sewage. In the early 1990s Denmark ranked among 50 nations with the heaviest industrial carbon dioxide emissions. In 1996, emissions totalled 56.5 million metric tons per year[10].

Denmark was ranked as the 10th best country in the world for "Living Green" by a 2007 Readers Digest survey, and the capital Copenhagen is recognised as one of the most environmentally friendly cities in the world. Much of the city's success can be attributed to a strong municipal policy combined with a sound national policy; in fact, in 2006 Copenhagen Municipality received the European Environmental Management Award. Recently many of Denmark's smaller Municipalities, like as Lolland and Bornholm have also become environmental leaders. Denmark is home to five of the world's ten largest central solar heating plants (CSHP).

In February 2008, the Danish government entered a broad energy agreement with most of the parliamentary parties. The agreement lays down Denmark's energy policy for 2008-2011, which meets or surpasses EU environmental goals in several areas.

[10] http://www.nationsencyclopedia.com/Europe/Denmark-ENVIRONMENT.html#b

The new energy policy also makes Denmark the first country in the world to commit itself to reducing overall energy consumption - the target is a 2% reduction by 2011 in relation to 2006. By 2011 it is further expected that renewable energy will provide 20% of the country's total energy needs[11].

In March 2008, the Danish Government published its "Climate Adaptation Strategy". The Strategy systematically reviews the climate challenges we are facing. The Strategy contains a systematic review, sector by sector, of the climate challenges we are facing. Examples of the adaptation initiatives, which have already been implemented, are used as a springboard for an analysis of future options.

2.1.4.1. Weather and climate

The Danish climate and weather are determined by the country's position on the edge of the continent of Europe close to large sea areas and in the zone of prevailing westerlies.

Denmark's weather is quite mild and the climate is temperate, thanks to west winds and to the seas surrounding. The winters are not particularly cold, but they are overcast. The summers are rarely hot, but they are temperate with sunny days.

Denmark doesn't have a lot of fluctuation between day and night temperatures, but wind gusts and changes in wind direction can quickly change the weather and temperatures. The wind is stronger in winter. Series of low pressure systems (cyclones) moving north-eastwards, often forming over Newfoundland, are the basis of the characteristically changeable weather: within a few days the weather changes typically from steady precipitation preceding a warm front to brighter or slightly misty weather, possibly still with a little drizzle in the following warmer mass of air. Finally, the passage of the cold front will produce precipitation in the form of heavy showers followed by clear weather with few clouds.

Denmark has an average of 170 wet days a year[12]. In the summer, sudden and powerful showers are common but the downpours rarely last long.

Usually, snow is rare. The 2010 was a very snowy year. In fact, in the beginning there was snow for nearly three months but in 2011 there was only two snowy weeks, for now!

[11] http://www.denmark.dk/en/menu/Climate-Energy/Denmarks-Energy-Policy-2008-2011/
[12] http://goscandinavia.about.com/od/denmar1/ss/weatherdenmark.htm

In the coldest month (February) there is 0 degree (32°F), and in the warmest (July) 17°C (63°F). The rain comes on a regular basis year-round, there are no true dry periods. The average of annual rainfall is 61 cm (24 in) of precipitation. The greatest rainfall comes between September and November.

Because of Denmark's northern location in Europe, the length of the day with sunlight varies greatly. There are short days during the winter with sunrise coming around 8 am and sunset 3:30 pm, as well as beautifully long summer days with sunrise at 3:30 am and late sunsets at 10 pm.

2.1.5. Social Factors (Federico)

The Danish society, since some years, recognized the need to protect the environment and to promote sustainable development. The basic idea of sustainable development is to respect as much as possible the environment and the human beings, looking both the present and the future.

The development of Denmark is an example of how economic growth and the increasing consumption can go to the same hand with sustainable development. In the last 25 years, the Danish economy has grown by 70% while energy consumption has remained largely unchanged and CO2 emissions have continuously declined.

Since the mid seventies successive Danish governments have prioritized more efficient energy exploitation, while at the same time enacting tough legislation on environmental protection. This has benefited both the environment and the energy balance, and has strengthened the Danish corporate sector. It has forced Danish companies to think innovatively and dynamically.

This in turn has given the country a useful lead in tackling issues like sustainable generation of energy, energy efficiency, district heating, wastewater treatment and waste management. Today, green technology is one of Denmark’s biggest exports. The country has well-established programs of research and numerous companies with expertise and production capability in the field of sustainable technologies. Denmark is thus well prepared for meeting the challenges of climate change, and welcomes opportunities for partnership in the fight against global warming.

New incentives are introduced to continue innovation in the energy and environment-saving technologies necessary to keep Denmark as a leader. In fact, Danish exports of energy technology have increased dramatically over the past ten years, compared to most other countries in the EU and most other Danish export sectors.

Denmark will redouble the share of renewables

Recently the Danish government presented a new long-term plan with the goal of freeing Denmark from dependency on fossil fuels such as coal, oil and natural gas. In 2025 renewable energy sources will account for at least 30% of total Danish energy consumption. In total, renewable energy currently covers 15% of gross consumption and more than 28% of the electricity generated. Renewable energy sources in Denmark include wind, waste, biomass, solar, and geo- thermal energy.

Energy production based on renewable energy sources is an important pillar in the overall Danish energy supply, as the use of renewable energy contributes to security of supply and the management of environmental concerns. In the years to come, these concerns will be met most efficiently through the energy market, because an efficient and reliable energy market is a key element in a growth strategy.

Further expansion will be based on the continuous development of existing technologies as well as on research efforts within new technologies.

In relation to the Kyoto Protocol, ambitious government policies and regulations will globally stabilize or reduce emissions. Curbing greenhouse gas emissions are not the sole responsibility of any company or government. It requires global agreement and cooperation. Technologies developed in Denmark lead the way.

2.1.6. Technological Factors (Federico)

Denmark - a Bright Green nation

Denmark is a world champion in renewable energy, energy efficiency, and the development of new technologies to maintain this position.

The Danish energy competences

Traditionally Denmark has depended exclusively on imported fossil fuels, but the country is now self-sufficient in energy. Very early, Danish companies started to focus on a broad range of energy-saving innovations and initiatives – re-thinking products and processes. Danish companies are among the world leaders in developing and commercialising new energy-efficient and renewable energy technologies, and for many years Denmark has been focusing on new ways to reduce energy consumption, CO2-emissions, and other kinds of emissions. This has been done without compromising economic development and the welfare of the Danish people.

Renewable Energy	Energy Efficiency
» **Wind Energy**	» Energy Efficient Power Plants
» **Biomass Energy**	» Combined Heat and Power
» **Bioethanol**	» Micro Combined Heat and Power
» **Solar Energy**	» District Heating and District Cooling
» **Fuel Cells**	» Metering
» **Hydro and Wave Power**	» Building Materials
» **Geothermal Energy**	» Efficient Electrical Motors
	» Pumps

Table 2: Important key technologies

The Danish Technological Lead

In order to maintain Denmark's technological lead, the Danish government has decided to allocate EUR 150 million per year for more energy research and development, including a programme to demonstrate and further develop new energy and environmental technologies in practice. The programme is geared towards commercialising Denmark's key competences within fields such as second-generation biofuels for transportation, high efficient wind turbine materials, energy-efficient buildings, and hydrogen and fuel cell technology. Other fields will also come into consideration.

Intelligent energy solutions for the future

A real energy revolution is underway, driven by the world's need for affordable energy and by the very real threat of climate change. The coming decades will bring huge changes in energy systems throughout the world.

In 2030, almost eight billion people will be living on the Earth, nearly two billion more than today. 95% of this growth will take place in cities. As a result, tomorrow's energy providers will face enormous challenges. How will it be possible to supply so many people with electricity, heat and cooling in a sustainable manner, which is economically, environmentally and socially acceptable?

However, solutions are in sight. The systems are expected to change from central power plants producing electricity and maybe heat for the customers to a combination of central units and a variety of distributed sources such as renewable energy technologies, fuel cells and smart houses with a positive energy balance moving from being a passive to an active player on the energy markets.

The following development can be expected:

- Closer link between supply and end-use
- Closer link between the various energy carriers distributed through grids such as electricity, heat, natural gas and maybe hydrogen in the future
- Increased energy trade across national borders

Global energy challenges require new long-term solutions, such as future systems based more on renewables and other non-fossil sources, and more energy efficient end-use. Closer links are required between electricity, heat, and other energy carriers, including links to the transport sector. There is also a need for closer links between supply and end-use.

A possible and quite promising solution is to base future energy systems on more distributed generation and flexible demand, which is needed if the system should be able to absorb high volumes of intermittent production from renewable energy sources.
Seen as a whole, some of the necessary elements in a development towards distributed systems are available now; the future task lies in combining these elements and implements them in the energy system.
Such a system could have the following characteristics:

- Increased robustness through decentralization
- Distributed production combined with intelligent end-use
- New information and communication technologies (ICT) to provide system control transforming the current passive electric distribution network into an active system
- Control systems with a higher level of intelligence
- Exploitation of the potential to reduce end-use energy consumption

The Danish energy system is to a large extent diversified and distributed and renewable energy technologies play an increasingly important role. This also means that Denmark already now is an international key player in the development of future intelligent energy systems.

Conclusion

Before starting with the project it was important decide where will be the implementation of the product that the team propose. The team group decided that the implementation will be in Denmark, so in this chapter was made a macro-analysis only for this place.
After this analysis, all the members know the main economical, political, environmental, social and technological aspects present in the Danish territory.
Denmark is very careful to the preservation of the country. Most laws in this area concern the protection for the environment. In this way, Denmark promotes all the activities that can reduce the air pollution and sustainable development.

3. Chapter

3.1. Green Energy (Tobias)

Most likely every human of the modern world has heard about green energy. But what are green energies in detail? Where do they come from and what are their advantages and disadvantages compared to conventional energy? To keep it simple, “green energy” is a term, which mainly refers to electrical power production out of natural forces. These forces can be wind power, waterpower, solar power or even geothermal power. The most important characteristic of these powers is that they are unlimited and completely free of greenhouse gas emissions unlike fossil fuel like coal, gas and oil. Furthermore, most of them are freely accessible.

What is the difference between green energy and renewable energy?
All green energies are also renewable but not all renewable energies are green. As mentioned before, green energies are free of emission when it comes to greenhouse gases like CO_2. The term “renewable energies” includes also energy generation from non-emission-free energy sources. For example, these energy sources are “bio gas”, bio fuel and wood pellets. These resources are called renewable because they are made from renewable raw materials like corn and wood.

In this project some variants of green energies will be used in order to recharge the batteries of electric bikes in so called “renting stations”. Therefore, the need occurs to analyse the different types of green energy as well as the different methods to make them usable and evaluate them regarding their suitability.

3.1.1. Geothermal electricity production

Geothermal energy, once made usable, is one of the most reliable energy sources without the emission of greenhouse gases. It can be used in areas, where the earths' inner heat reaches regions that are near to the earth's surface. In order to make geothermal energy usable, holes need to be drilled into the ground, down to a depth, where the earth's crusts temperature surpasses a specific temperature. Water becomes pumped into the ground with high pressure, into hot rock layers where the water heats up. The water starts boiling and converts into hot steam. According to elementary laws of physics, the water expands while changing into steam, which leads to high pressure. As visible in **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**, the steam leaves the rock layer through another drilled hole and heads under high pressure towards the surface. When leaving the ground, a pipe directs the steam into a gas turbine. The steam rotates the rotors in the turbine while passing it with a high speed, which results from the steams high pressure and the resulting torque on the rotor blades. The turbine drives a generator, which is producing usable electricity, which is directly sent to the local grid. After the steam leaves the turbine, the steam is directed into a so called "condenser". In this condenser, a big part of the steam is cooled down to a temperature where it liquefies back into water again. The steam that becomes not liquefied in the condenser leaves the system. This also means that this kind of system needs a constant supply of new water to counterbalance the loss of water in the form of steam. The concept of electricity production by using geothermal energy is a very clean one. Nevertheless, this kind of technique is only efficient on a very small part of the earth's surface[14]. Also, geothermal electricity production is (unlike geothermal heating of

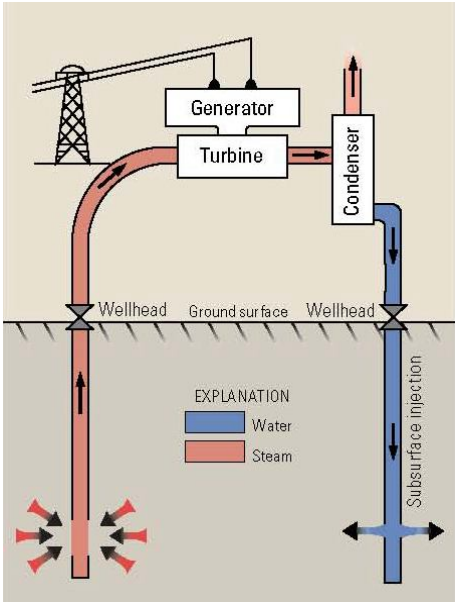


Figure 1: Concept of geothermal electricity production[13]

[13] http://en.wikipedia.org/wiki/File:Diagram-VaporDominatedGeothermal.jpg [06.10.2011]
[14] http://www.clean-energy-ideas.com/articles/disadvantages_of_geothermal_energy.html [14.12.2011]

houses) only economic in a big scale. These facts make it mostly unsuitable for use as a reliable green energy source in this project.

3.1.2. Water Power

Another type of green energy is waterpower.

Waterpower, also called hydrokinetic or hydraulic power, is made usable by many different techniques but all of them are based on the same principle of pressure. In order to make waterpower usable to generate electricity, the pressure, which is caused by water current has to be used to drive a generator. There are different ways of serving this purpose. The oldest procedure to make waterpower usable is the use of a waterwheel as it can be found on old water mills. The water pressure and its resulting force turn the wheel and the wheel can drive a generator, in most cases indirectly by using a gear. In order to produce more electricity in the same time, the pressure must be increased[17]. This is currently done by using water damns. By collecting the water, its surface level rises and the pressure at the ground of the sea increases. The water becomes guided into pipes which entrances are located near the ground of the sea. The water, which flows into the pipes is guided into huge high pressure turbines which are turned by the enormous water pressure and the resulting force on the turbines rotor blades. The resulting torque is conducted into a generator, which turns due to the torque as well. By rotating the generators coils in a magnetic field, the generator produces electricity.

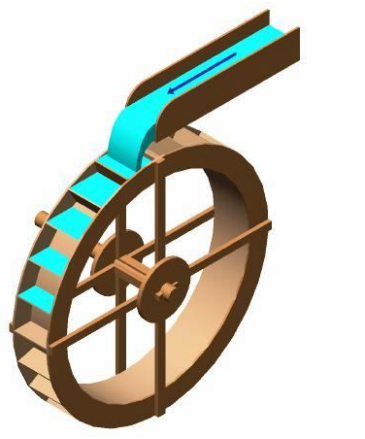


Figure 2: Waterwheel[15]

Using waterpower enables people to produce huge amounts of electricity. The only problem is that the amount of electricity is a matter of scale. A good example for the power of scales this is

Figure 3: Three Gorges Dam in China[16]

[15] http://www.waterdesign.ch/images/Wasserrad-gross.jpg [12.10.2011]
[16] http://upload.wikimedia.org/wikipedia/commons/a/ab/ThreeGorgesDam-China2009.jpg [12.10.11]
[17] http://www.youtube.com/watch?v=cEL7yc8R42k [14.12.2011]

the Three Gorges Dam (see Figure 3: Three Gorges Dam in China).

It has an installed capacity of 20,300 MW[18], which makes it the biggest dam (in refer to power) in the world. When it comes to the autonomous rent stations, the possible size of the waterpower plant will be very limited. Due to the limited size, the produced amount of electricity would be that low, that this kind of electricity production would be completely uneconomic regarding the initial invests for building. Furthermore, the water power plant would not provide the possibility of a standardized design (no matter if it would be a dam or a waterwheel) because these structures would have to be designed individually for each place of action. Also, waterpower isn't available everywhere. Due to these reasons the use of waterpower does not suit to this project, because the goal lies within the development of a standardised system, which is easy to implement anywhere. Waterpower obviously has too many limitations to fulfil these requirements.

[18] http://en.wikipedia.org/wiki/Three_Gorges_Dam [12.10.2011]

3.1.3. Wind Power

Wind power is one of the oldest natural forces, which has been known and used by mankind. It is available on nearby every spot on and above the earths' surface. Only the intensity differs. To make wind energy usable, the wind has to cause a force. On sailing ships this is done by using big sails, which are a resistance to the wind. Due to the inertia of the air current (which we call "wind") a force is caused which is pressing the sail away. The same basics are used in windmills as they were used to mill corn in the past. All of the mentioned "devices" transfer kinetic energy from the wind to the system in order to cause a movement[20]. Today the same principles are used in bigger windmills, which produce electricity. The wind causes a force on the rotor blades, which causes a torque at the shaft where the rotor blades are attached. This torque turns the rotor which turns a generator, directly or indirect by using a gear[21]. These "windmills" are called wind turbines and they are available in many different forms and sizes. The wide spectrum of different products regarding wind turbine technology allows to the choice of a suitable solution, which fits to the projects' requirements. Regarding availability and usability of wind energy it is a suitable solution for "in-place" energy production.

Figure 4: Wind turbine[19]

Out of this reason, this report will deal in deeper detail with wind energy, the electricity production out of wind energy as well as with the different types of wind turbines, in order to find the most suitable solution.

[19] http://www.robaid.com/wp-content/gallery/wind-power/wind-turbine-sky.jpg [06.11.2011]
[20] http://www.howstuffworks.com/environmental/green-science/wind-power.htm [14.12.2011]
[21] http://www.youtube.com/watch?v=mcNCXIUfJlY [14.12.2011]

3.1.4. Solar power

The solar power, which is bound in sunlight is available everywhere on earth surface, even if the intensity may differs. To keep it easy, sunlight is the purest form of energy that is known until now. What a human eye perceives as visible light is electromagnetic radiation in a wavelength of approximately 400 to 700 nanometres[22] [23]. The energy in this radiation can be made usable. A proof for the high amount of energy, which is transported by sunlight is delivered by a favourite toy of many children, the magnifying glass. Just a small magnifying glass is enough to collect enough sunlight to burn a piece paper. Of course, the suns energy is collected and concentrated on a small spot by the use of a magnifying glass, but it's important to keep in mind that the whole amount of energy, which is necessary to ignite the paper is only taken from the sun.

Until the current day, various ways of making sunlight usable are available. Sunlight can heat up water if the water is pumped through black painted pipes (in order to absorb sunlight in the widest possible spectrum), which are exposed to sunlight. A related method which is supposed to generate electricity lies within the sunlight's' capability of even boiling and evaporating water. Big areas in regions, which are rich of sunlight, can be covered with mirrors. These mirrors reflect the received sunlight on a pressure tank, which is filled with water. Caused by the intense radiation of sunlight the tank heats up. The water starts boiling and evaporates which leads to an increased pressure in the tank. The high pressure water vapour is guided through pipes into a pressure turbine which becomes turned by the high pressure current of the water vapour.

Figure 5: A Spanish solar thermal power plant[24]

[22] http://cmb.physics.wisc.edu/tutorial/spectrum.html [14.12.2011]
[23] http://en.wikipedia.org/wiki/Electromagnetic_spectrum#Visible_radiation_.28light.29 [14.12.2011]
[24] http://www.dailygreen.de/2011/10/06/spanien-neues-solarthermie-kraftwerk-liefert-auch-nachts-strom-27323.html [06.11.11]

The torque is transmitted to a generator, which also starts turning and thereby produces electricity. The described techniques which are turning sunlight into heat are summarized under the term “solar thermic”.
Of course, these methods are completely unsuitable for this projects purpose. But there is still one method left, which is not making a detour on heating up water.

The final technique, which turns sunlight into usable electricity works with photovoltaic cells, so called “solar cells”. The cells contain different layers of semi conducting material, for example silicon. One layer has a positive doping, the other layer has a negative one. When photons of the sunlight hit these layers, electrons in these layers become separated from their atoms due to the transmitted energy of the photons. As a result, electrical charges are building up in the different layers[25]. While discharging the layers through applied electrodes, an electrical current occurs, which can drive electrical devices. Solar cells are available in many different sizes and shapes. As a result they are perfectly fitting for use in this project. Therefore, photovoltaic cells will be investigated in more detail during in the following chapters.

3.1.5. Result

The only technologies for electricity production, which are generally suitable for the projects purpose are wind turbines and solar panels. Due to this fact, only solar and wind energy were investigated in the further project.

[25] http://science.howstuffworks.com/environmental/energy/solar-cell1.htm [14.12.2011]

3.2. Solar Power (Nikolaos)

3.2.1. General

The main and primary source of energy for the earth is the Sun, and there is nothing on earth that could exist, or live and move, without the enlivening energy of the sun. Today is known that the sun is a fiery celestial body, which emits huge amounts of heat in the solar system by fusing big amounts of hydrogen into helium. No matter how much mysteries were solved by science that surrounded the sun in the past, the most important conclusion is that there would be no life on earth without the existence of the sun. Earth would be just a small, frozen, dead planet without any trace of life. The solar irradiation, or solar energy as it used to the saying, has supplied and continues to supply energy to almost all renewable and non-renewable resources. The energy of the Sun, however, is by itself a major source of energy, which was used from ancient times till today.

3.2.2. History of the sun and solar energy systems

Prior to about five billion years, when the evolution of a primordial cloud created the sun, the space around it was flooded with light, which was emitted by the new star. In the neighbourhood of the hot star, the planets came to existence, originated from the rest of the cloud material, which was not contributing to the creation of the sun. The sun is a star with a mass of 2 x 1030 kg, a radius of 700.000 km, an age of 5 billion years and a further life expectancy of almost the same amount of years. The surface temperature is estimated at 5,800 K, the core temperature of 15,000,000 K. This temperature results from the fusion of hydrogen into helium.

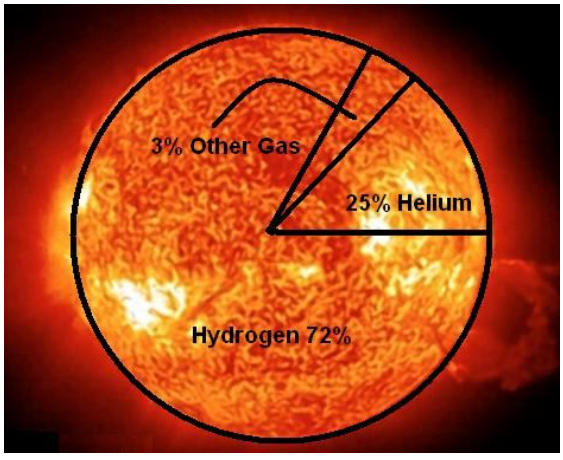


Figure 6: Structure of the Sun

It has been estimated that for every gram of hydrogen converted into helium produced energy equivalent to U = 1.67 x 105 kWh. The energy is transferred from the core to the surface and then diffuses into space in the form of electromagnetic radiation. Studies of the spectrum of solar radiation have revealed that the spectrum extends to all wavelengths. In detail, the spectrum of solar radiation is divided into three parts: the UV spectrum ($\lambda < 380nm$), the visible spectrum ($380nm < \lambda < 700nm$) and the infrared spectrum ($\lambda > 780nm$).

Apart from electromagnetic radiation simultaneously a weak particle radiation is emitted. It consists of charged particles, mainly protons and electrons and is called “the solar wind”. The average distance from Earth and the Sun (as the earth makes an elliptical orbit) is 150.000.000 km. The time, in which light travels with a speed of 300.000 km / s to earth, lies around approximately 8, 5 min.

Each day the sun illuminates the earth with several thousand times of the amount of energy that would be sufficient to meet the requirements referring the amount of used energy. Even the small amount of solar radiation hitting the roof contains much more energy than all the electricity that enters the house from the local grid for the daily needs. In a uniform acre of land with is directly rays exposed to the sun, light delivers an amount of energy of Watt which equals four thousand horse powers, the power of a large locomotive. In less than three days, the energy of the suns’ light, which is reaching the earth in less than three days is more than the estimated total amount of energy in fossil fuel on earth.

The logical question that arises by this fact is, why not use this advantage in the form of solar energy usable of course, the answer is that ‘we use it already but we are still in the beginning’. Solar energy is also included in almost any natural compound that includes chemical energy. A car which runs on fossil fuel also operates in a particular way with solar energy in the same time. The plants, from which the fossil fuel originates, grew by consuming sunlight. Later they became transformed into coal and oil by seismic activity and resulting pressure and heat. But the included energy still originates from the sun. As a result, by using fossil fuel is already trapped a amount of solar energy. The advantage of solar energy lies within the fact that it can be converted directly into electricity. By doing so, it is a non-polluting form of energy generation.

Early photovoltaic applications were geared more towards sensing and measuring light (like a camera's exposure meter) than towards producing power.

With the advent of the transistor and the accompanying semiconductor technology, the efficiency of photovoltaic power increased dramatically and the photovoltaic power became practical. Over the years, many companies have worked to increase the efficiency of the photovoltaic effect.

Today, commonly available solar panels show an efficiency of averagely 12%, which is four times larger than a few years ago. Today, in order to use heat which is generated out of solar radiation, solar power is used in two primary techniques: solar heat, where the sun's heat is used to heat water or another fluid in order to transfer heat or drive a turbine and another technique that generates electricity out of a photovoltaic process, where electricity is generated directly from the sun with no moving parts (like turbine and generator).

Today the solar radiation has many different ways to be used positive:

1. With the use of solar thermal systems it is possible to collect sunlight and converting it into heat in an insulated container. This system is called an active solar system ( )

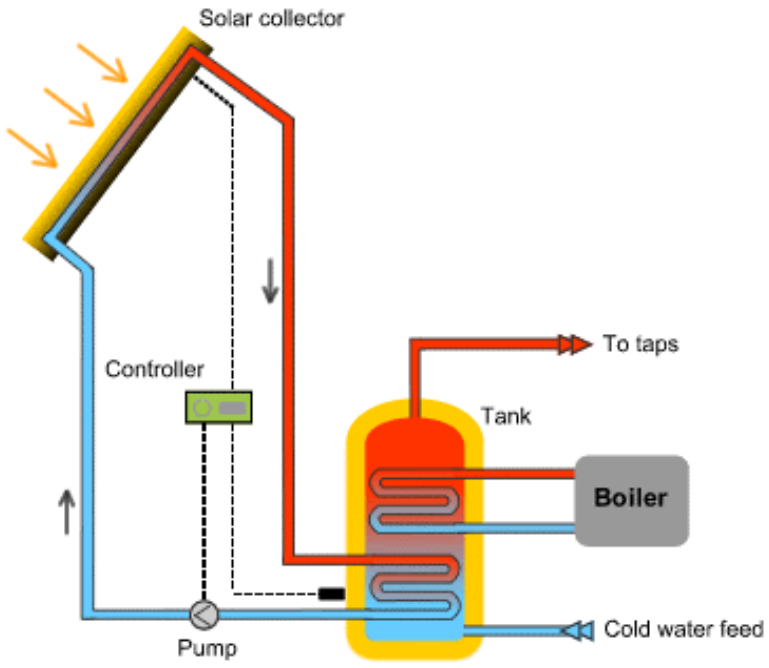


Figure 7: Solar System Assets

2. In passive solar systems, all properly designed and combined components of building structures (buildings) to assist the best direct or indirect use of solar energy either for heating the buildings in winter or for cooling them in summer.

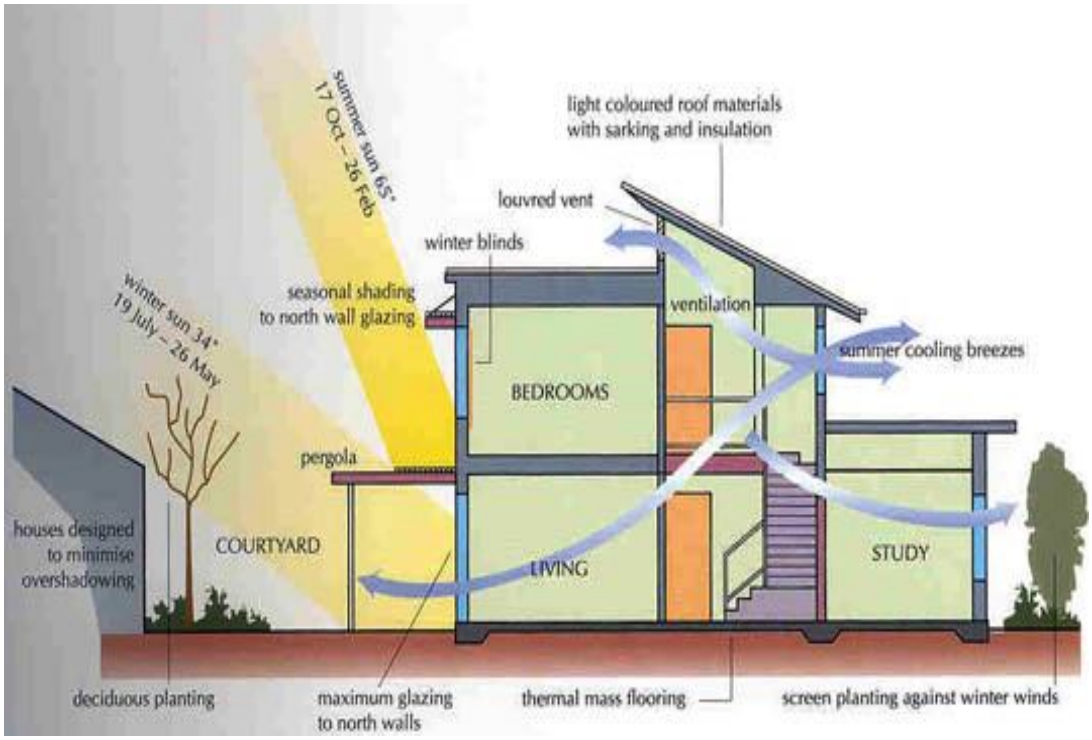
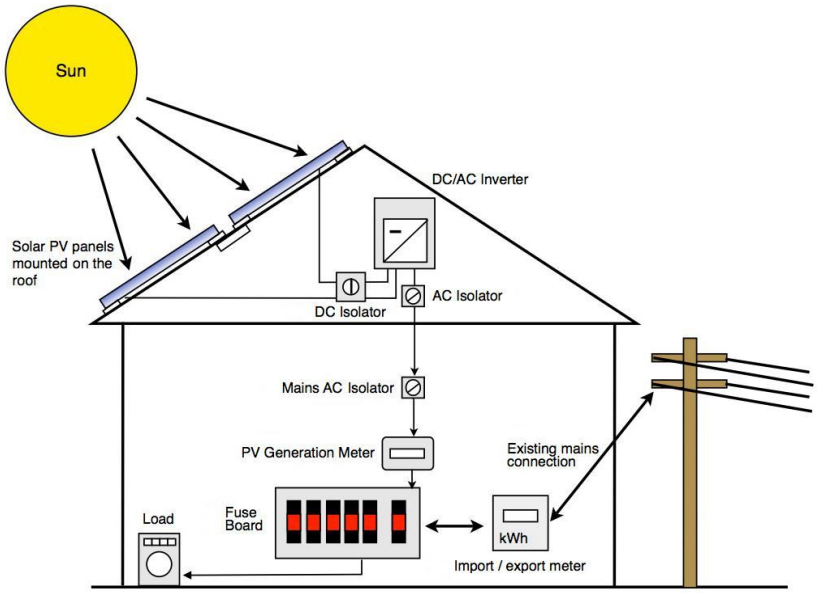


Figure 8: Passive solar system

3. The direct conversion of solar energy into electricity by using photovoltaic's.



4.

Figure 9: Passive solar system

This project deals with photovoltaic technology.

The name of this technology 'Photovoltaic'[26] is a compound word containing the word: 'photo', from Greek roots, that meaning light, and 'voltaic', from 'volt", which is the unit used for measuring electrical potential between two points. Photovoltaic is the direct conversion of light into electricity at the atomic level. Some materials show a property known as the photoelectric effect that makes them absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity.

The photoelectric effect was first noted by a French physicist, Edmund Bequerel, in 1839, who found that certain materials would produce small amounts of electric current when exposed to light. In 1905, Albert Einstein described the nature of light and the photoelectric effect on which photovoltaic technology is based, for which he later won a Nobel Prize in physics.

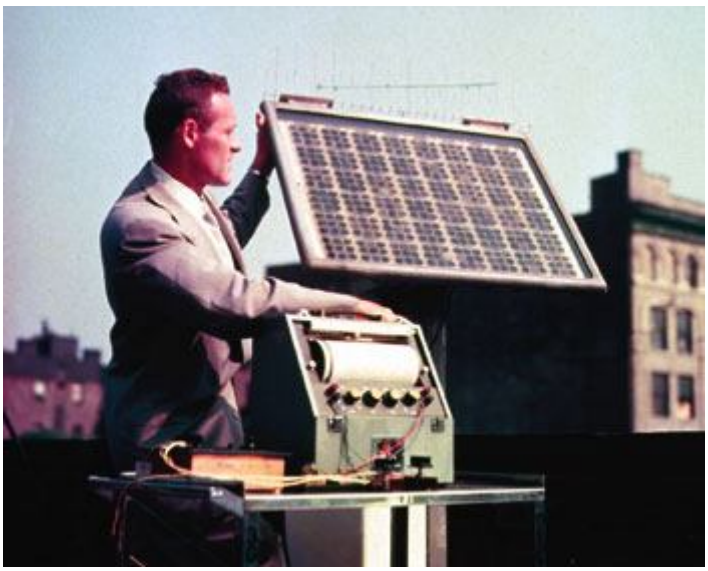


Figure 10: Bell-Labs-testing-solar-battery-1954

The first photovoltaic module was built by Bell Laboratories in 1954(Figure 5)[27]. It was billed as a solar battery and was mostly just a curiosity as it was too expensive to gain widespread use. In the 1960s, the space industry began to make the first serious use of the technology to provide power to spacecrafts. Through the space programs, the technology advanced, its reliability was established and the costs began to decline. During the energy crisis in the 1970s, photovoltaic technology gained recognition as a source of power for non-space applications. The diagram above illustrates the operation of a basic photovoltaic cell, also called a solar cell. Solar cells are made of the same kinds of semiconductor materials, such as silicon, used in the microelectronics industry. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy hits the solar cell,

[26] http://www.epia.org/solar-pv/how-does-pv-work.html

[27] http://nkloc.wordpress.com/2010/11/03/development-history-and-applications/

electrons are knocked loose from their atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current -- that is electricity. This electricity can then be used to power an electrical device, such as a light or a tool.

3.2.3. How solar energy systems are working.[28]

The photovoltaic effect is based on the semiconductor material, which can be adapted to release electrons, the negatively charged particles that form the basis of electricity. The most common semi-conductor material used in photovoltaic (PV) cells is silicon, an element most commonly found in sand.

All PV cells have at least two layers of such semi-conducting material, one positively doped and one negatively doped. When light shines on the semi-conductor, the electric field across the junction between these two layers causes electricity to flow, generates DC current. The bigger the intensity of the light the bigger the flow of electricity.

A photovoltaic system does not therefore need bright sunlight in order to operate. It also generates electricity on cloudy days but its energy output deepens to the density of the clouds. Due to the reflection of sunlight, days with only a few clouds can even result in higher energy yields than days with a completely blue sky.

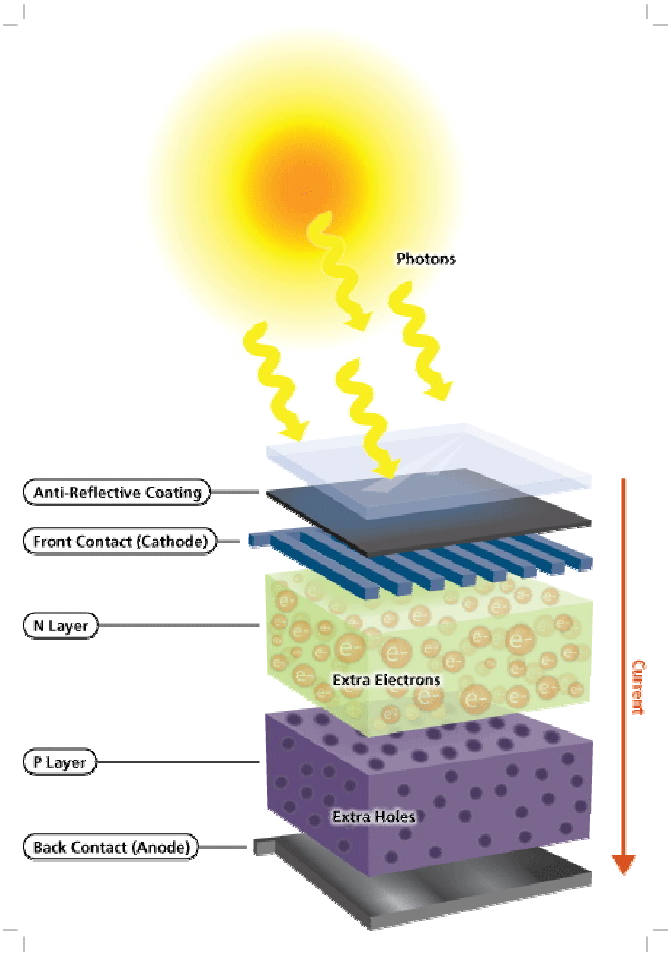


Figure 11: Basic cell funtionality

[28] http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/

3.2.4. The type of PV panels – collectors

Various materials have been investigated for solar cells. There are two main criteria - efficiency and cost. Efficiency is a ratio of the electric power output to the light power input. Ideally, near the equator at noon on a clear day, the solar radiation is approximately 1000 W/m^2. So a 10% efficient module of 1 square meter can power a 100 W light bulb. Costs and efficiencies of the various materials vary greatly. By far the most common material for solar cells (and all other semiconductor devices) is crystalline silicon. At the present time, most commercial photovoltaic cells are manufactured from silicon, the same material from which sand is made. The silicon price is extremely cheap. Other, more exotic materials such as gallium arsenide are just beginning to make their way into the field and the price is really high.

The four general types[29] of silicon photovoltaic cells are:

- Monocrystalic silicon (also known as Single-crystal silicon).
- Polycrystalic silicon (also known as multicrystal silicon).
- Amorphous silicon (abbreviated as "aSi," also known as thin film silicon).
- Ribbon silicon.

3.2.4.1. Monocrystalic silicon

The thickness is about 0.3 mm. Their performance in the industry ranges from 15 to 18%. The workshop achieved higher performance up to 24.7%. The monocrystalline solar cells are characterized by the advantage of better yield per area, also called "energy density". Another feature is the high manufacturing costs compared to polycrystalline. Basic technologies of production are monocrystalline photovoltaic method CZ (Czochralski) method and FZ (float zone). Both are based on silicon ingot growth.

Figure 12: Monocrystalic silicon cell

[29] (Planning and Installing Photovoltaic Systems, 2007) http://books.google.gr/books?id=fMo3jJZDkpUC&printsec=frontcover&dq=Planning+and+installing+photovoltaic+systems:+a+guide+for+installers+.&hl=el&ei=DfPnToTnJo3GtAbUkeSTBw&sa=X&oi=book_result&ct=result&resnum=1&ved=0CDwQ6AEwAA#v=onepage&q=Planning%20and%20installing%20photovoltaic%20systems%3A%20a%20guide%20for%20installers%20.&f=false

The monocrystalline photovoltaic module with the highest performance the market today is a module with 18.5% module efficiency. It is indeed the only one that has the metal contacts on the back for obtaining greater surface interaction with solar radiation.

3.2.4.2. Polycrystalic Silicon:

The thickness is also about 0.3 mm. The method of production is cheaper than that of monocrystalline silicon, hence their price is usually a bit lower. Visually one can observe the individual monocrystalline areas. The greater the extent of the monocrystalic regions the greater the yield for polycrystalline photovoltaic cells. In laboratory applications have achieved yields of up to 20%, while cells with polycrystalline structure are available with efficiencies from 13 to 15% for solar modules (panels). Main production technologies are: the method of direct solidification DS (directional solidification), the development of molten silicon ("casting") and electromagnetic casting of EMC.

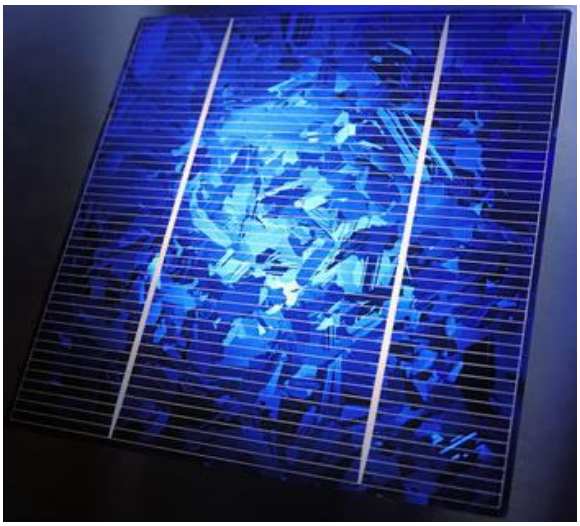


Figure 13: Polycrystalic silicon cell

3.2.4.3. Amorphous silicon:

The photovoltaic elements made of amorphous silicon have significantly lower returns than the two previous categories. The used thin film coatings are produced by depositing semiconductor material) onto a substrate support, low cost such as glass or aluminium. Because of less use of silicon their price is generally much lower. The characterization of amorphous photovoltaic comes from the random way in which the atoms of the silicon are arranged.

Figure 14: Amorphus silicon cell

The performance achieved by using thin films of silicon photovoltaic ranges from 6 to 8%, while laboratory experiments have achieved yields of even 14%. The major advantage of the photovoltaic element a-Si is the fact that not much affected by high temperatures. An advantage for the use of such a cell is the good performance of crystalline PV under circumstances with diffuse radiation (cloudy weather). The disadvantage of amorphous frameworks is their low energy density which means that we need almost twice the surface area in order to produce the same energy compared to crystalline solar cells. There are also doubts about what the life time of an amorphous framework would be, until there is no evidence or reference data from old plants because the technology is relatively new. Nevertheless, manufacturers now offer performance guarantees for 20 years. The thickness of silicon is about 0.0001 mm and the substrate can be from 1 to 3 mm.

3.2.4.4. Ribbon silicon.

This is a relatively new technology of photovoltaic elements. It's offers up to 50% reduction in the use of silicon than the "traditional techniques" in manufacturing monocrystalline and polycrystalline silicon solar cells. The performance for solar cells has now reached around 12-13%, while the thickness is about 0.3 mm. The workshop has achieved returns of 18%.

Other types of photovoltaic panels are:

Figure 15: Ribbon silicon cell

3.2.4.5. Copper Indium Gallium di Selenide adding French(CIGS)

The Copper Indium di Selenide30 (CuInSe2) has excellent absorbency to the incident light, but nevertheless the performance with modern techniques is around 11%. Laboratory performance was possible at the level of 19.5% which is the largest efficiency ever reached between the thin coating of photovoltaic technologies. The problem is that the indium is present in limited quantities in nature. In subsequent years, however, expected costs are considerably lower.

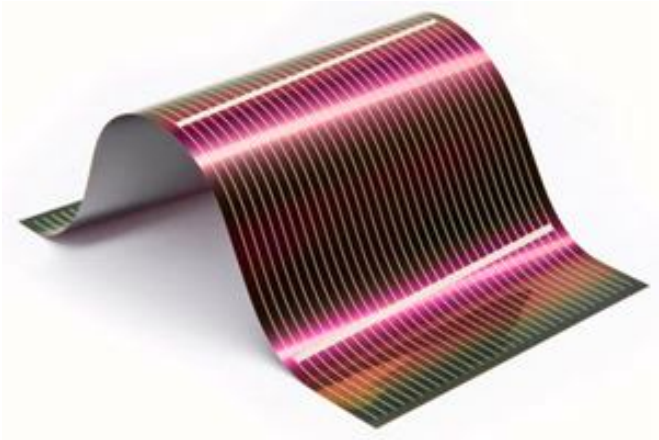


Figure 16: Copper Indium Gallium cell

3.2.4.6. Cadmium Telluride (CdTe)

The Telluride Cadmium has the energy gap around 1eV, which is very close to the solar spectrum, which gives serious advantages as the ability to absorb 99% of incident radiation. Modern techniques, however, offer us a framework that gives around 6 - 8%. In the laboratory performance in solar cells has reached 16%. Future costs are expected to drop considerably. A hinder to the use of these cells is the fact, that cadmium, according to some surveys, has carcinogenic effects, which leads to concerns about the possibility of extended use. Greenpeace already has opposed the use. Another a point of concern lies within the lack of tellurium. More important is the development of an encapsulation into glass in order to make it suitable for the use as a building material (BIPV Building Integrated Photovoltaic).

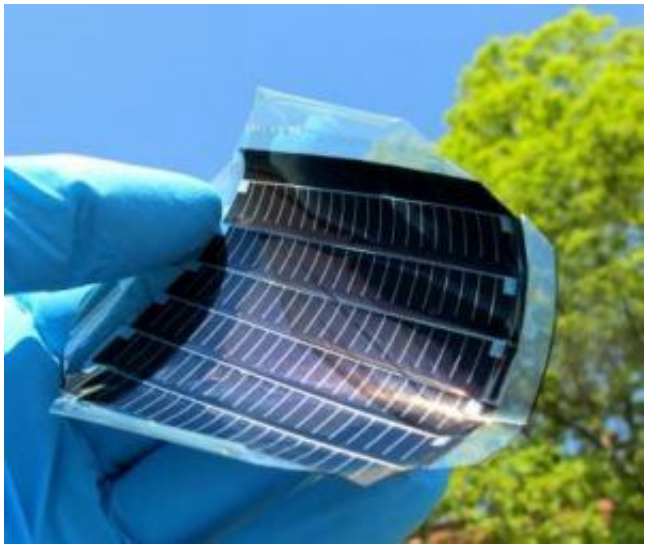


Figure 17: Cadmium Telluride (CdTe) cell

[30] http://www.sst.nrel.gov/photovoltaics_pub/CIGS_GB_HetzerAPL03.pdf

3.2.4.7. Gallium **GaAs**[31]

The Gallium is a by-product of the realization of other metals such as aluminium and zinc. It is even more rare than gold. The male is rare but has the disadvantage of being poisonous. The gallium arsenide is the energy gap of 1,4 eV which is ideal for the absorption of solar radiation. The yield in the form of multiple combinations (multifunction) is the highest yield achieved until today and reaches 30.6 %. Also, GaAs solar cells are extremely resistant to high temperatures, which imposes virtually their use in solar concentrator systems applications (solar concentrators). The GaAs solar cells have the advantage of withstanding very high amounts of solar radiation for this but also because of very high performance suitable for space applications. The biggest drawback of this technology is the excessive cost of monocrystalline (GaAs) substrate.

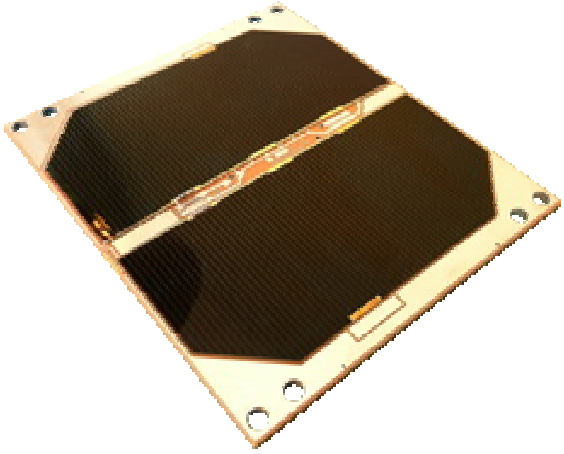


Figure 18: Gallium GaAS cell

3.2.4.8. Hybrid Modules

A hybrid solar cell is composed of layers of materials of different technologies.

- HIT (Heterojunction with Intrinsic Thin-layer). The most famous commercial hybrid solar cells composed of two layers of amorphous silicon (top and bottom). There is an intermediate layer of monocrystalline silicon. The big advantage of this technology is the high efficiency of the framework. When it comes to commercial applications it lies around 17.2%, which means less available surface to have the same installed capacity of energy generation.

Figure 19: Hybride module cell

[31] http://apl.aip.org/resource/1/applab/v91/i2/p023502_s1?isAuthorized=no

The corresponding solar cells have an efficiency of 19.7%. Another advantage for hybrid solar cells is their high efficiency at high temperatures and their high performance in diffuse light. Of course, since it offers so much, the hybrid photovoltaic is somewhat more expensive than conventional solar panels.

3.2.5. Advantages

adhfsdf

- The electricity production from solar cells is a process of non-polluting. The only energy source that required is sunlight. The photovoltaic systems are not harmful to the environment during of their life time and producing energy much more from that they need until to built up and to put them in to operation, furniture is harmless for humans and animals.
- Photovoltaic systems are quiet and visually distinctive.
- Applying small-scale solar plants in existing buildings can benefit assess free surfaces on rooftops.
- Operate reliably for long periods without requiring almost no maintenance.
- Solar energy is a locally available renewable resources
- There needs to be imported from other regions of the country or around the world.
- It reduces the dependence on imported oil.
- The size of a PV system can be increased or even be moved to another location very easily.

3.2.6. Disadvantages

- Some types of PV panel contain certain toxic chemicals such as cadmium and arsenic, these through recycling are bound without great problems.
- Solar energy is still more expensive than conventional sources of energy, this difference will decrease over time as the efficiency of photovoltaic rise and production costs shrinking, so it becomes more economically competitive source of energy with conventional fuels.

3.2.7. Result

The solar energy technologies are developing dynamically and special implementation over the last decade. A continuously increasing number of architects, civil engineers and contractors recognize the value of solar systems and apply them in their constructions. This effort is supported by government initiatives such as tax incentives and local communities by investing in these systems, making them more affordable. In addition, as the cost of solar photovoltaic energy continues to decrease, these systems will penetrate the market even more. The trend for the coming years is that the solar PV industry aims to provide 50%[32] of total electricity generation in the U.S. until 2025. Solar energy will play a leading role in ending global dependence on fossil fuels to combat the threat of global warming, and safeguarding the future based on clean and sustainable energy.

[32]http://www.ucsusa.org/clean_energy/technology_and_impacts/energy_technologies/how-solar-energy-works.html#Photovoltaics

3.3. Wind Energy (Nikolaos)

3.3.1. General

Figure 20: World elements

Our World is based on the 4 elements, Wind, Water, Fire (In free translate is the solar power), and the earth. All of them they have a common characteristic they involve the meaning of energy. The life in our planet is based on the Sun. Generally we are able to understand why the Sun is essential for life to the Earth. One of these procedures that happened in Earth because of the Sun is the wind. The Wind is based on the suns energy and special in the heating part, because for that producing the Wind and the other is the light. In our days technology is in a high level and we can take advance of that kind of energy.

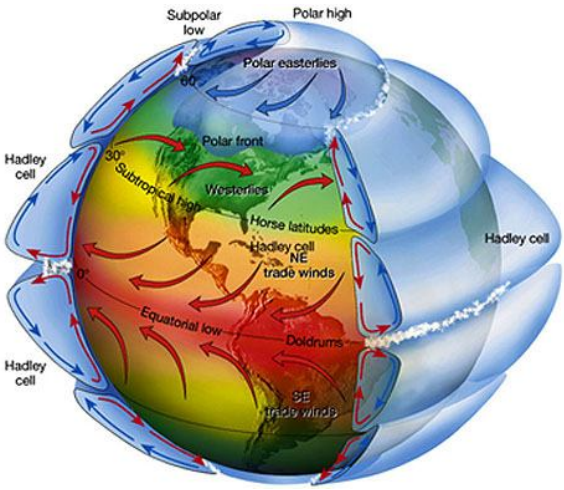


Figure 21: Global Wind

Wind energy it coming from the sun. When the sun is heating a place on earth, that place absorbs the energy and gains a higher temperature than another place which is not heated by the sun. The difference in temperature in the air over these areas creates different atmospheric pressures which cause air currents, also known as wind. According to estimates by meteorological agencies the power of wind in global scale is 3.6 x 109 MW while the usable energy in various locations around the world lies at 1% and is estimated to be 175 x 1012 KWh.

3.3.2. HISTORY OF WIND ENERGY

The wind, one of the oldest forms of natural energy has been used from very early to produce mechanical work and played an important role in the technical evolution of humanity. The importance of wind energy reaches back to ancient times where it was originally used to move the first sailing ships which contributed decisively to the development of shipping. The first machines which utilized wind power were windmills. Although it appears that the ancient peoples of the East were using windmills, the first report of such machines is shown in works of Arab authors in 9th century AD. The windmill was brought to Europe by the Arabs and was used in countries like France and England in projects in the form of hydraulic wheel. In our days we have a huge amount of choices between different amounts of produced energy as well as between different types of wind turbines. That fact is a result of a big effort for more than 115 years.

3.3.3. How the wind turbines are working

The wind spins the blades of a turbine which is connected to a rotating shaft. The axis passes through a gearbox transmission with rising speed. The gearbox is connected to a high speed shaft which drives a generator producing electricity. If the wind speed increases, the turbine uses a brake that limits the overgrowth of rotation of the blades in order to reduce wear and avoid destruction. The wind speed should be more than 15 kph to enable a common turbine to produce electricity.

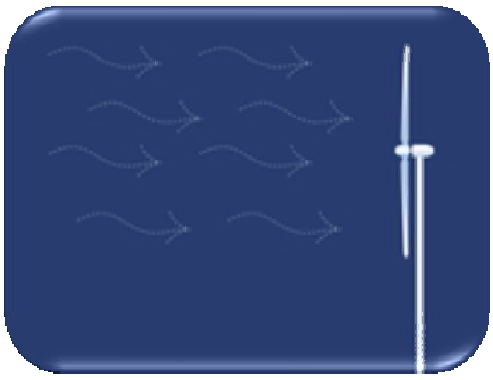


Figure 22: How the wind blows to the wind turbine

The typical production of power is around 50-300 KW for each turbine. A KW of electricity can light 100 lamps of 100w. As the generator spins, producing

electricity with a voltage of 25.000 volt. The electric current passes from a first transmission the transforming facility, which raises the voltage at 400.000 volt. When electricity travels long distances it is better to have high voltage in order to lower the losses. The large, thick wires which are carrying the electricity are made from copper or aluminum in order to pose only small electrical resistance to the transfer of power. The greater resistance of the wire the more thee wire becomes heated. So some amount of electricity lost because converted into thermal energy. The current carrying wires leading to a substation where transformers convert high voltage back to low voltage in order to make it usable to operate electrical appliances.[33]

3.3.4. Wind turbines categories

Wind turbines are classified according to the mechanical power P supplied in three major categories.

1. Small wind generators when the power rating is between: 50W ≤ N ≤ 10kW
2. Mesaiesanemogennitries when the rated power is between: 10kW ≤ N ≤ 200kW
3. Large wind turbines when the rated power is: 200kW ≤ N

Small Wind Turbines

Small wind turbines refer to systems which have a rated power up to 10kW. Wind turbines have rotor diameters from 0.58m to 8m and are usually mounted on towers with a height ranging from 10meos the 40m.

Small wind turbines are divided into three subcategories according to the nominal power output, which is:

[33] http://science.howstuffworks.com/electricity.htm

1. Micro wind turbines with rated power 50 ≤ N ≤ 1kW,
2. Mid-range wind turbines with a rated power 1kW ≤ N ≤ 5kW,
3. Mini wind turbines with a rated power 5kW ≤ N ≤ 10kW

3.3.5. Types of Wind Turbines (regarding output power)

The wind turbine in our days exists in basically two types. One is the vertical axis wind turbine and the other is the horizontal axis wind turbine. They both have their advantages and disadvantages.

- The horizontal-axis variety, as shown in the photo. Its looks like the typical wind turbine and the design is for system with low load from 200 W until 10 MW.

Figure 23: Horizontal wind turbine:

- The vertical-axis variety. This type of wind turbines has 4 different main designs as they can be seen in the next figures.

Figure 24: Savonius type[34]

Figure 25: Cyclo turbine[35]

Figure 26: Giromil[36]

Figure 27: Darrius type[37]

The vertical axis wind turbine rotates around an axis perpendicular to the ground. The vertical axis wind turbines, by way of construction, it able to "catch" the wind from every direction, which contributes to its use in residential areas where changes in wind direction are frequent.

3.3.5.1. Advantages[38]:

34

35

36

37

[38] Article Source: http://EzineArticles.com/3521815
http://www.energybeta.com/windpower/vertical-axis-wind-turbine/

- The basic advantage of the vertical axis is does n't need'tail to orient in the direction of the wind. This results in areas with turbulent air and non-fixed orientation (Urban) operated more steadily.
- The vertical wind turbines are able to continue to work by high wind speeds
- They can still work on low wind speed
- The problem with the pulsating torque has already solved
- The bladeless, are on board and by that are bird-friendly.
- Design and efficiency of VAWT's make them generally turn at lower wind speeds than other variants. This is particularly true of magnetic wind turbines or (Maglev turbines) that have low resistance because of the use of magnets.
- The VAWT's are able to apply closer to the ground for instance upon a rooftop rather than a 50 ft. to 300 ft. tower.
- The Various VAWT's have a cylindrical or helical design, which makes them less affected by cross winds.
- The VAWT's turbine blades make the turbine silent and suitable for urban use.
- As the blades do not cut across the airflow, there is **less stress** on the blades.
- Low maintenance requirements because of less electronic systems to control blade pitch or revolution speed.

- There is not gearbox and brake pads and that means easy and economy maintenance.
- They can be designed to a wide range of formats and styles, able to blend in with architects' concepts especially in an urban environment.
- They can be used for outdoor advertising.
- The fact that the blades do not cut across the airflow, there is less stress on the blades when it is applied in a public area.
- Its easily integrated into constructions or buildings because do not need free area for the blades movement.

3.3.5.2. Disadvantages

- They have complicated in structure and that increase the cost.
- The power efficiency is low.
- In unusual wind speeds they can be unstable.

3.3.6. The Future of Wind Power

Great environmental concerns and the imperative need for a Resource Efficient World have consequently led scientists towards the exploration of new technology that would lead to the optimal exploitation of renewable resources, such as the wind power and the promising new technology that will allow the exploitation of its energy even at lower wind speeds. Indicative to this trend, of this turn towards the wind power, are the data published by the Global Wind Energy Council which states that: "projects global wind capacity will reach 332 GW by 2013, almost triple its current size, with growth especially concentrated in the United States and China. In 2013 alone, new installations could reach 56 GW, more than double the current annual global market"[39]. Several thorough studies that have been done have also indicated that the benefits of using wind energy will not only enhance substantially the global efforts for the reduction of greenhouse effects and the saving of water resources but will also facilitate development and thus the creation of a lot of new 'green' jobs, factor that will tackle the grave problem of unemployment (see study by the US Department of Energy[40]). As promising as the usage of the wind power sounds, it is certainly not without any difficulties both technical and practical. As it was anticipated, the worldwide financial crisis has affected the sector of wind power technology. Technical problems on the other hand, like the unexpected collisions with birds on the turbines, have to be also tackled. However, the exploitation of wind power could be the key to address the nowadays challenge for the need of a resource efficient and less dependent to fossil fuels world.

[39] http://www.gwec.net/fileadmin/documents/Publications/Global%20Wind%202008%20Report.pdf
[40] http://www.20percentwind.org/Black_Veatch_20_Percent_Report.pdf

3.3.7. Renewable energy sources and Eco mobility (Nikolaos)

Providing the Eco mobility for the people of all the ages and activities this project offer not a simple bike but an electric bike (e-bike). The obvious is that the electric bike needs electric energy, and the point is: recharge the e-bikes by the local grid, how much "ecological" is that source of energy? The answer is simple, consider that the commitment by the countrys of European Union about the energy production is until the end of 2020 the 20% of produced energy. It will be from renewable energy sources, as already mentioned in the PEEST analysis. In the real market there is an other parameter where the emission trading scheme is one of the main means of fulfilling emissions trading is regulated pollutants through of the stock market. So through the stock market prices rise plus the fine for any excess corresponds to 750 DKK/tone CO2. Supporting this effort[41] and a general supporting the Eco mobility in this project will be implemented renewable energy systems like solar energy system and small vertical wind turbine in order to produce zero carbon emission charging the e-bikes.

Applying this systems to our constriction there are two possible ways to use the green energy.

1. Is to apply directly the green energy to e-bikes or,

2. Selling the energy to the local grid and, buy it again from the local grid.

The first option it will dissever to chose it only in the case that there is not electricity grid available, and that because when producing 1kwh from wind turbine, you are able to shell it back to the local grid for 0.60dkk/kW and when using 1kwh from the local grid it coast 0.36 dkk/kW. Also with the second option requiring less money for the system because does not required batteries, controllers or other parts who are expensive and with small life period. At the end in the case that the system produces more energy than necessary is required to serve the e-bikes the extra energy can be shell to the local grid and earn money from that procedure.

Choosing the second option, again they are coming two options of Eco mobility,

1. First producing energy only for the e-bikes

[41] http://www.ens.dk/EN-US/CLIMATEANDCO2/EMISSIONTRADINGSCHEME/Sider/Forside.aspx

2. Second option supporting with Eco energy all the devices for this construction by renewable energy systems.

This answer needs a further investigation and calculations.
These calculations can be divided in five (5) main categories :

1. Available surface from our construction.
2. The Renewable energy systems.
3. The energy needs for the bikes and for all the electronic devices.
4. The meteorological data for Horsens.
5. The price of energy.

3.3.8. The Renewable energy systems

In order to produce as much energy is it possible with our construction, two systems are combining.

1. Solar energy system with Photovoltaic Panels.
2. Wind energy system with vertical wind turbine.

Available surface from the construction

The advantage of this construction is the utilization of the all ready used area by apply the PV panels and the wind turbine on the roof. The characteristics of this construction depends on some important parameters that it will describe the needs that must to serve. Those parameters are:

- The number of slots for the bikes.
- The dimensions of the bikes, of PV panels and the available space for the necessary manoeuvre.

After observation from other all ready exist bike station in Europe the station serve 6-8 bikes, for this reason reached to offer six (6) electric bikes available for rent and two (2) empty slots available per bike station, for the owners of electric bikes in order to recharge them Each bike has a length 1.9m and the length of the stirring wheel is 0.30m the gap between two bikes it will be 0.65m for 8 slots, Sow the total length of the parking station it will be 8m and the high it will be 2.30m. The roof for this construction it will be the surface from the PV panels. Choosing the LG PV modules the surface of the roof for the constriction it will be 19,32 m^2 by 12 PV panels, and a second plan is to apply 14 SANYO PV panels with 17,64m^2 surface. This diferent models of PV panels has specific and diferent caracteristic that are usefull for the resone tha must suport. The other system of this construction is the wind turbine, that it will use the high of this constraction in order to be in the property high of 6m, that is nesseccary in order to produce energy.

The PV panels are from LG & SANYO Company with these characteristics:

Prod. No.	LG235M1C-G2	SANYO HIT-N235SE-10
Type	Monocrystalline	Hybrid
Surface m^2	1.61	1.26
Efficiency w/m^2	14.60%	18.60%
Wp/(Surface*Price)	0.46	0.39
Wp	235	235
Price	2.387,55 dkk	3.600,00 dkk
		
Internet add	http://www.tsokaktsis-solar.gr/Product.aspx?pid=261	http://www.tsokaktsis-solar.gr/Product.aspx?pid=258

Table 3: Specifications for the LG235M1C-G2 PV panels and SANYO HIT-N235SE-10 [42]

[42] http://www.tsokaktsis-solar.gr/Product.aspx?pid=261

The Vertical wind turbine has these characteristics:

Product name	**Eddy GT**[43]	**Helix S322**[44]
		
Physical		
	Vertical	Vertical
Height	2.7m (8.85 ft)	2.65m
Width	1.8 m (5.9 ft)	1.21m
Weight	175 kg (386 lb)	135 kg
Swept Area	4.62 m^2 (50 ft^2)	
Blade Materials	Carbon Fiber & Fiberglass	Ultra Tough Aluminium Alloy
Performance		
Rated Power	1000 W	2000 W
Cut-in Wind Speed	3.5 m/s (7 mph)	5 m/s (11 mph)
Rated RPM	180 RPM	
Survival Wind Speed	55 m/s (123 mph)	
Rated Wind Speed	12 m/s (26 mph)	16 m/s (36 mph)
Annual Energy at 5.5 m/s	1750 kWh/yr	1500 kWh/yr
Sound level at 12 m/s according	to IEC 61400-11: < 38 dB	
Electric Generation		
Grid-Compatible	110V, 120V, 208V, 220V, 230V, 240V	110 VAC - 240 VAC
Rated Output		
Off-Grid	24 Vdc	24 Vdc
Grid-Tie	600 Vdc	600 Vdc
Price in dkk	69.900,00 dkk	58.288,83 dkk

Table 4: Specifications for the vertical Wind turbines

[43] http://www.urbangreenenergy.com/
[44] http://www.helix.com

3.3.9. Energy needs

Each rental station it has to serve the bikes and the equipment. Each bike has a battery of 250Whatts and the total energy for 8 bikes its 0.4kW. The extra need fro the equipment are the inverter[45] (0.25W), the computer (250W), the LCD monitor (50W), the camera (0.75W) 24h for 360 d of the year the 2 led lamps (24 W) and Led[46] tape 50W/m 14m each advertisement board and 3 board needs (450 W). Approximately the total energy needs are 1.175 kW. The roof surface has lent 8m and width 3,2 that give as 25.6m^2 sure face to apply 12 LG PV modules 0,235kw each one, total energy size 2,82 kW.

3.3.9.1. The Energy Price policy in Denmark

The application for all the renewable energy sources is based on a relationship between the apply cost, the efficiency, and the market price for this energy. After the market research and decision for which system it will be used, the best step is the available resources, and in this case the resources are depend from the meteorological data of the specific area in which to implement the solar system and the e-bike station, and combine them with the economics of the region.

For Wind energy

The market output of wind energy operation is DKK 0.12 per kWh and is granted for electricity production corresponding to 12,000 full-load hours for double the installed capacity of the decommissioned wind turbine. However, if the total amount of this price supplement of DKK 0.12 per kWh, the market price and the ordinary price supplement of DKK 0.10 per kWh exceeds DKK 0.48 per kWh, the price supplement of DKK 0.12 per kWh will be reduced.

[45] http://www.tsokaktsis-solar.gr/Product.aspx?pid=179
[46] http://www.ledworldlighting.com/

For the solar energy

The market output of photovoltaic operation corresponds to 2,00 DKK/kWh for producers until 6kWh[47].

[47] http://www.ens.dk/da-dk/undergrundogforsyning/elogvarmeforsyning/elforsyning/elproduktion/stoette_til_vedvarende_energi/solceller/sider/forside.aspx

3.3.10. Meteorological data

The renewable energy systems are interrelated with the weather and more specify with the meteorological data. For that reason before to invest in a specific area it is necessary to advise the energy maps. The energy maps include information about the wind speed, the solar radiation, the temperature, and the moisture, of any location. The first two its the basics, in order to figure out if there are available sources in the area, and the other two if the energy systems are able to work in a properly way with safety and high efficiency. The energy data for the city of Horsens are:

For the wind energy[48] the annual wind speed is 8 knots that is equal with 4 m/s.

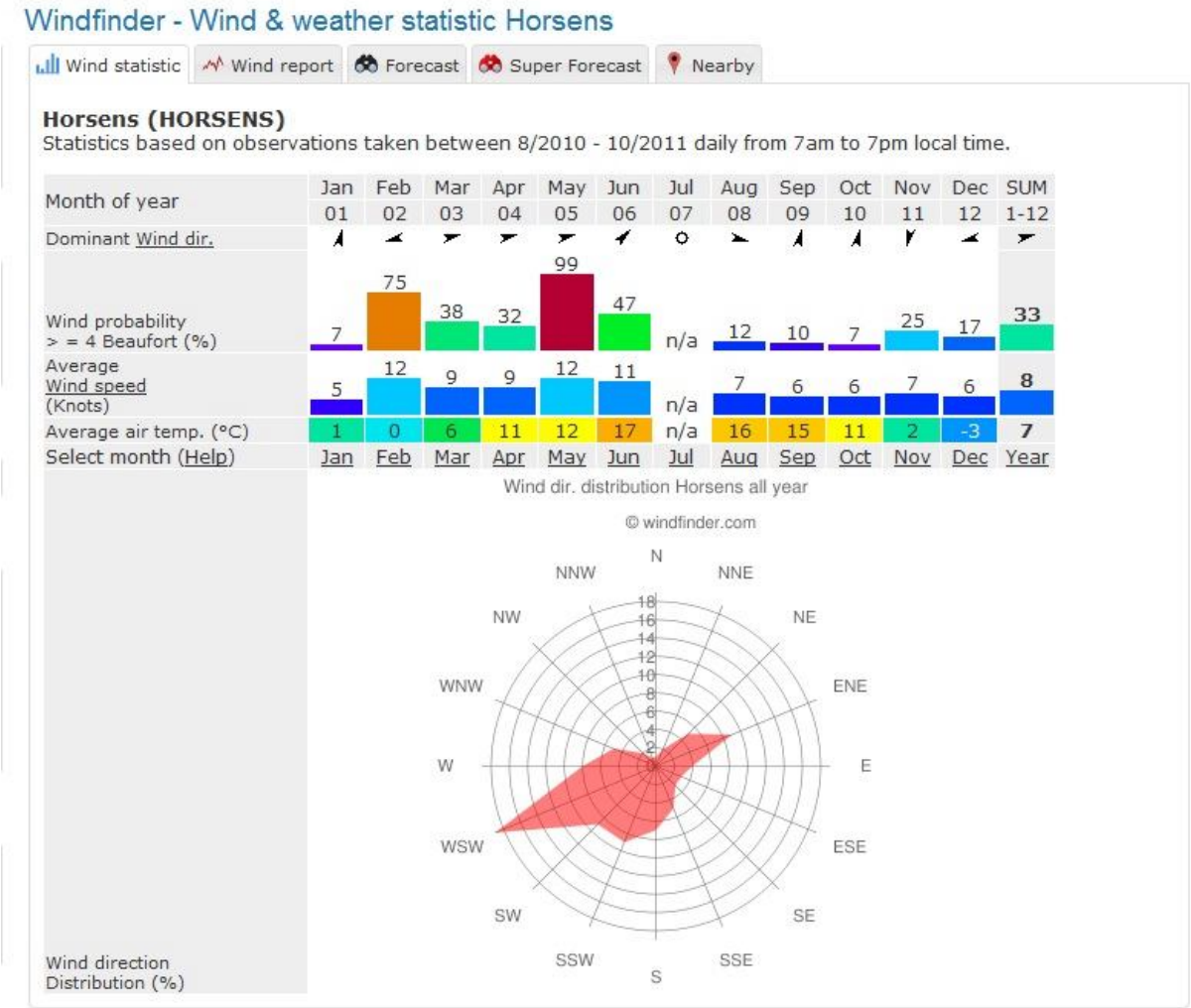


Figure 28 Weather statistics data for the city of Horsens

[48] http://www.windfinder.com/

For the solar irradiation is close to 864 kWh/kWp

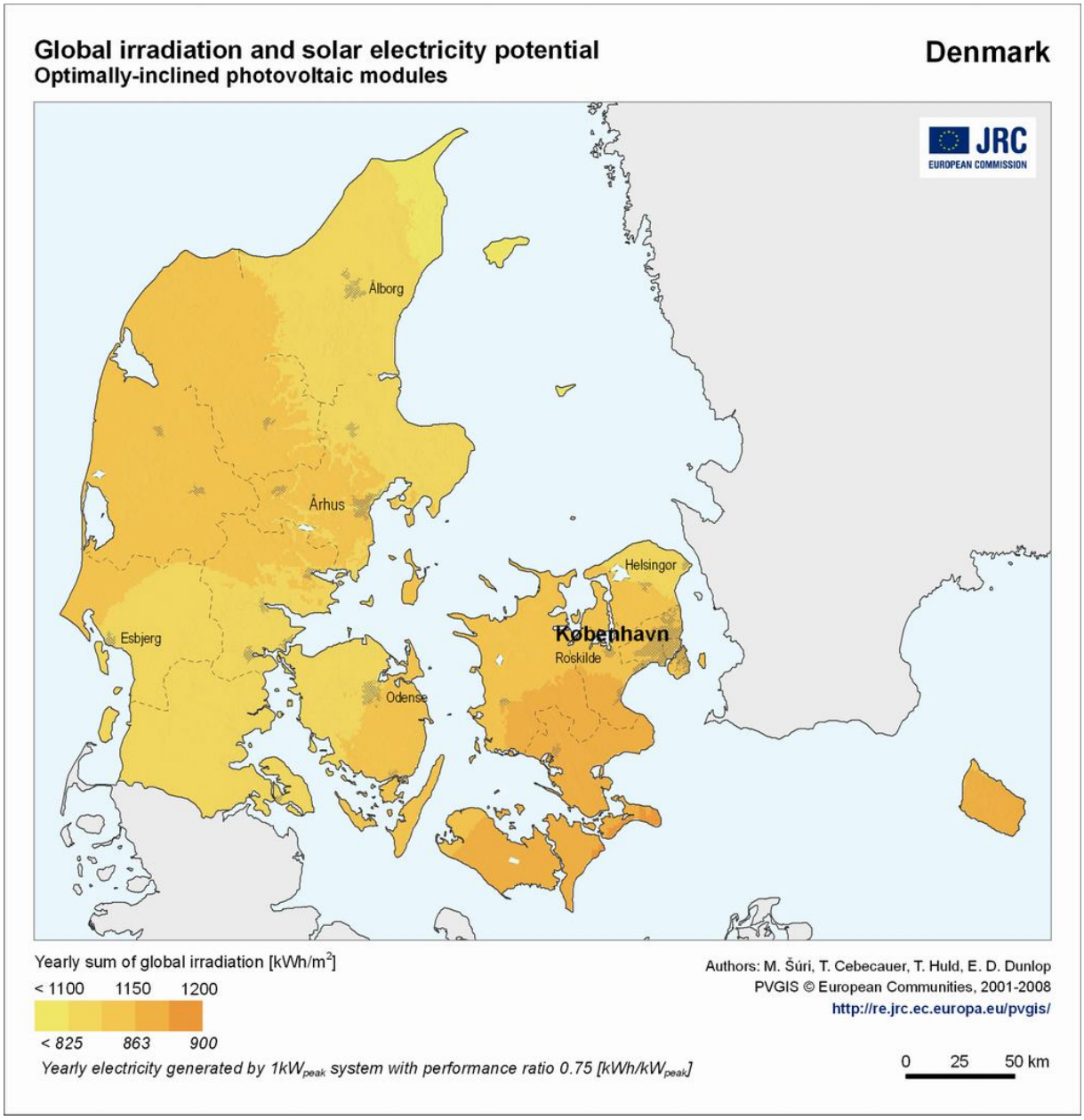


Figure 29 Global Irradiation and sola electricity potential for Denmark

3.4. Produced energy analysis

3.4.1. Wind Energy Analysis

In this project the chosen location is the city of Horsens, who the wind potential, based on annual measurements about the wind speed, is marginal, only 4 m/s (table 3.3) which is all most the minimum wind speed in order the wind turbine start to producing electricity (Cut in Wind-Speed 3.5 m/s Table 3.2) That fact make the application of wind turbine unprofitable, cause the wind turbine with this amount of energy is no able to produce the necessary amount of energy in order to produce profit even the cost market. That's happening cause the wind turbine rated power is min 1kW, and the power curve of eddy GT vertical wind turbine (Figure 3.1) sow as that with 4 m/s the wind turbine producing approximately 0,05kW, that means it will produce in one year 8640h x 0,05 kW = 432kWh pear year. The profit bye selling this energy to the local grid is 432kWh (pear year) x 0,60 DKK/kWh = 609,12 DKK pear year, and in 20 years it will be 12.182,40 DKK when the market cost is 69.900,00 DKK.

If the location it was deferment with higher wind speed like Hals in Aalborg with 10,2 m/s annual average wind speed the profit it will be approximately in 20 years 2676,80 dkk. It's still the profit to be really small, but at list in this case if cause of the investment is to provide the renewable energy, or education. But in the case that the wind speed it was the property like 14,5 m/s the profit from Eddy GT in 20 years it will be approximately 59.700,00 dkk or with Helix S322 it will be 43.711,67 dkk.

`Rated Power of one wind turbine of 1 kW	Wind speed m/s	Price dkk/Kwh	Produced energy by the Wind speed kW	Produced energy by the annual speed per year kW	Incoming in dkk	Incoming in 20 years dkk	Profit in dkk
Price of eddy GT in dkk	4	0,6	0,05	432,00	259,2	5184,00	-64716,00
69.900,00	10,2		0,7	6048,00	3628,8	72576,00	2.676,00
	14,5		1,25	10800,00	6480	129600,00	59.700,00
Price of Helix S322 in dkk	4	0,6	Cut in W.S. 5 m / s	0,00	0	0,00	-
58.288,33	10,2			2000,00	1200	24000,00	-34.288,33
	14,5			8500,00	5100	102000,00	43.711,67

Table 5 Calculations about annual wind speed, produced energy, market cost, and profit

3.4.2. Solar Energy Analysis

The solar analysis has specific characteristics. There are different aspects of solar irradiation, which differ between specific locations on earth. These aspects affect the angle of PV system and the temperature. This project analysis is based on "Photovoltaic Geographical Information System - Interactive Maps"[49]. The city of Horsens has a specific location: 55°51'37" North, 9°50'26" East. These coordinates can be used with the solar radiation database: PVGIS-classic. By adding the installed peak PV power and the PV technology the program calculating the:

- Average daily electricity production from the given system (kWh)

[49] http://re.jrc.ec.europa.eu/pvgis/apps4/databasehelp_en.html

- Average monthly electricity production from the given system (kWh)
- Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)
- Average sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)

Additionally estimated several losses, like losses form the temperature, or from the angular reflectance effects, and also other losses from the cables, inverter and generally combined PV system losses.

Due to the fact that the project deals with two different concepts of energy production (regarding the two different types of PV panels), the following calculations will be done for both PV panels. By investigating all the different aspects, which will be done by the calculations, the different advantages and disadvantages of both PV panel will become visible.

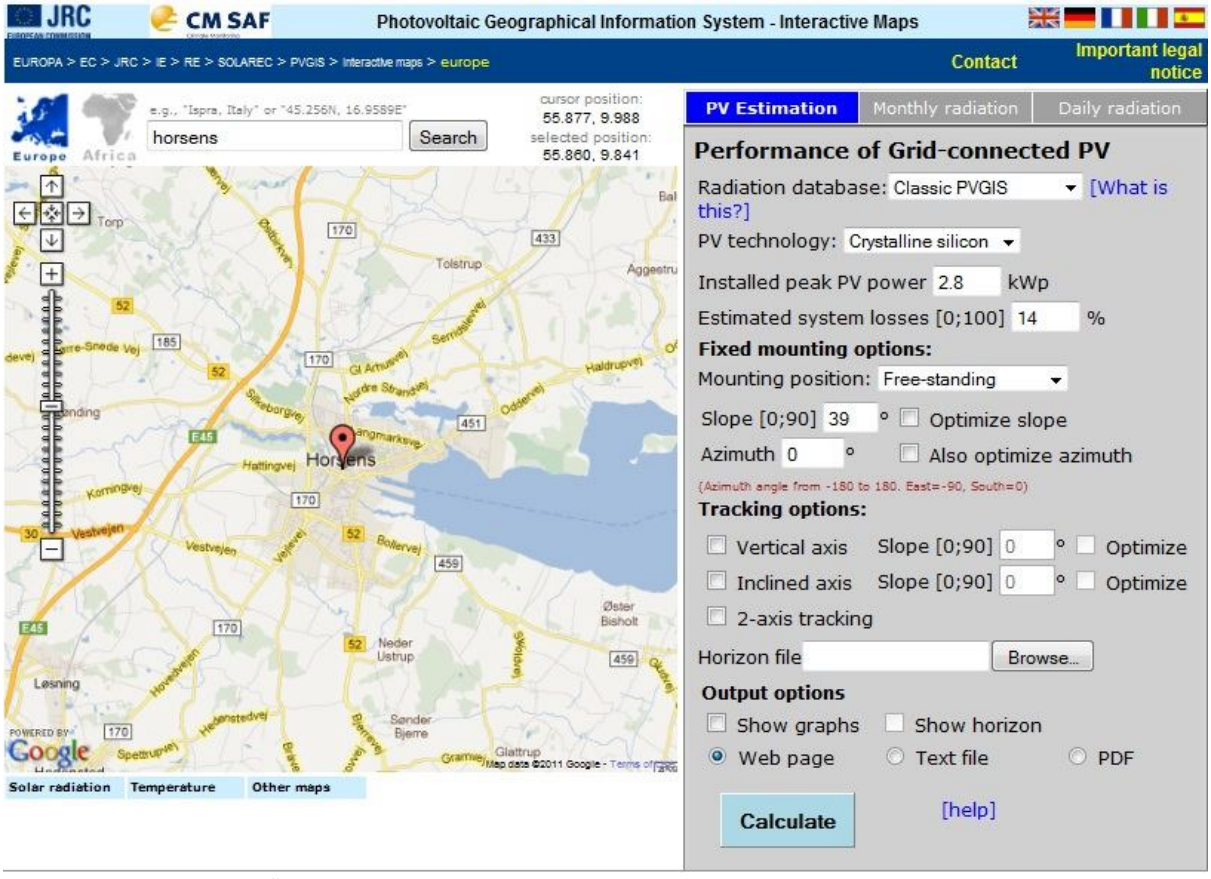


Figure 30 "Photovoltaic Geographical Information System - Interactive Maps"

Nominal power of the SANYO PV system: 2.8 kW (Hybrid)

Estimated losses due to temperature: 8.3% (using local ambient temperature)

Estimated loss due to angular reflectance effects: 3.0%

Other losses (cables, inverter etc.): 14.0%

Combined PV system losses: 23.5%

Fixed system: inclination=39°, orientation=-2° (optimum)				
Month	**E_d**	**E_m**	**H_d**	**H_m**
Jan	2.15	66.8	0.9	28
Feb	4.24	119	1.82	51
Mar	6.05	188	2.67	82.9
Apr	9.31	279	4.27	128
May	11	342	5.26	163
Jun	10.4	313	5.02	151
Jul	10.6	329	5.12	159
Aug	9.39	291	4.53	140
Sep	7.16	215	3.34	100
Oct	4.67	145	2.09	64.7
Nov	2.79	83.8	1.2	36
Dec	1.52	47.2	0.64	19.8
Yearly average	**6.62**	**201**	**3.08**	**93.6**
Total for year	**2420**		**1120**	

Table 6 Average daily, monthly and total year electricity production from the 2.8kW SANYO PV solar system (kWh)

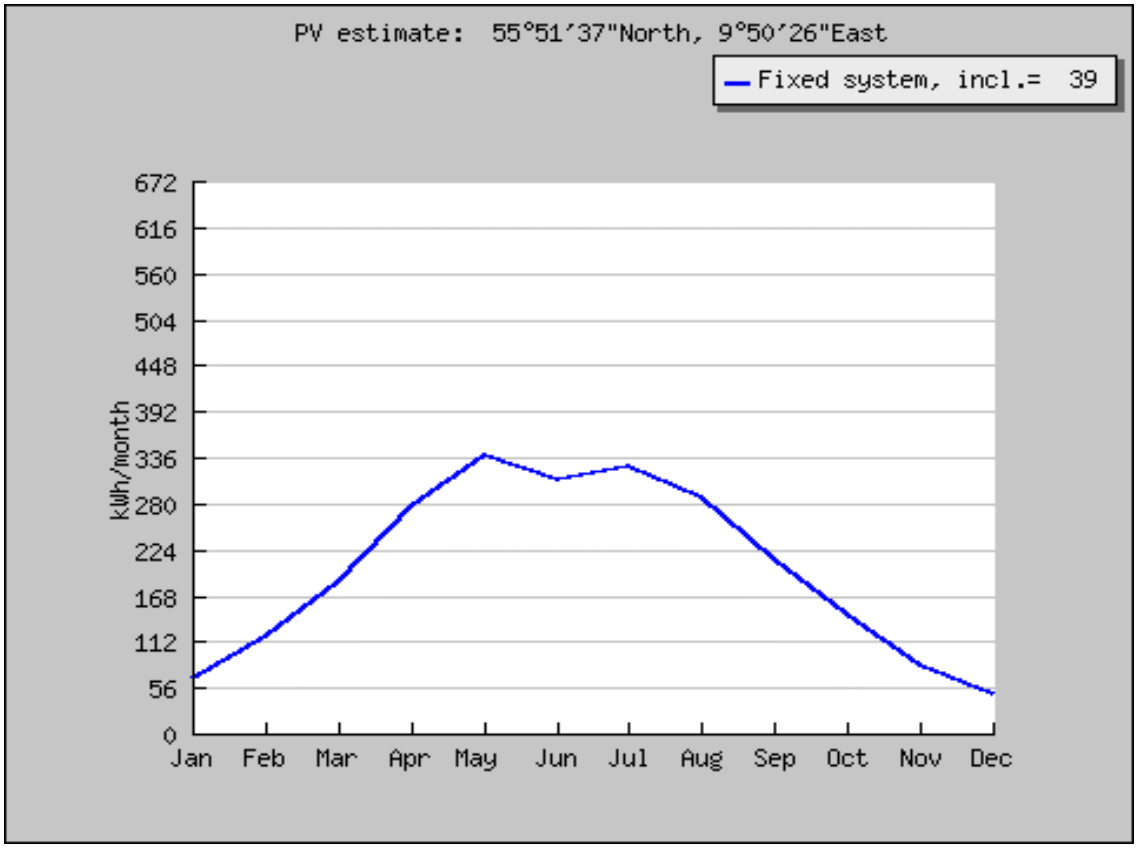


Table 7 Annual graph of produced energy fro 2.8 kW SANYO PV system

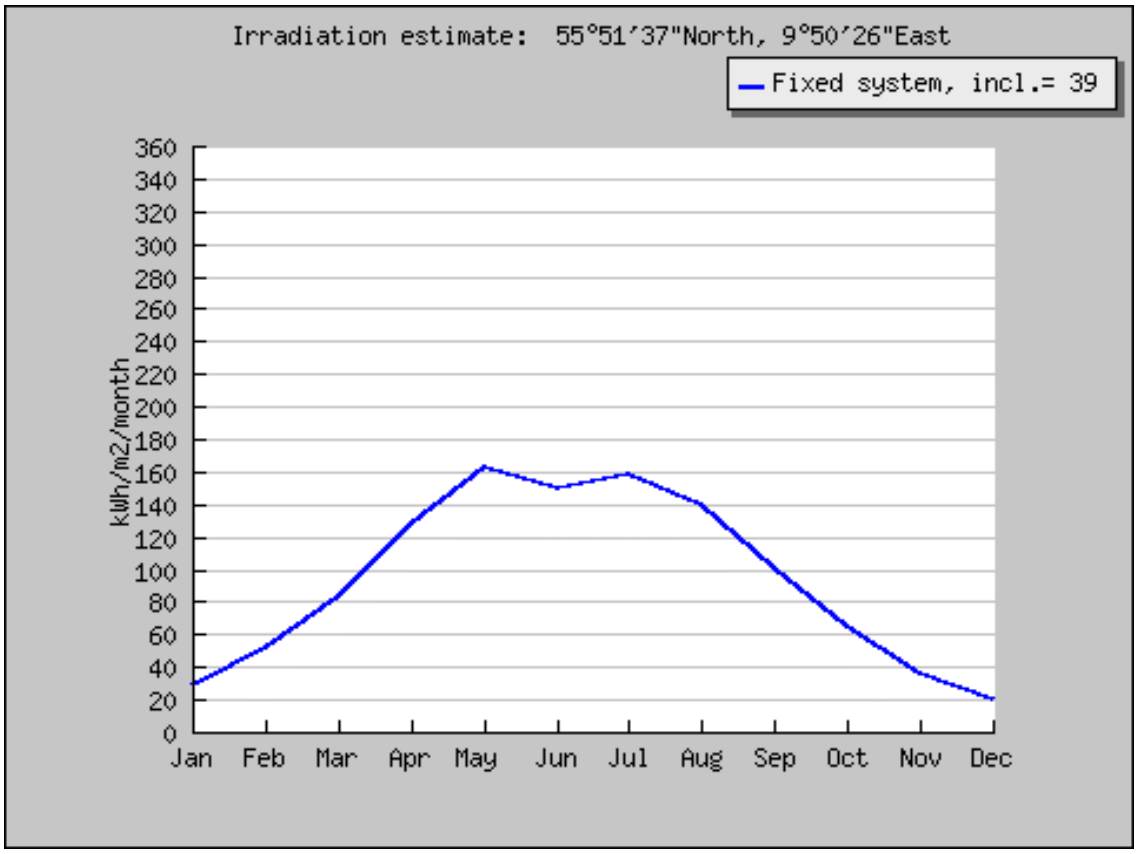


Table 8 Annual graph of produced energy fro 2.8 kW per m² SANYO PV system

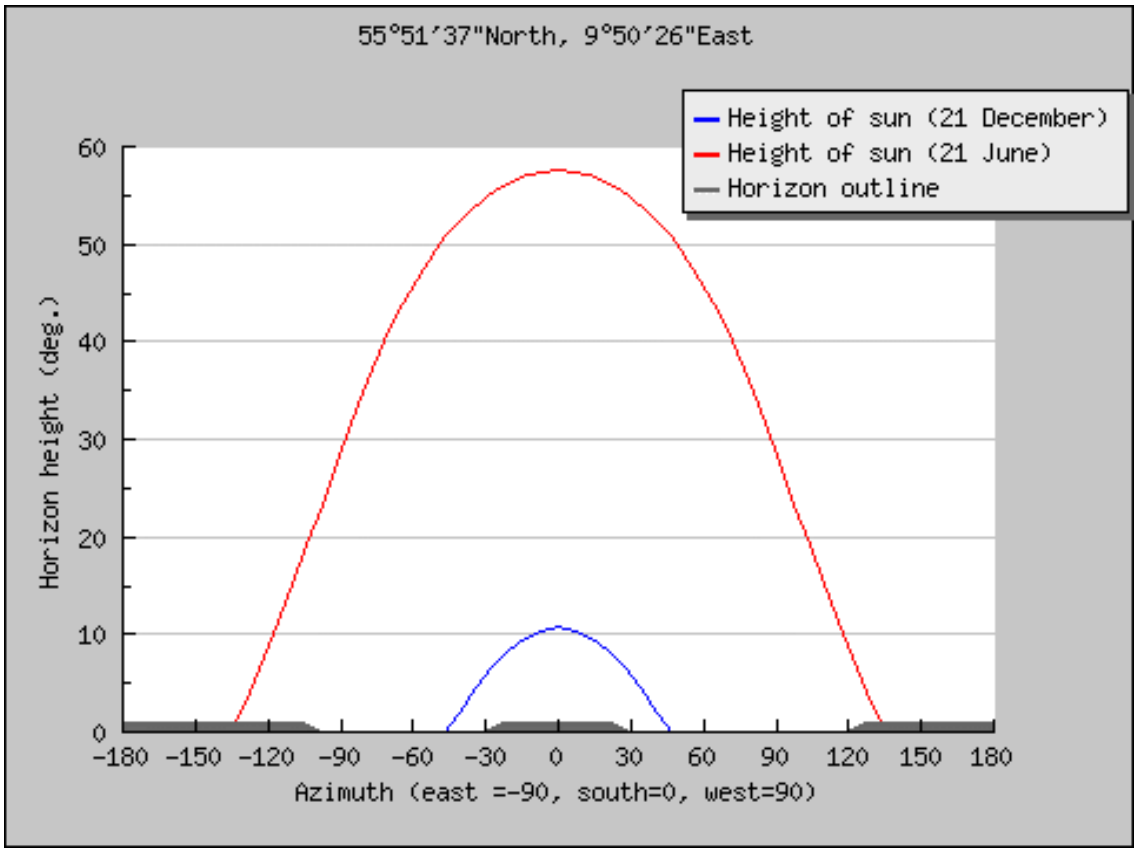


Figure 31: Effect of relation between angle and azimuth fro 2.8 kW SANYO PV solar system

Nominal power of the LG PV system: 2.4 kW (monocrystalic silicon)

Estimated losses due to temperature: 8.3% (using local ambient temperature)

Estimated loss due to angular reflectance effects: 3.0%

Other losses (cables, inverter etc.): 14.0%

Combined PV system losses: 23.5%

Fixed system: inclination=39°, orientation=0°				
Month	**E_d**	**E_m**	**H_d**	**H_m**
Jan	1.85	57.4	0.91	28.3
Feb	3.63	102	1.83	51.3
Mar	5.16	160	2.68	83.1
Apr	7.92	238	4.27	128
May	9.34	289	5.24	163
Jun	8.85	265	5	150
Jul	8.99	279	5.1	158
Aug	7.98	247	4.52	140
Sep	6.1	183	3.35	100
Oct	3.99	124	2.1	65.1
Nov	2.4	71.9	1.21	36.3
Dec	1.31	40.6	0.65	20
Yearly average	**5.64**	**171**	**3.08**	**93.6**
Total for year	**2060**		**1120**	

Table 9 Average daily, monthly and total year electricity production from the 2.4kW LG PV solar system (kWh)

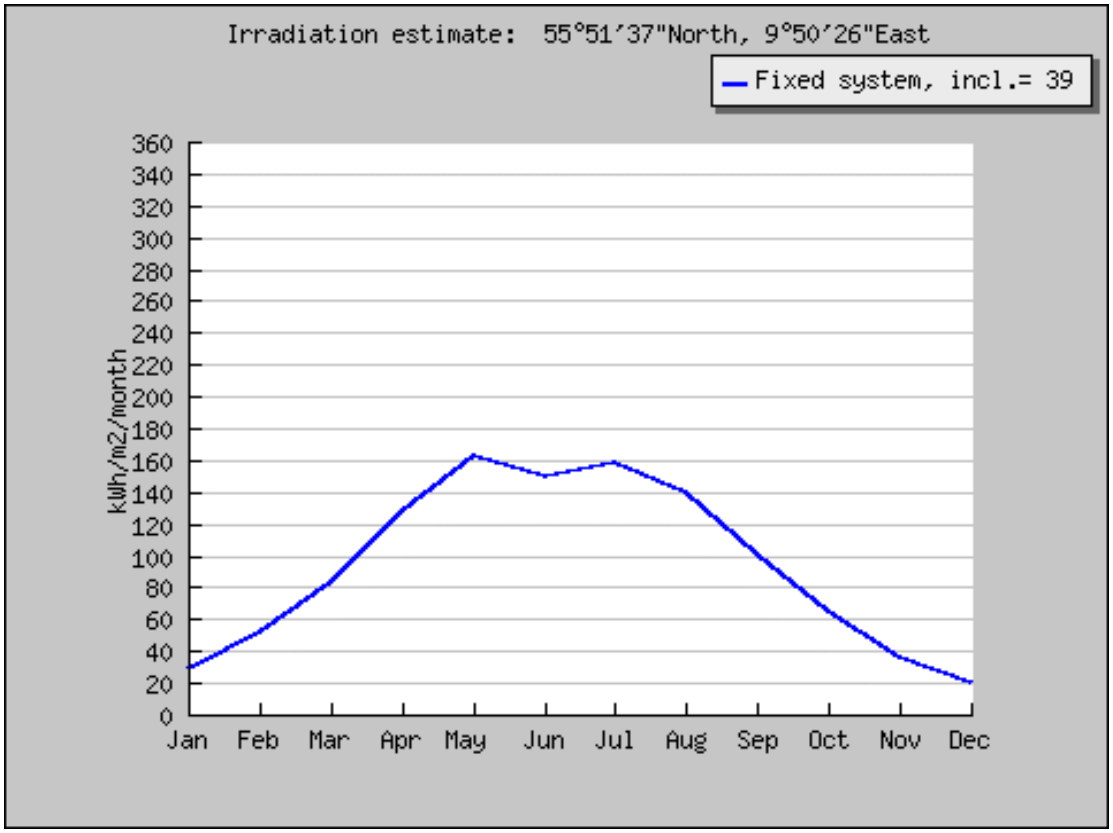


Figure 32: Anual graf of produced energy for 2.4 kW LG PV system

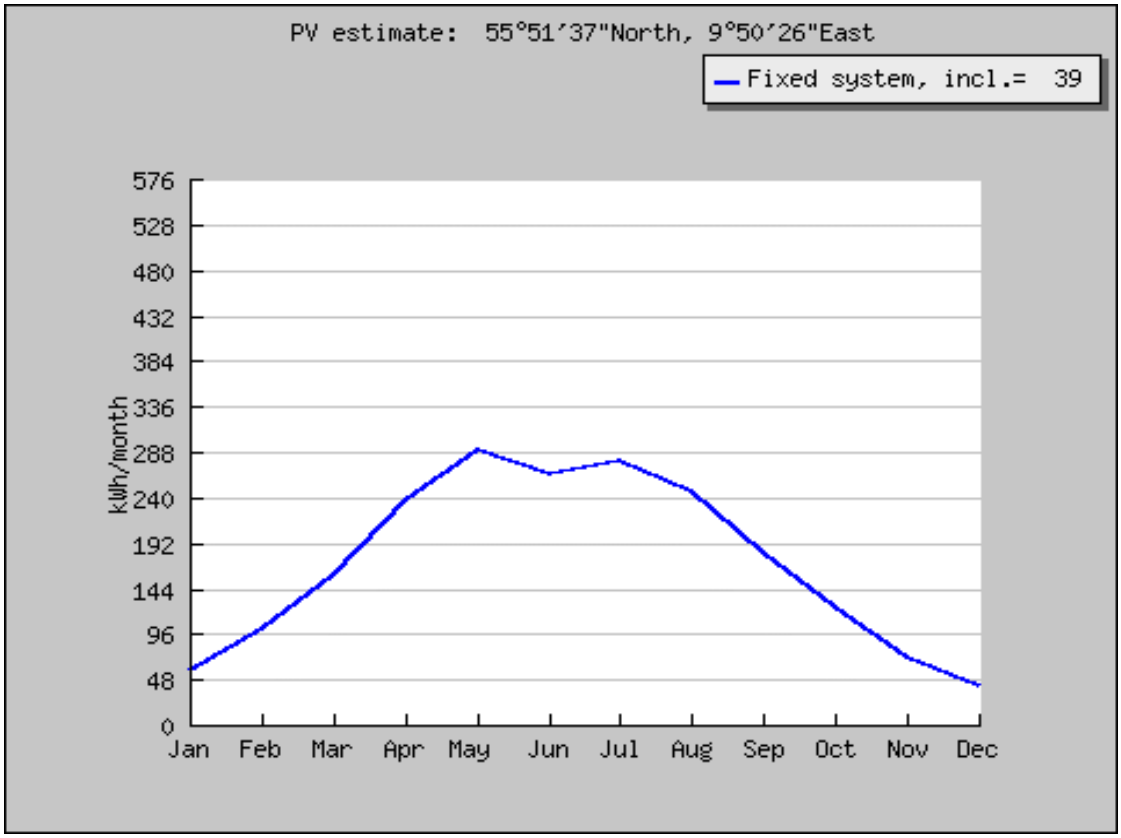


Figure 33: Annual graf of produced energy fro 2.4 kW per m² LG PV system

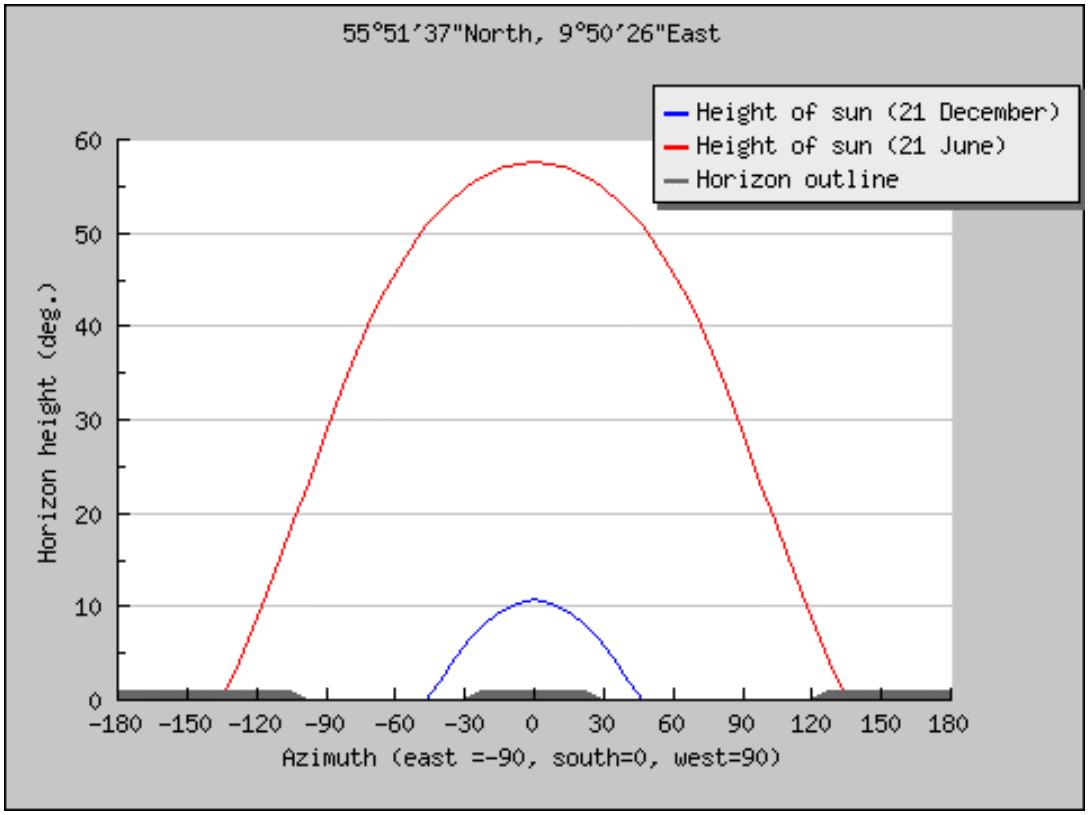


Figure 34: Effect of relation between angle and asimoth fro 2.4 kW LG PV solar system

E_d: Average daily electricity production from the given system (kWh)

E_m: Average monthly electricity production from the given system (kWh)

H_d: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)

H_m: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)

In the region of Horsens the annual average of solar irradiation corresponds to 858.15kWh/kWp Table . The LG solar system has 12 PV panels and each one has 0,235kwp with 14,6% efficiency and the total Power is 2,82 kWp. The annual produced energy it will be 2,42 kWp x 858.15 kWh/kWp = 2077.24kWh. By offering that energy to the local grid with price 2,00 dkk / kWh you earn 4154.48 dkk and in 20 years, 83089.55 dkk. That means the profit it will be close to 54438.95 dkk and that make this investment acceptable and profitable. Other wise by choosing the SANYO solar system has 14 PV panels and each one has 0,235kwp with 18,6% efficiency and the total Power is 2,82 kWp. The annual produced energy it will be

2.81kWp x 858.15 kWh/kWp = 2416.23kWh. By offering that energy to the local grid with price 2,00 dkk / kWh you earn 4832.46 dkk and in 20 years, 96649.13 dkk. In this case the profit it will be close to 46249.13 dkk that is lower comparing that with LG system but the big advantages with this solution is that this system is able to produce 6779.79kWh more energy in 20 years which implies less 2955.99 tons CO_2 in the atmoshere, and at this time in the stock market the price for each tone of CO_2 is close 100€/tone CO_2.

Number of LG PV Panels	Size of pv panel m2	Energy per Pv Panel kW	Solar Irradiation kWh/m2	Price dkk/Kwh	Total energy from The Con kW	Total produced energy from The System
12	1.61	0.125	858.15	2.00	2.421	2077.24
Incoming per year in dkk	Total Surface of PV panels	Incoming in 20 years dkk	Price per Panel in dkk	Price of 12 Panels	The Profit in dkk	
4154.48	19.32	83089.55	2,387.55	28650.60	54438.95	

Table 10 Produced energy from the LG PV system and the Profit

Number of Sanyo PV Panels	Size of pv panel m2	Energy per Pv Panel kW	Solar Irradiation kWh/m2	Price dkk/Kwh	Total energy from The Con kW	Total produced energy from The System
14	1.26	0.160	858.15	2.00	2.816	2416.23
Incoming per year in dkk	Total Surface of PV panels	Incoming in 20 years dkk	Price per Panel in dkk	Price of 12 Panels	The Profit in dkk	
4832.46	17.64	96649.13	3,600.00	50400.00	46249.13	

Table 11 Produced energy from the SANYO PV system and the Profit.

Number of PV Panels	Total produced energy from The System in 20 years kWh	Buy Coast	Incoming in 20 years dkk	The Profit in dkk	Saved tones of CO2
12	41544.77	28650.60	83089.55	54438.95	18113.52
14	48324.56	50400.00	96649.13	46249.13	21069.51

Table 12 Total Produced energy, Saved tones of CO_2 and the profit of each system

Energy per Pv Panel kWh from the Table 4	Price dkk/Kwh	Incoming per year in dkk	Incoming in 20 years dkk
2420	1,41	3412,2	**68244,00**

Solar Irradiation for Horsens is
858,1578 kWh/m^2

Table 13 Solar irradiation for the city of Horsens.

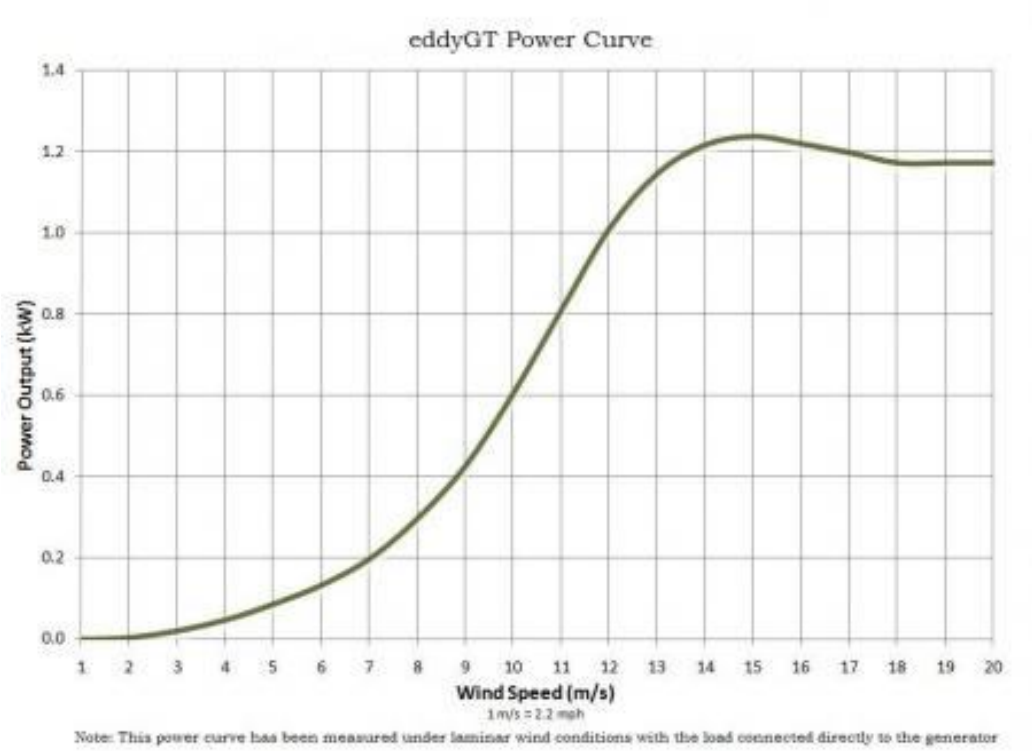


Figure 35: Annual prudaction Curve of eddy GT vertical wind turbine

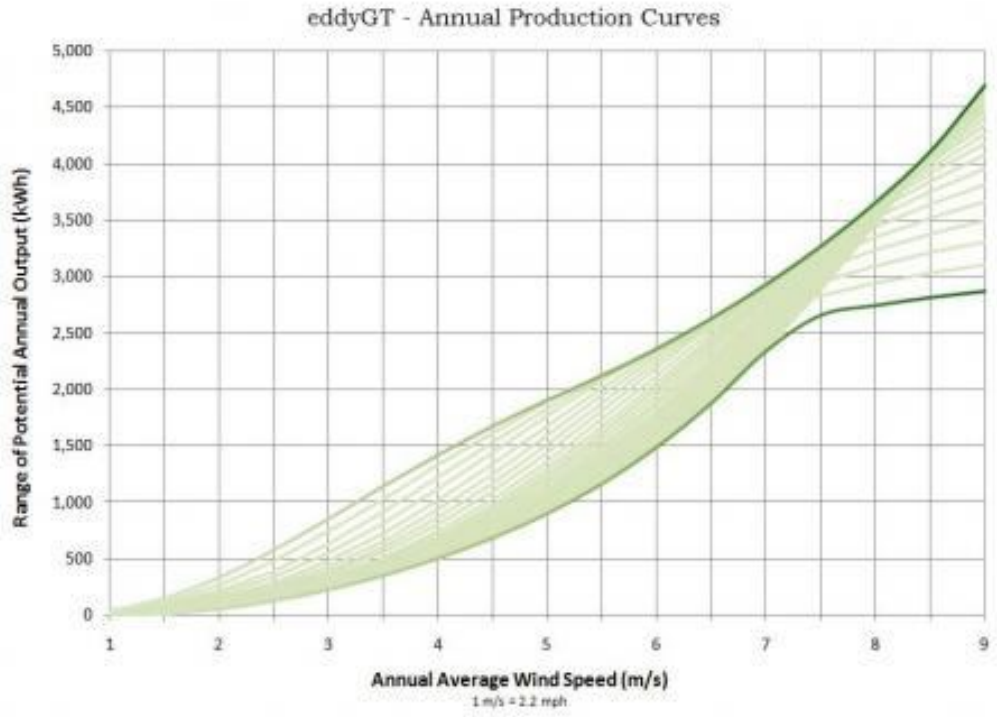


Figure 36: Power Curve of eddy GT vertical wind turbine

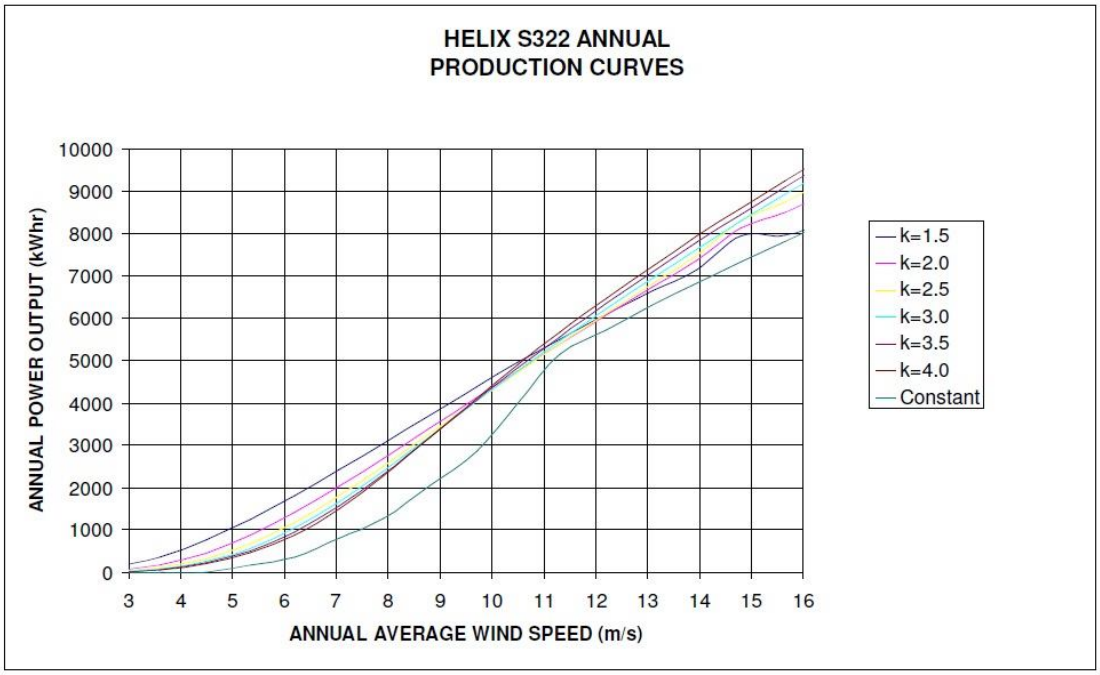


Figure 37: Power Curve of Helix S322 vertical wind turbine

3.5. Conclusion

From the available renewable systems and suitable sources for electricity production about this projects purpose are wind turbines and solar panels. Due to this fact, only solar and wind energy it will be investigated in the further project. This project is motivated by the great environmental concerns and the imperative need for a Resource Efficient World have consequently led scientists towards the exploration of new technology that would lead to the optimal exploitation of renewable resources, such as the wind power and the promising new technology that will allow the exploitation of its energy even at lower wind speeds. Indicative to this trend, of this turn towards the wind power, are the data published by the Global Wind Energy Council which states that: "projects global wind capacity will reach 332 GW by 2013, almost triple its current size, with growth especially concentrated in the United States and China. In 2013 alone, new installations could reach 56 GW, more than double the current annual global market"[50].

50 http://www.gwec.net/fileadmin/documents/Publications/Global%20Wind%202008%20Report.pdf

Several thorough studies that have been done have also indicated that the benefits of using wind energy will not only enhance substantially the global efforts for the reduction of greenhouse effects and the saving of water resources but will also facilitate development and thus the creation of a lot of new 'green' jobs, factor that will tackle the grave problem of unemployment[51] . However, the exploitation of wind power could be one of the keys to address the nowadays challenge for the need of a resource efficient and less dependent to fossil fuels world. Specially in this effort the solar energy technologies can support it cause are developing dynamically over the last decade. A continuously increasing number of architects, civil engineers and contractors recognize the value of solar systems and apply them in their constructions. This effort is supported by the government's initiatives such as tax incentives and local communities by investing in these systems, making them more affordable. In addition, as the cost of solar photovoltaic energy continues to decrease, these systems will penetrate the market even more. The trend for the coming years is that the solar PV industry aims to provide 50%[52] of total electricity generation in the U.S. until 2025. Solar energy will play a leading role in ending global dependence on fossil fuels to combat the threat of global warming, and safeguarding the future based on clean and sustainable energy.

[51] http://www.20percentwind.org/Black_Veatch_20_Percent_Report.pdf
[52]http://www.ucsusa.org/clean_energy/technology_and_impacts/energy_technologies/how-solar-energy-works.html#Photovoltaics

4. Chapter

4.1. Introduction

In this chapter the team group decided to insert the market research that they did for choose all the components necessary for the station and their prices. In the same section are selected the places in Horsens where will be placed the renting points.

4.2. Product (Laura R.)

The product offered to the customers is a combination of different components that are already on the market. The different components are described below:

- Electric Bike: To allow all people, young and old, to use the service it was introduced an electrical bike and not normal ones. Everyone, with the motor assist, can move in Horsens, so also the old people, who can not move with normal bike, may start to have a fun bike tour around the city.
- Solar panel: In order to recharge the electric bikes were implemented a system with solar panel, so will be used green energy and not the normal electricity.
- Charging column: To allow the e-bike to reload with the energy stored from solar panels.
- GPS Tracker: Placing a GPS tracker on the e-bikes is possible to know the exact location of them. This is useful for the manager of the rental who can see where his e-bikes are and for the people that want rent them to know on the web site where they are available.
- Canopy: In order to cover the electrical bike and the other product and to protect them from the bad weather (rain, snow, etc.) the station need a canopy.
- Kiosk: To pay the rent for the e-bikes. Before rent them, the customer have to make sure that the bike is in good condition, in order to blame someone in case of breakages.
- Modem Wi-Fi: To allow the connection between our station and the web site.

- Seven-Segment Display: To indicate how many e-bikes there are in the station
- Security System: it could be possible two different security systems: firstly, is to defend the e-bikes against thieves; secondly, to protect all the components of the product from fire.
- Lighting system: To illuminate the station during the night and in the dark days.
- Web site: To book e-bikes on-line and see where they are located. In the web site is possible book also the free spaces where the costumers want to leave their e-bike. The web site is also useful to advertise our product.

4.2.1. Electric bike (Laura R.)

Electrical bikes came to Denmark for the first time around the year 1998 and previously were electrical bikes mostly a thing for the elderly or the disabled, but today it is slowly beginning to change, so also ordinary people are using electrical bikes. An important explanation is that modern electrical bikes have gotten more modern design and now looks like any other bike. In Holland, a country where they traditionally use bicycles a lot there was in 2007 sold 100,000 electrical bikes, which represents approximately 10% of the market. If there were an equal number sold in Denmark it would equate to a figure of 50,000 cycles[53]. Globally are electrical bicycles sold in the millions and this figure is expected to rise because prices of electrical bikes are constantly falling, while the quality keeps getting better - bikes are running longer and longer on a charge simultaneously with the batteries that are getting lighter and the bikes get a nicer design. On the market there are a lot of different types of electric bikes: by function (racing, recreation, etc.); number of riders (one, two, or more); by construction or frame type (upright, folding, etc.); by gearing (single speed, derailleur gears, etc.); by sport (mountain biking, BMX, triathlon, etc.); by means of propulsion (human-powered, motor-assisted, etc.); and by rider position (upright, recumbent, etc.). In the *Green Mobility*'s renting stations the EWheels model EW-620LA[54] is the solution.

[53] http://www.folkecenter.net/gb/rd/transport/two-three-wheels/
[54]http://www.amazon.com/dp/B004FWM0D4/ref=asc_df_B004FWM0D41752177?smid=A1Y31HCJ2WOJLN&tag=nextagusmp0381789-20&linkCode=asn&creative=395105&creativeASIN=B004FWM0D4

Figure 38: Electric Bike

This bike is really easy to use. The central tube of frame of bike is not invasive and all the people, also the older ones, can get on the bike. The seat and the handlebars allow the rider to sit in a more upright position. Also, the tires are a medium width hybrid type for a comfortable ride. There are a lot of possible colours: the orange one distinguishes the bike from this project.

Colour	Light Blue, Pink, Orange
Power	Electric
Watts	250 W
Motor Type	Brushless motor rear drive
Gears and speed	Shimano derailleur six speed
Amps	10 AH
Volts	24 V
Batteries	Lied acid
Tire size	26”*2.125” dual wall alloy
Charger	Smart charger included
Speed	Up to 17 MPH or 27,36 km/h
Distance	Up to 15 miles or 24 km per charge-can still pedal if charge is lost (distance varies by riders weight, terrain, road surface etc.)
Throttle Type	Variable speed control- Twist Throttle-or-pedal assisted
Key start	Yes
Frame type	Steel
Braking System	Front brake V-Brake, rear brake expansion brake
Drive system	Rear hub motor (motor is in rear rim) or Pedal Power
Head light	Yes
Weight	31.3 kg (69 lbs)
Battery indicator	Yes
Cargo Rack	Yes

Table 14: Characteristics of the electric bike

4.2.2. Solar panel (Laura R.)

Figure 39: Solar panel system

A solar cell is a device that converts solar energy directly into electricity by the photovoltaic effect and is used as a current generator in a photovoltaic system. A solar panel (photovoltaic module or photovoltaic panel) is a packaged, connected assembly of solar cells, also known as *photovoltaic cells*. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in different applications. Because a single solar panel can produce only a limited amount of power, many installations contain several panels.

The types of solar panel that the bike station need were chosen in a group of ten different products with different characteristics. These ten solar panels are selected by mechanical engineers, Nikos and Tobias, based on a data collection.

Company	Model	Type	Surface (m)	Efficiency W/m2	Watt Peak	Price
HIT	250E01	Hybrid	1,39	18%	250	511,00€
SANYO HIT	N235SE-10	Hybrid	1,26	18,60%	235	480,00€
CONERGY	PP 230 M	Monocristalline	1,63	14,13%	235	417,00€
BP SOLAR	3230N 230Wp	Polycrystalline	1,67	13,80%	235	430,97€
TRINA SOLAR MODULE	TSM-235PC05	Polycrystalline	1,64	14,4%	235	319,62€
KYOCERA	KD235GH-2PB	Polycrystalline	1,65	14,28%	235	321,95€
SOLON SOLAR MODULE	230/07 Blue	Monocristalline	1,64	14,63%	230	492,97€
SUNTECH	STP280-24/Vd	Polycrystalline	1,94	14,40%	280	348,51€
REC	REC240PE	Polycrystalline	1,65	14,50%	240	345,46€
LG	235M1C-G2	Monocrystalline	1,61	14,60%	235	318,37€

Table 15: Different types of PV panels

Between these ten solar panels the mechanical engineers, who have the knowledge necessary, chose three of them that they think are the best ones: one monocrystalline, one polycrystalline and one hybrid. They chose the Sanyo for its high efficiency, Suntech for its high watt peak and LG for its low price.
From these three models all the member of the group decide the two types to implement in their two business plans.

In order to achieve this point they did all together an evaluation of them. As the teacher of Project Methodology showed during the course, these students did a similar evaluation for the solar panels [55]. They decided to evaluate their characteristics: price, surface, efficiency and watt peak. For each characteristic was given a weight (for a total of 1) and a score (from 1 to 10). These are the results:

	SANYO HIT- N235SE-10												
	Tobias		Nikos		Fede		Laura R		Laura B				
	Weight	Score	Weight	Score	Weight	Score	Weight	Score	Weight	Score	Average Weight	Total score	Total weight score
Price	0,14	3	0,14	3	0,35	3	0,35	3	0,35	4	0,266	16	4,256
surface	0,21	5	0,21	5	0,15	4	0,15	4	0,2	8	0,184	26	4,784
efficiency	0,36	10	0,36	10	0,3	9	0,28	9	0,3	8	0,32	46	14,72
wattpeak	0,29	7	0,29	7	0,2	4	0,22	4	0,15	4	0,23	26	5,98
	7,1	25	7,1	25	5,15	20	5,05	20	6	24	1	114	29,74

Table 16: Sanyo Panel

	SUNTECH STP 280-24/Vd												
	Tobias		Nikos		Fede		Laura R		LauraB				
	Weight	Score	Weight	Score	Weight	Score	Weight	Score	Weight	Score	Average Weight	Total score	Total weight score
Price	0,14	6	0,14	6	0,35	8	0,35	7	0,35	5	0,266	32	8,512
surface	0,21	8	0,21	8	0,15	8	0,15	8	0,2	4	0,184	36	6,624
efficiency	0,36	3	0,36	3	0,3	3	0,28	2	0,3	3	0,32	14	4,48
wattpeak	0,29	10	0,29	10	0,2	8	0,22	7	0,15	8	0,23	43	9,89
	6,5	27	6,5	27	6,5	27	5,75	24	4,65	20	1	125	29,506

Table 17: Suntech Panel

	LG23 5M1C-G2												
	Tobias		Nikos		Fede		Laura R		Laura B				
	Weight	Score	Weight	Score	Weight	Score	Weight	Score	Weight	Score	Average Weight	Total score	Total weight score
Price	0,14	8	0,14	8	0,35	9	0,35	9	0,35	8	0,266	42	11,172
													0
surface	0,21	7	0,21	7	0,15	6	0,15	5	0,2	6	0,184	31	5,704
													0
efficiency	0,36	2	0,36	2	0,3	6	0,28	6	0,3	5	0,32	21	6,72
													0
wattpeak	0,29	7	0,29	7	0,2	10	0,22	8	0,15	4	0,23	36	8,28
	5,34	24	5,34	24	7,85	31	7,34	28	6,1	23	1	130	31,876

Table 18: Suntech Panel

[55] Lecture_19_21_Analysis_Idea_Generation_decision_making.pptx slide 22

The higher final values are in the LG23 SM1C-G2[56] and in the SANYO HIT-N235SE-10[57]. So, the decision is to implement these two solar panels in our business plans.

4.2.3. Charging Column (Federico)

The charging column is important in order to charge the electric bike and lock it. Tobias designed it and so in the mechanical part there is the specific description. (chapter 6 at the paragraph charging column)

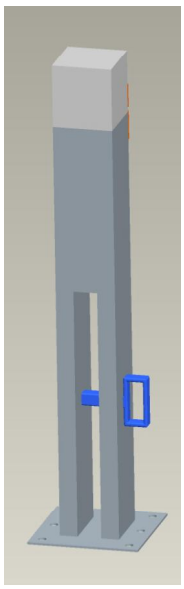


Figure 40: Charging Column

4.2.4. GPS tracker (Laura R.)

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides location and time information with all the weather conditions, anywhere on. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver with some technical limitations, which are only removed for military users. The GPS program provides critical capabilities to military, civil and commercial users around the world.

A GPS tracker is a device that uses the global positioning system to determine the precise location of a person, vehicle, or other asset to which it is attached and to record the position of the asset at regular intervals. The recorded location data can be stored within the tracking unit, or it may be transmitted to a central location data base, or internet-connected computer, using a cellular (GPRS or SMS), radio, or

[56] http://www.tsokaktsis-solar.gr/Product.aspx?pid=261
[57] http://www.tsokaktsis-solar.gr/Product.aspx?pid=258

satellite modem embedded in the unit. This allows the asset's location to be displayed against a map backdrop either in real time or when analysing the track later, using GPS tracking software.

Three different types of GPS tracker constitute the market: data loggers, data pushers and data pullers. The first type simply logs the position of the device at regular intervals in its internal memory. The second one pushes (i.e. "sends") the position of the device as well as other information like speed or altitude at regular intervals, to a determined server that can store and instantly analyse the data. This is the most common type of GPS tracking unit, used for asset tracking, personal tracking and vehicle tracking system. The third one is also known as GPS transponder. Contrary to data pushers, that send the position of the devices at regular intervals (push technology), these devices are always on and can be queried as often as required (pull technology).

The product chosen on the market is an Eglemtek tracker GPS/ GSM/ GPRS locator bike Tk-12[58]. It is possible to implement it on the e-bikes because it is not invasive and heavy. It is a really small product, in fact it stays on one hand.

Figure 41: GPS tracker on a hand

[58] http://www.eglem.com/index.php?page=scheda.php&id=20

The characteristics of Eglemtek GPS tracker are described in this table:

Device Tri-Band GSM/GPRS	900/1800/1900MHz
GPS Chip	Sirfstar III
GPS Module	Simcom
GPS Receiver	20 parallel channels
Button for emergencies	SOS Button
Response time HOT	1 sec "Time To First Fix" TTFF
Response time WARM	35sec TTFF
Response time COLD	45sec TTFF
Accuracy	5 meters
Antenna GSM e GPRS	Internal
Active GPS antenna	Internal
Battery life	48 hours in standby modality if it is completely charge
Measures	65mm x 45mm x 15mm
Weight	50 g
Optimal temperature for operation	-20°C +55°C

Table 19: Characteristics of GPS tracker

4.2.5. Canopy (Laura R.)

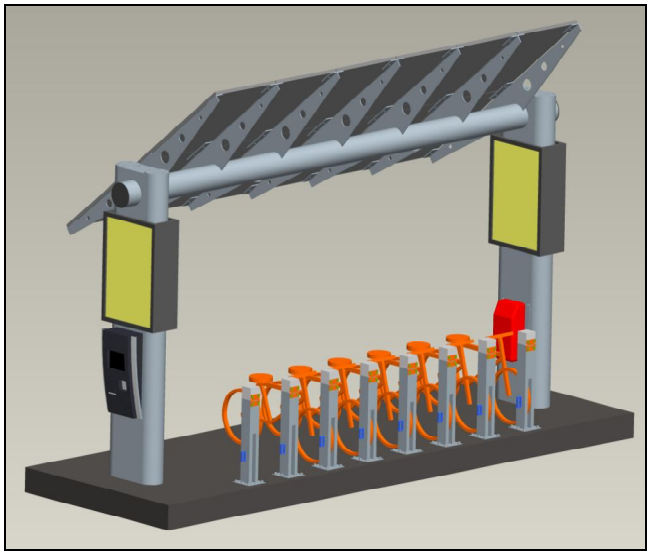


Figure 42: Canopy

The canopy is the construction under which e-bikes are protected. It is composed by two columns and the roof consists in solar panels. The material for our canopy is galvanized steel. Tobias, the mechanical engineer, designed the canopy to make unique our product. For the specific description go to chapter 6 in the paragraph canopy.

4.2.6. The Kiosk (Federico)

Figure 43: Kiosk Protouch - Xen X4

The kiosk is the machine that allow to pay the renting for the electric bike. The market offer some different choises of them with dissimilar characteristic. There are kiosk tuch screen and other with a keyboard. Some only with the cash payment, some only with the card payment and some with both of them.

The kiosk Protouch – Xen X4[59] is composed by:

- 19" LCD Screen
- Mild stell body
- Speakers integrated
- Computer
- Chip and pin

It also contain component like us DSL modem and electronic devices. The kiosk is able to manage the customer data and communicate with the central server by internet. The kiosk gives the user a visual interface giving access to all information on the various stations: number of bikes available, number of empty places, charge level, etc.. The totem also allows the user to report a problem with a bike or a terminal and communicate automatically to service. This kiosk is waterproof and wall mounted type, this allows to be attached on the column.

[59] http://www.protouch.co.uk/Item/CF_X4KIOSK/#overview

4.2.7. DSL Modem (Federico)

Figure 44: Modem ASUS

The need to install a DSL modem at each station to allow the connection of our kiosks to the Internet to communicate with our website move the team members in search of it. The modem is connected to the optical fibber network in the city and offers the possibility to connect via LAN and via Wi-Fi IEEE.

The decision to connect the kiosk to the network via LAN born for two main reasons:

- Connection speed: a normal LAN easily reaches the 100 Mbs;
- Security: to connect to the network is essential to use a LAN port, this prevent anyone not able to open the kiosk to intercept the connection.

The modem chosen is the ASUS DSL-N10[60]. This is a true 2-in-1 device, serving as a wired and wireless modem and router. It combines all the functionality of both device classes, and adds to it with a range of features:

Technical Detail:	
Plug-n-Surf Installation: CD free	
Graphic oriented user interface	
Multiple SSID: bandwidth access control	
5dBi detachable antenna	
Wireless on/off button	
Product Detail:	
Dimension	16.51 x 11.68 x 3 cm
Shipping Weight	0,6 kg
Skipping	Currently, item can be shipped only within the U.S

Table 20: Characteristics of the Modem

[60] http://www.amazon.com/DSL-N10-serving-Wireless-N-coverage-Addition/dp/B0054L6XHY/ref=sr_1_11?s=pc&ie=UTF8&qid=1323252627&sr=1-11

4.2.8. Seven-Segment Display (Federico)

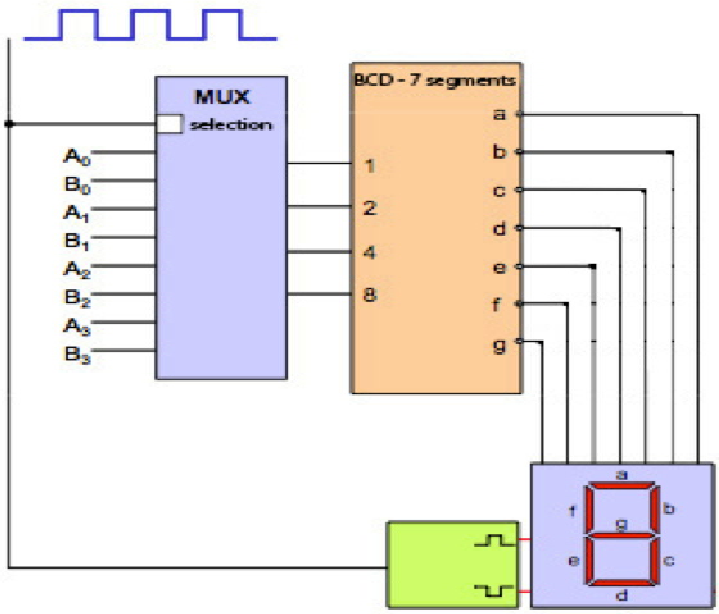


Figure 45: SSD application

The Seven-segment display (SSD) is an electronic component containing seven rectangular LEDs to express decimal numbers. The seven segments are placed in order to form different letters or numbers depending on the electrical impulses they receive from a component called Decoder.

There are two important types of 7-segment LED digital display:

- *The Common Cathode Display (CCD):* in the common cathode display, all the cathode connections of the LED's are joined together to logic "0" and the individual segments are illuminated by application of a "HIGH", logic "1" signal to the individual Anode terminals.
- *The Common Anode Display (CAD):* In the common anode display, all the anode connections of the LED's are joined together to logic "1" and the individual segments are illuminated by connecting the individual Cathode terminals to a "LOW", logic "0" signal.

The CCD is the solution for the bike point. This display is placed in the station in order to inform the customers how many bikes are available. Because when the bikes have the batteries discharged it is not possible rent it.

The product is a Dongguan Houjie Keming Electronic Factory with the follow characteristics:

Number colour	Blue
Surface colour	Black
Number of value	One
Energy	Saving energy
Use	External
OEM	Yes
Dimension	22.2 x 16.7 cm
Number high	20.3
Light intensity	109 mcd/segment

Table 21: Characteristics of the seven-segment-display

4.2.9. Security System (Laura R.)

In the analysis of components of a product is important to not overlook the safety aspects. Offer to the costumers a complete product including also security devices it could be an advantage.

It is possible to think to a security system in two different ways: firstly, to prevent that someone still or damage the structure and bikes; secondly, to limit damages in case of fire.

4.2.9.1. Surveillance camera

Figure 46: Surveillance camera

Surveillance cameras are video cameras used for the purpose of observing an area. They are often connected to a recording device, IP network, and/or watched by a security guard/law enforcement officer. Now with cheaper production techniques, it is simple and inexpensive. Analysis of footage is made easier by automated software that organizes digital video footage into a searchable database, and by automated video analysis software (such as VIRAT and HumanID). The amount of footage is also drastically reduced by motion sensors, which only record when motion is detected.

The use of surveillance cameras by governments and businesses has dramatically increased over the last ten years.

There are on the market different types of surveillance camera: for outdoor or for indoor, static or flexible, big or small and so on. The product that it was found on the market is a Videosecu camera, its item model number is VD60P[61]. This infrared dome camera is designed for outdoor and indoor environment. The weather-proof dome assembly is a versatile, cost-effective, integrated surveillance solution. Its compact size of 3 1/2" is unobtrusive, providing a high quality CCD sensor and a precision lens in a sleek, attractive housing. It provides sharp images with colour at daytime and black/white at night. The camera rotates manually 360° and tilts +/- 90° for maximum angle selection. With its quality images, simplified installation and attractive cosmetic appearance, this professional dome is an ideal surveillance solution.

The characteristics of this surveillance camera are summarized in the table below:

Outdoor/indoor security
Surveillance weather-proof CCD camera
Build-in 20 infrared led
0 Lux
Night vision
420 TV lines
Small size: 4x3x4 cm
Weight: 2,7 kg
Discreet installation
Build-in f 3.6 mm lens for wide view angle
Free power supply 12 V DC
Free security decal

Table 22: Camera characteristics

[61] http://www.amazon.com/dp/B000TGC03U?tag=autob04-20&camp=14573&creative=327641&linkCode=as1&creativeASIN=B000TGC03U&adid=0G53VMSWDH1TMC2PS3DP&&ref-refURL=http%3A%2F%2Fsecurity-camera-guide.blogspot.com%2F

4.2.9.2. Fire extinguisher

A fire extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situations. Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent, which can be discharged to extinguish a fire.

There are two main types of fire extinguishers: stored pressure and cartridge-operated. In stored pressure units, the expellant is stored in the same chamber as the fire fighting agent itself. Depending on the agent used, different propellants are used. With dry chemical extinguishers, nitrogen is typically used; water and foam extinguishers typically use air. Stored pressure fire extinguishers are the most common type. Cartridge-operated extinguishers contain the expellant gas in a separate cartridge that is punctured prior to discharge, exposing the propellant to the extinguishing agent. This type is not as common, used primarily in areas such as industrial facilities, where they receive higher-than-average use. They have the advantage of simple and prompt recharge, allowing an operator to discharge the extinguisher, recharge it, and return to the fire in a reasonable amount of time. Unlike stored pressure types, these extinguishers use compressed carbon dioxide instead of nitrogen, although nitrogen cartridges are used on low temperature (-60 rated) models. Cartridge operated extinguishers are available in dry chemical and dry powder types in the US and in water, wetting agent, foam, dry chemical (classes ABC and BC), and dry powder (class D) types in the rest of the world.

Fire extinguishers are further divided into handheld and cart-mounted, also called wheeled extinguishers. Handheld extinguishers weigh from 0.5 to 14 kilograms (1 to 30 pounds), and are hence, easily portable by hand. Cart-mounted units typically weigh 23+ kilograms (50+ pounds). These wheeled models are most commonly found at construction sites, airport runways, heliports, as well as docks and marinas.

There are different types of extinguishing agents: dry chemical, foams, water, clean agents and carbon dioxide. The first ones is a powder-based agent that extinguishes by separating the four parts of the fire tetrahedron. It prevents the chemical reaction involving heat, fuel, and oxygen and halts the production of fire sustaining "free-radicals", thus extinguishing the fire. The foam is applied to fuel fires as either an aspirated (mixed & expanded with air in a branch pipe) or non-aspirated form to form a frothy blanket or seal over the fuel, preventing oxygen reaching it. Unlike powder, foam can be used to progressively extinguish fires without flashback.

The water, instead, cools burning materials. The last ones is an agent displaces oxygen (CO2 or inert gases), removes heat from the combustion zone (Halotron, FE-36) or inhibits chemical chain reaction (Halons). They are labelled clean agents because they do not leave any residue after discharge, which is ideal for sensitive electronics and documents.

Whereas the product is composed by electric components, use the last agent among those described above, the CO_2 agent, is the solution.

The product found on the market is a carbon dioxide fire extinguisher of 5 kg[62]. It is a homologated portable fire extinguisher (D.M 7 January 2005 - UNI EN 3-7).

Figure 47: Fire extinguisher

The technical characteristics are described in the table below:

Tightening Torque	170 N/M
Weight	15 kg
Tank	138 mm
Material	34 Cr Mb
Thickness	3,5 mm
Height	760 mm
Width	280 mm
Extinguishing	Carbon Dioxide
Nominal charge	5 kg
Approximately discharge time	15 s
Approximately length of the jet	3,5 M
Pressure tested in according with 97/23/CE	250 bar
Burst pressure	> 400 bar
Working temperature	-20°C +60°C

Table 23: Characteristics of the fire extinguisher

The fire extinguisher needs a box to protect it from the sun, rain, snow etc. So, was chosen a deposit extinguisher model that is an ABS with cover red for 4 and 6kg fire extinguisher[63].

[62] http://www.tuttoperlasicurezza.it/prodotto-143661/-.aspx

Figure 48: Box for fire extinguisher

The signs, inside an area where many people are turning, are very important. Indicate the presence of fire extinguishers in case of fire is very useful for people who need them. It is position over the extinguisher the sign detector. On the market, there are signs in different materials and different sided (one-sided or two-sided). The renting points are not very large so it is possible to use a signs one-side in aluminium sheet. It size is 120x120 mm[64].

Figure 49: Fire extinguisher's sing

[63] http://www.tuttoperlasicurezza.it/prodotto-143781/Cassetta-portaestintore-in-ABS-con-coperchio-in-ABS-rosso---per-estintore-da-4-e-6kg.aspx
[64] http://www.tuttoperlasicurezza.it/prodotto-143661/-.aspx

4.2.9.3. Web Site (Federico)

The teamwork wants to offer at their customer a web-based platform in which there are a variety of services.

To build the Website, Federico used the "Eclipse" program. The languages used are:

- HTML language
- JAVA language
- CSS language

Follow there are some examples that show the programming in Eclipse (all the other pages of scripture are in the appendix Web Site):

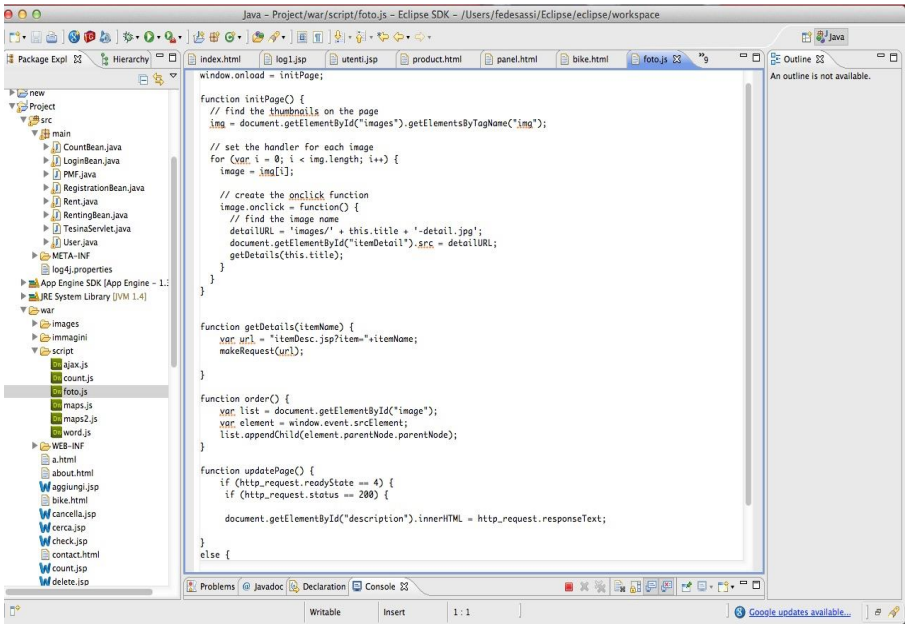


Figure 50: Programming in Eclipse

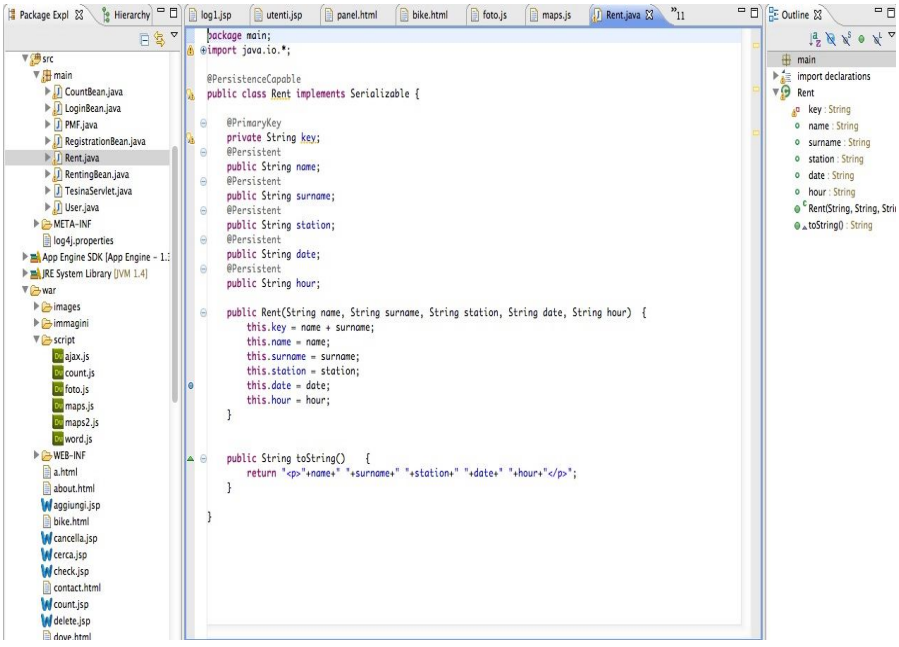


Figure 51: Programming in Eclipse 2

Java is a programming language developed and released in the 1995 by Sun Microsystems. Java is currently one of the most popular programing languages in use and his five main characteristics are:

- It should be "simple, object-oriented and familiar"
- It should be "robust and secure"
- It should be "architecture-neutral and portable"
- It should execute with "high performance"
- It should be "interpreted, threaded, and dynamic"

The web site is divided in two main parts:

- The public part: provides an introduction to our services to allow everyone to know who we are and what we offer;

- The private part: when the user has completed the registration and logged in, he is able to enter and use the service offered in this part.

In the Private part there is some different pages:

Stations: there are some small images of the charger column and the renting station, through a JAVA programming if a user is interested to see the photo, just click on it and the photo is opened in a larger view;

Figure 52: "Stations" page of the website

- Where: It is a page where it is inserted a JAVA function that invokes the API of Google maps with marker where the station are located; clicking on this

marker, the page will open a text box that report the name, address and the number of bike available.

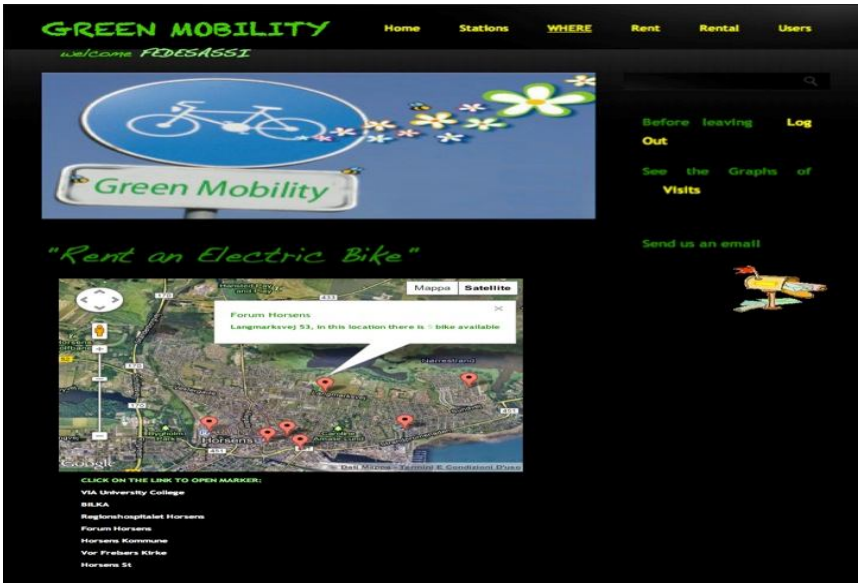


Figure 53: "Where" page of the web site

- Rent: This page provides a form that gives the possibility to book the bike directly from the site and pay when the customer arrives at the station. It is possible also book the free charger column where the users want to leave the e-bike when they finish to use it to prevent that there is not place in the stations. When they send the form the page communicate the data to a JAVA class that records them into a database. This database is also consulted by the server of the various stations to reserve the bike booked.

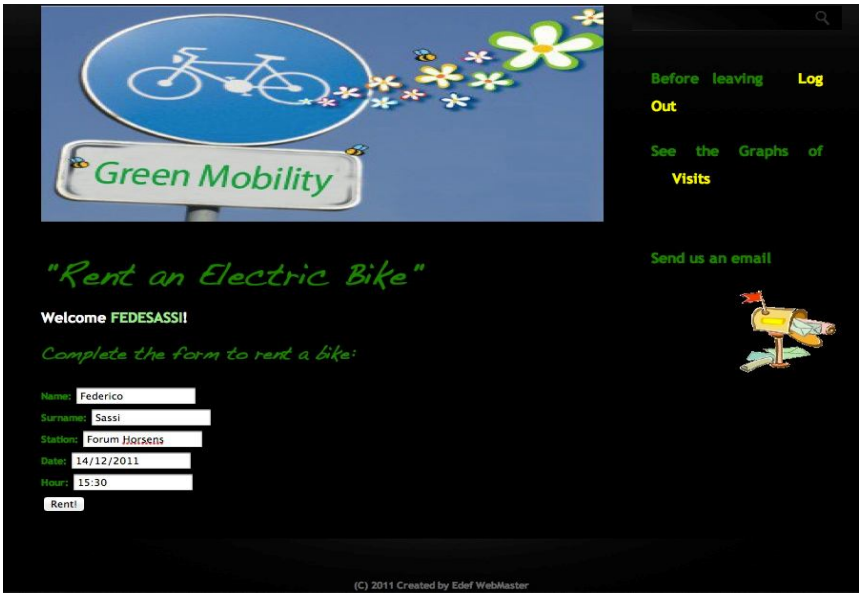


Figure 54: "Rent" page of the web site

- Rental: This page through the JAVA language do a recall to the database of rentals and show us all the rentals made until now.

Figure 55: "Rental" page of the web site

- User: This page through the JAVA language do a recall to the database of registrations and show all the Users registered until now.

Figure 56: "User" page of the web site

In the public part there are seven different pages:

- Home: Short introduction about the project that the Green Mobility's members developed.

Figure 57: "Home" page of the web site

- About Us: Who they are and where they came from

Figure 58: "About Us" page of the web site

- Product: This page is divided in two part:

  The bike: there are some small images of the bike, through a JAVA programming if a user is interested to see the photo, just click on it and the photo is opened in a larger view.

Figure 59: "Product" page of the web site

The solar panel: there are some small images of the two different types of Solar Panels, through a JAVA programming if a user is interested to see the photo, just click on it and the photo is opened in a larger view.

Figure 60: "Solar Panel" page of the web site

4.3. Price (Federico)

4.3.1. Electric Bike

In order to buy the electric bikes was analysed the market. The current situation shows that there are different types of e-bikes, ranging from the cheapest that cost 2000DKK until the more expensive can cost 15000DKK. The different parts used influence the difference in cost. The group of the engine and battery are those that affect more the price. For this use they have to find a fair compromise, the best possible quality at the lowest price. The model selected is EWheels model EW-620LA that cost 4446 DKK (442€) each ones. The price included the bike with motor and battery, cargo racks and headlight. In the price is also included the warranty, six months from the purchase date.

Figure 61: EWheels EW-620LA

4.3.2. Vertical Wind Turbine

The price for the vertical wind turbine ranges from 37.500DKK to 135.000DKK. At first the idea was to put on the roof of the canopy also the wind turbines in addiction to the solar panels. Through studies and research, was concluded that in this case it isn't convenient to install vertical wind turbines because with the climatic conditions of the places the system would not work enough to provide a monetary return. This analysis is explained in the chapter 3 paragraph Renewable energy sources and eco mobility

4.3.3. Solar Panel

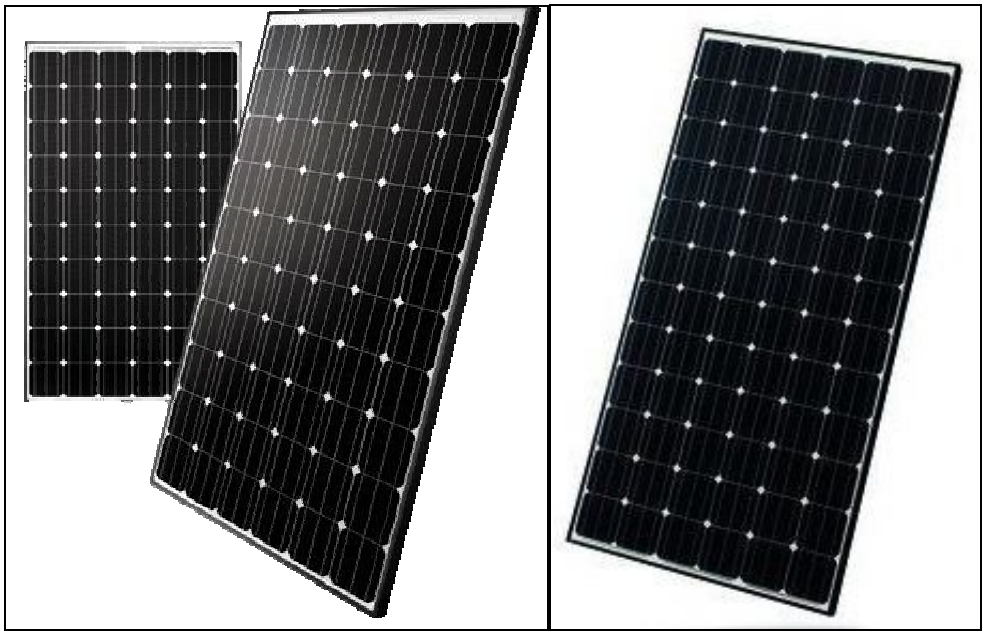


Figure 62: LG solar panel and Sanyo solar panel

The solar panel is the component that more then the other components change the final price of the product. For this reason the choice of them has required a lot of work. The price for the solar panel ranges from 1875DKK and 4875DKK. To offer two different types of product are needed two different types of solar panel. In fact the only one component that change in the two business plans is the solar panel. From the data analysed (reported in the product part paragraph Solar Panel) was chosen the LG23 SM1C-G2 and in the SANYO HIT-N235SE-10.

As is possible see in the table in the product part at the paragraph Solar Panel the LG is the cheaper one and SANYO is the most expensive one, but has also more efficiency. The LG is useful for the customers who want only recharge the e-bike and the provide power at the component in the station, the SANYO solar panel is for the customers who want to implement its business also thought the sell of energy to the local grid.

4.3.4. GPS System

The GPS price is from 371 DKK to 2230 DKK but for our use is not necessary an expensive GPS. The choice of GPS tracker for the bike has fallen in the Eglemtek tk-102. In the package is also included the GPS/GPRS tracker, this model cost 525 DKK (69,90€).

Figure 63: GPS Tracker

4.3.5. Modem

The modems available on the market are so many. The range of the price is between 200 DKK and 2500 DKK. This price difference is mainly due to the WI-FI module installed inside the modem. Since, for this use, there is no need of a particularly powerful WI-FI transmitter, it was chosen a modem with a N-wireless transmitter, quite cheap however able to satisfy the need. The model selected is the ASUS DSL-N10[65], which costs 330 DKK.

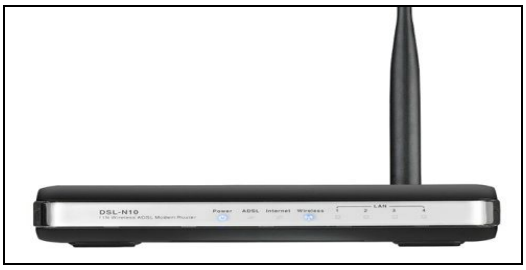


Figure 64: Modem Asus DSL-n10

4.3.6. Display Seven-Segment

There are on the market a lot of different types of 7-segment displays. The price started from 1 DKK to 750 DKK and the difference is mainly given by the size. The chosen display has dimension of 222x167mm and it cost 187,5 DKK[66].

[65] http://www.amazon.com/DSL-N10-serving-Wireless-N-coverage-Addition/dp/B0054L6XHY/ref=sr_1_11?s=pc&ie=UTF8&qid=1323252627&sr=1-11
[66] http://italian.alibaba.com/product-gs/big-seven-segment-led-display-462870146.html

Figure 65: 7 segment display

4.3.7. Kiosk

The kiosk for the payment of the renting e-bike chosen is a Protouch - Xen X4. It is a wall-mounted kiosk with a robust elegant design compatible with the canopy. This cash machine cost 15.000DKK. The range of the price on the market for kiosks is from 11150DKK to 26018 DKK.

4.3.8. Security System

They decided to offer to their customers also the security system. They want protect it from thieves and fire. The solution for the first one is to implement a surveillance camera. The markets offer a bug range of surveillance camera for each price from 75 DKK (10€). The camera chosen is for outside and its price is 278 DKK (37 €).
The solution for the second one is including a fire extinguisher, a deposit extinguisher and a extinguisher's sign. The carbon dioxide extinguisher of 5kg is a homologated portable fire extinguisher (D.M. 7 January 2005 – UNI EN 3-7) and its cost is 626 DKK (84,22€). The ABS deposit extinguisher to cover and protect the extinguisher costs 503 DKK (67,73€). Instead, to indicate the presence of the extinguisher was applied an extinguisher's sign that costs 22 DKK (3,05€).

4.3.9. Canopy, Charger column and web site

The canopy and the charger column are designed by Tobias, instead Federico is the designer of the web-site.
The prices for the canopy and the charger column were supposed looking on the market for similar product. For the canopy they send an e-mail to an Italian company that offer a similar product to decide a price for the budgeting. The e-mail that was sent is in the appendix (Italian E-mail). They answer in few days and say that the

canopy with the solar panel costs 149000 DKK (20000 €). For this reason was decided to insert in the budget a value of 74500 DKK only for the canopy.

The price of the charger column was created by an addition of two components: the price for the material and the price for the labour. On these two prices was decided to insert in the budget a value of 3717 DKK (500€).

Different is the price analysis for the web site. Federico designed it, so he has to include only the price for maintain on-line the pages. From the knowledge in IT engineering Federico can suppose that the average price is 3717 DKK (500 €).

4.4. Place (Laura B)

4.4.1. Introduction

To provide a complete analysis the team group should analyses where decide to implement the product that offering. In this part the group analyzed where want to implement the renting bicycle stations in the short term.
In the future it is possible extend the renting bicycle station in another place because this project are offered standard products that it can be implemented in all areas.

4.4.2. Denmark, capital of bicycles

The team decided to implement the electric renting bicycle system in Denmark because it is the country of bicycle.

Figure 66: Denmark map

The highest point of Denmark barely reaches 170 meters above sea level. The landscape is pleasantly undulating and steep slopes are never so steep that it can not be overcome by pedalling. And this is just one of the reasons that make Denmark the ideal country for cyclists.

The network of routes passable by bicycle in Denmark is unique. There are more than 10,000 km of cycle paths, safe, and well connected to each table, thanks to which you can reach even the remotest corners of the country.

The backbone of this network consists of 3,500 km of tracks that make up the ten domestic routes, which cross the country from north to south and from east to west. To these are added regional and local routes, all arranged so as to be easily passable by cyclists.

Denmark has been chosen by the UCI (Union Cycling Internally), for the first Bike City in the world to make its vast network of cycle paths of real highways for bikes. With 5.5 million inhabitants and about 4 million bicycles in Denmark, the official vision of the country has become the best biking city in the world, with the goal to empower 50% of citizens to go to work or school cycling by 2015. The current figure stands at 37% of people that run through each day 1.2 million km by bike, highest percentage in the world. With more than 390 km of cycle routes and popular public bicycles, the city really deserves the title of Bike City[67].

In particular the team decided to build the renting stations in Horsens.

Figure 67: Location of Horsens

Horsens is a Danish city in east Jutland. It is the site of the council of Horsens municipality. The city's population is 53,807 and the Horsens municipality's population is 82,835 (1 January 2011).

[67] http://www.visitdenmark.com/italien/it-it/menu/turist/inspiration/kampagner/city-break/billund.htm

The municipality is also a part of the East Jutland metropolitan area, which has 1.2 million inhabitants[68]. Horsens lies at the end of Horsens Fjord in eastern Jutland. The city is surrounded by typical moraine landscape with low hills and valleys created by glaciers during the last ice ages.

Analyses the locations where build a garage and position the exchangers to rent is very important for offer a convenient and comfortable service for users. The team group propose to search a strategic locations where install the garage and receivers. The team works believes that the most significant places where propose the build are in areas frequented by people, but difficult to access in a flexible manner.
To understand what are the most frequented places by our potential users, the team includes a specific question about the place in the questionnaire that we sent to the our stakeholders. The questionnaire and the results are in the appendix (Customer questionnaire and results).

Locations

Analyzing the map of Horsens and respecting the needs of stakeholders, the group reported and analyzed the places where to propose the installation of the bicycle stations.
The locations are:

1. Via University College
2. Sports Area
3. Horsens Market center
4. Train station
5. Hospital area
6. Centre of Denmark

[68] http://www.state.gov/r/pa/ei/bgn/3167.htm

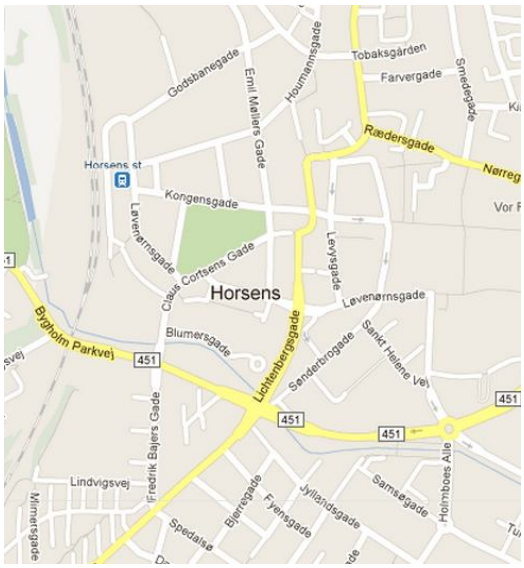


Figure 68: Map of Horsens

After the meeting with a Municipality (The interview is in the appendix (Interview municipality)), the group decides to implement this different location only in public area because some of these areas are private. The municipality is interested at these implementations so we decided the location and the team works propose to implement these in a public area.

4.4.2.1. Via University College

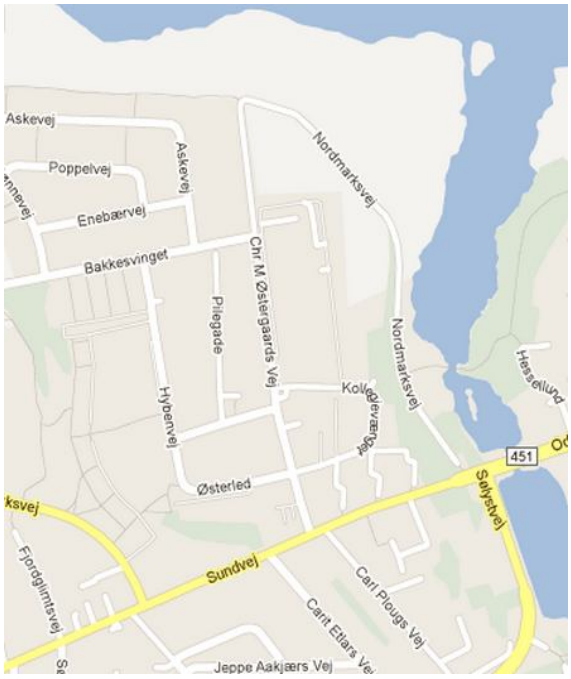


Figure 69: Map VIA University College Horsens

VIA University College is one of eight new regional organizations of different study sites in Denmark offering bachelor courses of all kinds in all of Central Denmark Region. VIA University College is Denmark's third largest educational institution after Copenhagen University and Aarhus University.

VIA has approximately 2,000 employees and 20,000 students. VIA operates within the pedagogical and social professional, the health professional and the technical-commercial area[69].

Overall VIA offers over 50 higher educations in English, with vocational education and participating in various research and development projects.

Figure 70: Via University College Horsens 2

The campus Horsens branch of VIA University College is an international environment with 2500 students, where 900 have an international background. The campus lies in the east end of the city, three kilometres from the centre. Around the school area, student houses have been built, to accommodate many of the students. A significant point where build a box is near the University, more precisely adjacent the Student Village, apartments in which reside students.

[69] http://www.viauc.com/Pages/default.aspx

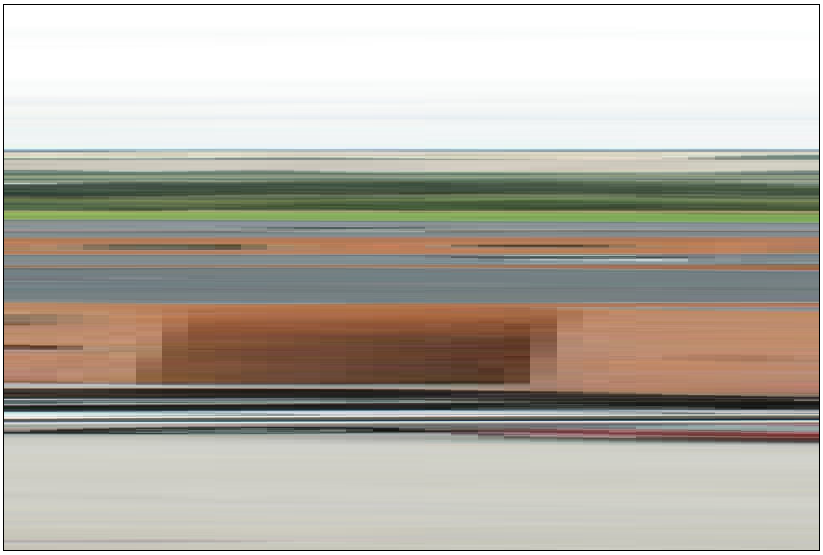


Figure 71: Student Village Horsens

Another important point is in Kamtjatka, this zone is before the centre where reside the students. It's important build a renting bicycle station in this place because a lots of students, all days, they must bear in university to follow the lessons. So it's must place a sampling point in this place, to ensure flexibility and make a great service for students.

Figure 72: Kamtjatka Horsens

4.4.2.2. Sports Area

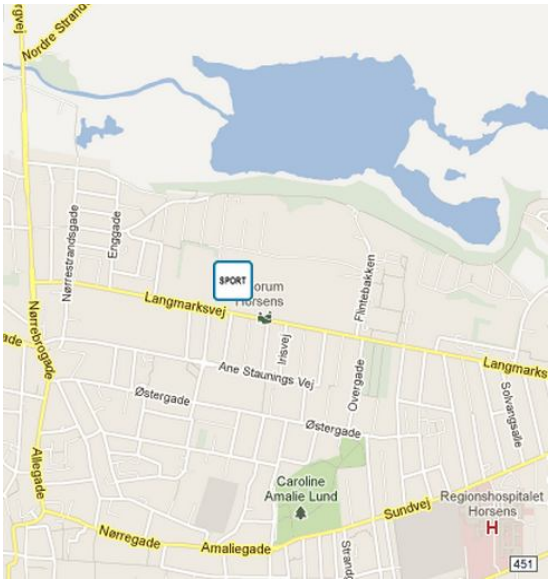


Figure 73: Map - Forum Horsens

A few miles from Horsens Centre is located an area dedicated to sport. The name of this area is Forum Horsens and it's an indoor arena. This area is very big and may also be use for concerts. There can be 4000 spectators for sports events[70].

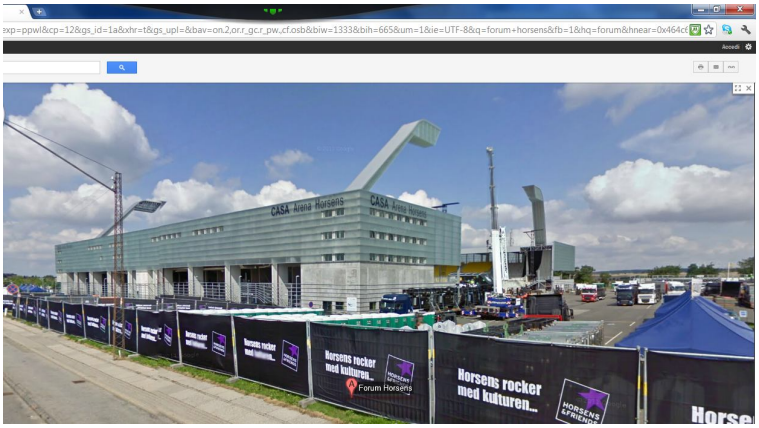


Figure 74: Sport area 1 Horsens

[70] http://forumhorsens.dk/

Figure 75: Sport area 2 Horsens

Forum Horsens includes CASA Arena and Aqua Forum. CASA Arena is a Danish football stadium and the home ground of AC Horsens. Aqua Forum is a large water park that includes Pool 25 meters long, a diving pool Wellbeing area with Turkish bath and sauna and in summer season, Friluftsbad, the heated swimming pool.

These area is frequented by people of all ages so it's definitely a good location where implement a renting box for bicycles.
This area is located a few kilometres from the centre of Horsens in an open area so it's definitely the ideal location where to capture energy through solar panels and wind turbines.

4.4.2.3. Market center

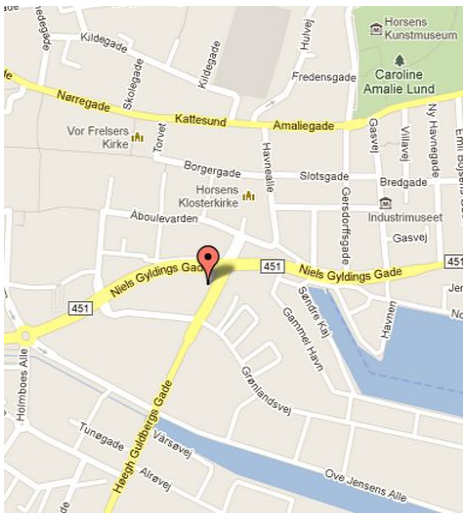


Figure 76: Map Horsens - Market centre

Near the centre there is a commercial area with a lots of supermarket as Bilka, Lidl, Fotex and another store house. These supermarkets are open every day of the week and are frequented by many people.

Figure 77: Supermarket area Horsens

Also in this area there are a few eateries and Horsens Sundshushed; it's an important structure that hold therapists and each offer preventive, health-care and wellness and influence of lifestyle.

It being a very popular area we should implement, in this portion of the city, a renting point station.

4.4.2.4. Train station

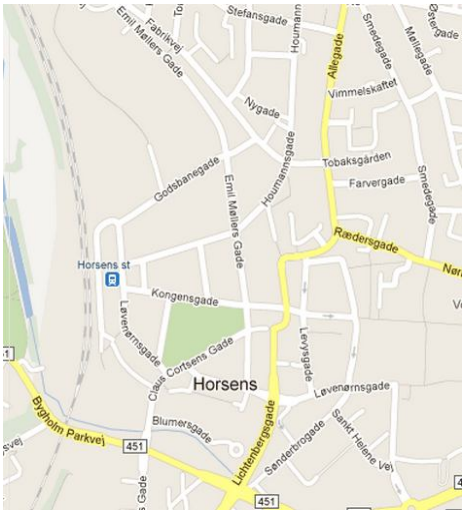


Figure 78: Horsens train station

Not far from the centre of Horsens there are train and bus station. In Denmark, many people travel by train or other public transport such as for commuting to work or to school.

Figure 79: Train station Horsens

4.4.2.5. Hospital area

The hospital is located 1 km from the city centre. In this place there are ambulance area with first aid, clinics with the doctors for specialist visits and departments.

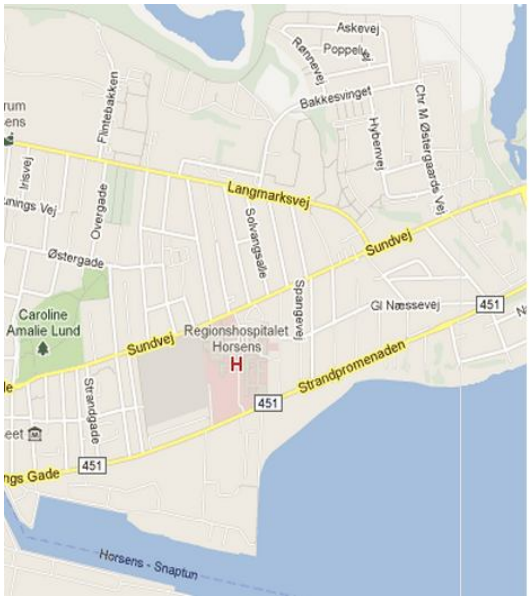


Figure 80: Map Horsens Hospital

Figure 81: Horsens hospital

4.4.2.6. Centre of Denmark

In the centre of Horsens there are main street where you can find a lot of shops, in particular, clothing stores, accessories stores, pharmacy, post office, movie house, pubs and restaurants. In this location we decide to implement two renting bicycle station, one before the centre end one in the end of the centre.

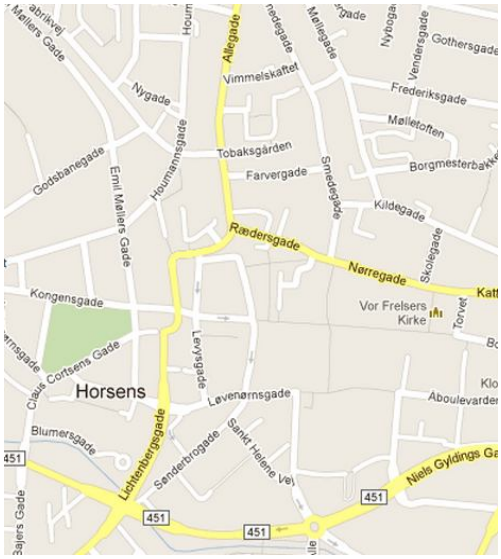


Figure 82: Horsens Centre

Figure 83: Horsens centre 2

4.4.3. Conclusion

In these part were analysed the product available on the market, for choose the right product for this use, were selected products with the highest quality / price ratio.
For the location, the team, choose the place more strategic and suitable to position the renting station. These solutions are places that define and reach the most frequented places of interest to Horsens. These places are frequented by citizens
The team came to the conviction that these locations may be strategic and suitable to position the exchangers to rent. These solutions are places that define and reach the most frequented places of interest to Horsens. These places are frequented by citizens, students and tourists as they are the central points of Horsens. Place the canopy on these points would facilitate the connection of locations used daily.

5. Chapter

5.1. Introduction

In this chapter the group members analyzed the possible stakeholder and competitors that who will be find In Horsens. After the group decided that was important made the SWOT analysis to know the strength and weakness of the project.

5.2. Market Analysis (Laura B)

The group proposes to implement the product in Denmark and in particular in Horsens, so it is important have a general vision of the actual situation in this market. Denmark is a highly industrialized country and is has excellent infrastructure.

PRIMARY LEVEL: Agriculture is very technologically advanced and it is exported (about two-thirds of agricultural production is sold abroad).
SECONDARY LEVEL: Industry is advance in many fields. The food industry, in particular, is one of the busiest in the world (production of beer, meat and dairy products). The long tradition of sea fishing has permission to have a strong fishing industry. Light industry is strong and technologically advanced, and it is primarily concerned with information technology, medicine, biotechnology, telecommunications, pharmaceuticals and wind energy. Other important sectors are the textile industry, chemical, electronics, furniture and construction. Energy is one of the most important exports of the country.
THIRD LEVEL: The service sector is another important level for Denmark. The service sector represents about 70% of GDP (Gross domestic product)[71].

The team decided to produce a product so it is possible to implement the solution in the secondary level, sector of the economy that provides the economic activity in the Danish industry.

[71] http://www.ats.agr.gc.ca/eur/4535-eng.pdf

Horsens is in the central Jutland of Denmark. The more developed regions are those of the central-southern Jutland, where it is concentrated largely in manufacturing.
The Danish market is interesting not only for itself but also as a bridge to other Nordic markets and Baltic countries. For its small size allows a testing of commercial products that are less demanding in quantitative terms and a useful preparation for expansion also in the neighboring Swedish and Norwegian.
It is useful to know that in just 24 hours you can establish a company in Denmark on the Internet and that here the corporate tax is 25%. In terms of ease of starting businesses, Denmark ranked at 5th place in the ranking of the World Bank.[72]

[72] www.ambbaku.esteri.it

5.3. STAKEHOLDER ANALYSIS (Laura R.)

Stakeholder analysis is a technique to use to identify and assess the importance of key people, group of people and institution that may influence the success of our project. The stakeholder concept was first used in a 1963 internal memorandum at the Stanford Research Institute. It defined stakeholders as "those groups without whose support the organization would cease to exist".[73]

They, for example, could be part of these groups: customers, suppliers, lenders (banks and shareholders), employees, but also external stakeholders such as residents living in the vicinity of the business or interest groups. In fact, was made the division of stakeholder in two different categories: market (or primary) stakeholders or non-market (or secondary) stakeholders. The first ones are those that engage in economic transactions with the business. The second ones are those who are affected by or can affect its actions: for example the general public, communities, activist groups, business support groups, and the media.

The possible stakeholders could be:

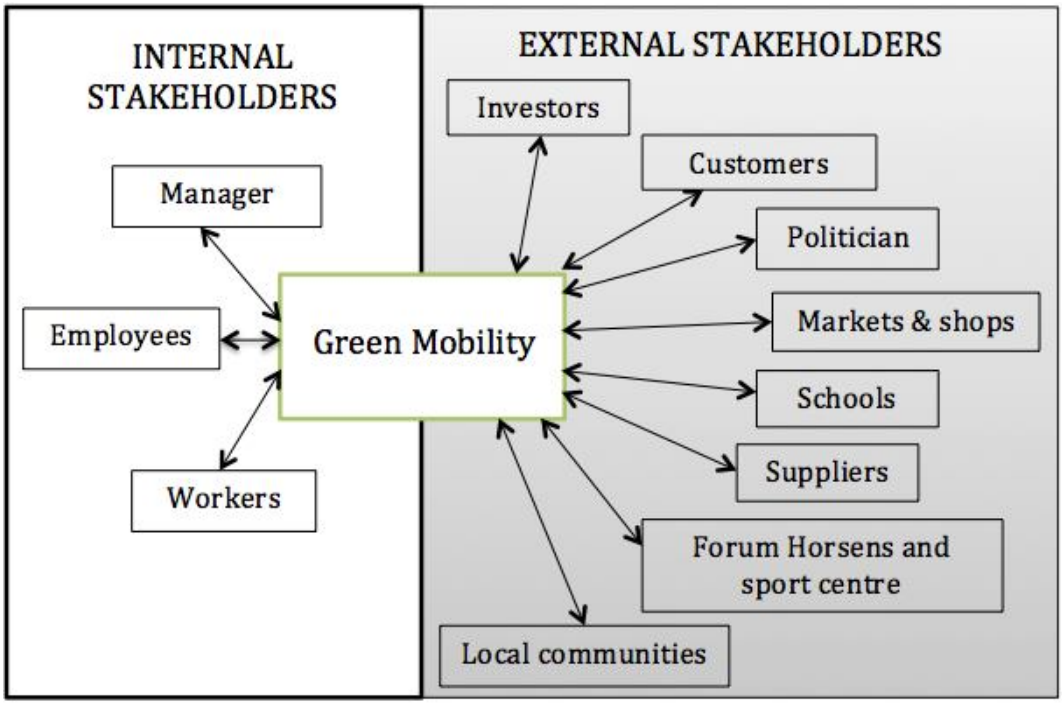


Figure 84: Stakeholders

1. [73] Stockholders and Stakeholders: A new perspective on Corporate Governance. By: Freeman, R. Edward; Reed, David L.. California Management Review, Spring83, Vol. 25 Issue 3, p88-106

5.3.1. Internal stakeholders

The internal stakeholders are the people who work in the organization. They could be summarized in three different categories: managers, employees and workers.

5.3.1.1. Manager

A manager is a person in the company (public or private) who has the responsibility of management. In particular he/she has the task of the process of defining the business objectives and of the guide the company in the pursuit of these objectives by taking decisions on use of available resources and, in particular, human resources.
In the beginning of this business the team members are the manager of their project and if they need help when the business become global, they will empower trusted persons.
The participants are very interesting to invest in this idea so they would to be the first stakeholders of their work and accordingly also the other manager will be investor.

5.3.1.2. Employees

The product will be sold has a lot of components and requires a lot of work to maintain the relation with the suppliers and customers. For this reason, there is a need of some employees who help the manager with the office works who will be stakeholders.

5.3.1.3. Workers

The teamwork decided to delegate the assembly work to other company that will be a stakeholder. Also manpower for the storage will be helpful: a responsible who controls the components and places them in the storage.

5.3.2. External stakeholders

The external stakeholders are people who are influenced by our organization but they are not members of it. They are really important for the business, so the project needs them. In this category it is possible find the follow stakeholder: investors, politician, suppliers, Forum Horsens and other sport centres, markets and shops, schools, local communities and customers.

5.3.2.1. Investors

An investor is someone who makes an investment in the project with the objective to make profit. The investors could help not only with money but also with their

support: maybe they know people that could be important for this business (like us customers, manager, researchers, engineers and so on) and could help the team when they have some problem because it is also their interest that the members achieve their goals and make a profit.

5.3.2.2. Politician

It is interesting include into the stakeholder also the politicians. The Green Mobility's group tried to meet the liberal politicians, Hans Bang Hansen, chairman of the technical committee at the municipality but he did not answer to their e-mail. It is important consider the politicians in the analysis because they could be interesting in the project and would it for their populations.

5.3.2.3. Suppliers

In this business there will be a big number of suppliers because for the final product the team needs component from different market and so several suppliers.
The stakeholder will be:

- EWheels for the e-bikes
- LG and SANYO for the solar panels
- Protouch for the kiosk
- ASUS for the modem
- Eglemtek for the GPS
- Videosecu for the camera
- The web site www.tuttoperlasicurezza.com for the security system (fire-extinguisher, deposit fire-extinguisher and extinguisher's sign)
- Dongguan Houjie Keming Electronic Factory for the display seven-segment
- Manufacture for the charge column and the canopy designed by us.

5.3.2.4. Forum Horsens and other sport centers

In all the places where will be position the stations, nearby there are some main points of the city. One of these one is the Forum Horsens, home of CASA Arena and Aqua Forum. The renting service could be useful for the customers of this centre and so they will be motivating to invest on it and become stakeholders of this project..
Also the other sport centres of the city could be interesting in the service and participate in it. In fact, the team members contacted also Fitness gym, Equinox Horsens and Butterfly Woman.

They sent e-mail to these sport services, but they did not answer them. (The e-mail are in appendix (Stakeholder questionnaire)

5.3.2.5. Markets and shops

All the supermarkets and shops that have near the station could generate profit thanks to it because the people who use the e-bike may be will go for shopping in the shop nearest the station. So, all the supermarkets or shops in Horsens could be stakeholders. One station's position is near in the Horsens market centre, near the street Høegh Guldbergs Gade where there are Bilka, Lidl and other shops.

5.3.2.6. Schools

The students did a meeting with Soren Gytz Olese, executive director at University College VIA. He, as representative of VIA, was interesting to become stakeholder of this project. In appendix (Interview University) there is the interview performed.
Also the other school in Horsens could find the project useful and decide to invest on it.

5.3.2.7. Local communities

The local communities that could be fascinating from the project are: association that take care elderly, association for tourist and other types of association.
The old people who want to move without public transportation or car could use the electric bike from the renting point. So, these stations will become important for the association that have to deal with them, like us Sund by. Sund by Horsens is the name of the institution that coordinates health promotion and sickness prevention efforts for the citizens in Horsens municipality.
The tourist information is one of the main points for a tourist in Horsens. If this project becomes real, the tourists will be one of the main costumers and so the tourist information could be interest in it.

5.3.2.8. Customers

The customers are the most important people for any company/organization. They are the resource upon which the success of the business depends.
In general, it is possible to identify the customers of the renting station in all the people that are interest in our system. A private person could buy the product and do his/her business, but also the company or the public organization.
In Horsens the team found one possible customer: the Municipality. They did a meeting with them and they found them very interesting in the project. In fact, the

municipality's representatives made some question to deepen in the project and give to the students a lot of important news and information. It was during this meeting that raise the problem about the places chosen. They said that a lot of them are private and not public, without this meeting the team will not come in this knowledge because the other possible customers or stakeholders did not answer at their e-mails. They suggest positioning the stations in the public areas near these private ones. After the team decides to follow this way.

At the end of the meeting, was important to understand that they are very positive in the project and they did not reject the main idea and a possible collaboration. The interview that the group did is in appendix (Interview Municipality).

To understand if the project could be useful for the people the members decided to make a questionnaire with ten questions. They sent it to students of VIA University College in Horsens on Facebook, the social network. This choice was done because VIA was the only one possible customers that they found for now and in order to convince them to invest in this project they did a specific analysis. Instead, the choice of Facebook was done because the students created different groups for each specialization of study, so the members could get answers from people with different characteristics and interests. Fifty-one are the responses. The results at the questions are in the appendix (customers questionnaire and results). The first questions are about general information to know the students who answer, the other one are specific about the project.

Know where they live is important to understand how many people will move with renting bikes and from/to which places. The fifty-one per cent live in the Student Village near the university, the thirty-five per cent live in the Kamjakta and the twelve per cent in other place in the city. So, near these two places is necessary to position stations because a large flow of people could move with e-bike from/to VIA University College and the city centre.

The answers about the places show that the places that we have chosen are necessary also for the other people. The places are: VIA University College Horsens (student village), Centre (one station in the top and one in the end of the main street), sport area, supermarket area, train station and hospital. The places are described in the Place part (Chapter 4). One of them, the hospital, was not mentioned by anyone.

Instead, the team members think that this place is significant for the people that live in Horsens especially the older ones that have to go there only for examinations.
Surprising was to know that a lot of them don not have bike and so it is possible suppose that they could use this service. A specific analysis was done to extrapolate essential conclusion from the questionnaire.
The division of the answers was done for months that the students will stay in Horsens. The people who will stay fewer months, for example, could be potential users because they do not spend money to buy a bike. The group are six: 5months of study, 6 mouths, 10 months, 11 months, 12 months, and more then 18 months.

Follow the table performed:

5month						Times per week		About our idea
		bike yes	bike no	normal bike	electric bike	Value Mean	Value of scale	Value Mean
Total	**3**	**1**	**2**	**1**	**0**	**3**	**3-4**	**3,3**
Student Village	2	0	2	0	0	3	3-4	3,5
Kamjatka	1	1	0	1	0	3	3-4	3,0
other	0	0	0	0	0	0	0	0,0

6month						Times per week		About our idea
		bike yes	bike no	normal bike	electric bike	Value Mean	Value of scale	Value Mean
Total	**21**	**11**	**10**	**11**	**0**	**3**	**3-4**	**3,6**
Student Village	13	5	8	5	0	3	3-4	3,8
Kamjatka	7	5	2	5	0	2	1-2	3,1
other	1	1	0	1	0	2	1-2	4,0

10month						Times per week		About our idea
		bike yes	bike no	normal bike	electric bike	Value Mean	Value of scale	Value Mean
Total	**7**	**3**	**3**	**4**	**0**	**3**	**3-4**	**4,1**
Student Village	3	1	2	1	0	3	3-4	4,0
Kamjatka	4	3	1	3	0	4	5-6	4,3
other	0	0	0	0	0	0	0	0,0

11month						Times per week		About our idea
		bike yes	bike no	normal bike	electric bike	Value Mean	Value of scale	Value Mean
Total	**2**	**2**	**0**	**2**	**0**	**2**	**1-2**	**3,5**
Student Village	1	1	0	1	0	3	3-4	4,0
Kamjatka	1	1	0	1	0	1	never	3,0
Other	0	**0**	**0**	**0**	**0**	0	0	0,0

12month						Times per week		About our idea
		bike yes	bike no	normal bike	electric bike	Value Mean	Value of scale	Value Mean
Total	**8**	**4**	**4**	**3**	**1**	**3**	**3-4**	**4,1**
Student Village	3	2	1	2	0	3	3-4	4,0
Kamjakta	2	0	2	0	0	4	5-6	4,5
Other	3	2	1	1	1	3	3-4	3,7

>18month						Times per week		About our idea
		bike yes	bike no	normal bike	electric bike	Value Mean	Value of scale	Value Mean
Total	**6**	**4**	**1**	**4**	**0**	**3**	**3-4**	**3,3**
Student Village	2	1	1	1	0	3	3-4	3,5
Kamjatka	3	3	0	3	0	3	3-4	4,3
Other	1	**1**	**0**	**1**	**0**	4	5-6	2,0

Table 24: Student analysis

At the beginning, the members expected that the people who will study in Horsens for a lot of time would not use the system because they thought that they had already organized with different transports. Instead, despite the majority of them have already a bike, they would use the renting bike for 3 or 4 times per week. This is a wonderful result for the renting stations. Also the average of the values that they give at the project are incredible: all the groups have an average higher of three (the mean value of the scale that we proposed).

5.4. Competitors (Federico)

The competitor's study consists in the Porter's five forces analysis designed by Michael E. Porter Of Harvard Business School in 1979. The five forces are useful to determinate the competitive intensity and therefore attractiveness of the market where an organization move into. Attractiveness in this context refers to the overall industry profitability. An "unattractive" industry is one in which the combination of these five forces acts to drive down overall profitability. A very unattractive industry would be one approaching "pure competition", in which available profits for all firms are driven to normal profit.

These five forces are:

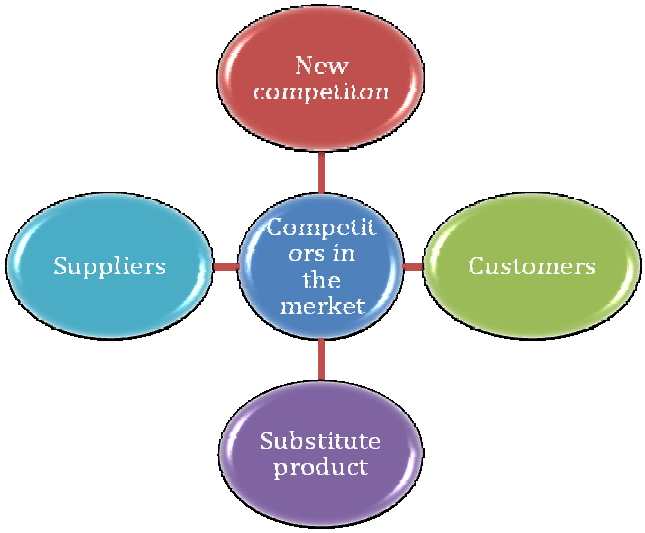


Figure 85: Potter's Five Forces

5.4.1. Competitors Analysis in the market

Competitor analysis in marketing and strategic management is an assessment of the strengths and weaknesses of current competitors. This analysis provides both an offensive and defensive strategic context to identify opportunities and threats. Profiling coalesces all of the relevant sources of competitor analysis into one framework in the support of efficient and effective strategy formulation, implementation, monitoring and adjustment.

The main competitors could be: company that offer a similar product and bike shops.

There are in the same market in which it would enter company that produce a similar product. In many cities there is already the system of bike sharing. The Danish capital, Copenhagen, is the also the capital of the bike. The strengths of these companies are that they are already in the market and they know how to move inside it and what the costumers want. One company that sell a similar product is Wattword from Switzerland but they offer only the renting station without the eco-energy[74]. Also the Vélib' in Paris has the same "problem".

Instead, an other company that produce only the station powered by eco-energy without bike is the Italian Giulio Barbieri S.p.A[75]. It was asked to them a preventive for the canopy including solar panels to understand if the canopy is expensive or if the price could be competitive. They were very nice and his system price is 20.000€ (without VAT), so their canopy was in the range.

The e-mail is in appendix (Italian E-Mail).

The bikes in Denmark have a big market so there are a lot of shops, which sell them. These shops will be their competitors because if a people buy a bike become owner of it, instead the owner of the electrical bike in these stations is who buy them and they are only users. The bike price is high and this is a weakness for them. In Horsens there bike shops are: Østbyens Cykler and Horsens Cykler.

Concluding, it can be stated that the competition in this market could occur but not so relevant because there are many competitors for the component of these product (like the Italian company for the canopy) but they do not offer a complete product like this.

5.4.2. Threat of substitute products or service

The existence of products outside of the realm of the common product boundaries increases the propensity of customers to switch to alternatives. Important is to underline that this should not be confused with competitors' similar products but entirely different ones instead.

The substitute products are the other type of transportation inside the city.

The public transports (Bus) in Horsens are made by middttrafik. Their strength is that they offer punctual bus in all the main point of the city. The weakness is that the

[74] http://www.wattworld.ch/mobility/Accueil
[75] http://www.giuliobarbieri.it/ita/azienda.asp

ticket is expensive: 20 DKK for one our in the first zone and 120 DKK is the price of the multi-ticket with ten run. Also the taxi service is a competitor because it is a substitute service in the city in particular when there are not buses, like us during the night. Instead the renting stations are designed to be used 24/24 hours.
In other city, like us the capital, there are a lot of similar services: the metro, panoramic buses that bring you in the main point of the city, etc. This could be a problem for the business of the company.

5.4.3. Bargaining power of customers

The bargaining power of customers is described as the market of outputs: the ability of customers to put the organization under pressure, which also affects the customer's sensitivity to price changes. The person who want buy a product that offer a renting service has to invest a lot of money. For this reason, is sure that he will look also the product of the competitors and he will compare the characteristic of both. In fact, the straight will stay in the ability of sell the product, listening the need of the customers and try to conclude the deal. But it can affirm that it is not a big problem for the company, for the same reason that it was wrote in the first force analysis.

5.4.4. Bargaining power of suppliers

The bargaining power of suppliers is also described as the market of inputs. Suppliers of raw materials, components, and services (such as expertise) to the firm can be a source of power over the firm, when there are few substitutes. Suppliers may refuse to work with the company or charge excessively high prices for unique resources. On the market there are many possible suppliers for the components, so this Porter's force it is so high for this project.

5.4.5. Threats of new competitors

In the market in which they want to enter there are some competitors and also could be enter new ones. For these reason they should be prepared for every changes in the market and also ready to modify part of the product with new technologies. The technologies of the components, for example the solar panel or wind turbine but also the electric bike, are update continuously. So, they have to be carful.

Reassuming the Porter five forces' analysis:

Competitors Analysis in the market	Medium
Threat of substitute products or service	Medium
Bargaining power of customers	High
Bargaining power of suppliers	Low
Threats of new competitors	Medium
Total	MEDIUM

Table 25: Analysis of Porter's five forces

It was chosen a scale of three values to describe the forces: low, medium and high. The results it is a medium value that means that in the market the members of the group could find some problem with the competitors.

5.5. SWOT Analysis (Laura B, Federico)

5.5.1. Introduction

The group members decided to do the SWOT Analysis because it is important know that are the most relevant Strengths and Weaknesses for this project.
SWOT (acronym which stands for Strengths, Weaknesses, Opportunities and Threats) analysis is a strategic planning method used to evaluate the Strengths, Weaknesses/Limitations, Opportunities and Threats involved in a project. It involves specifying the objective of the project and then identifying the internal and external factors that are favourable and unfavourable to achieve that objective.

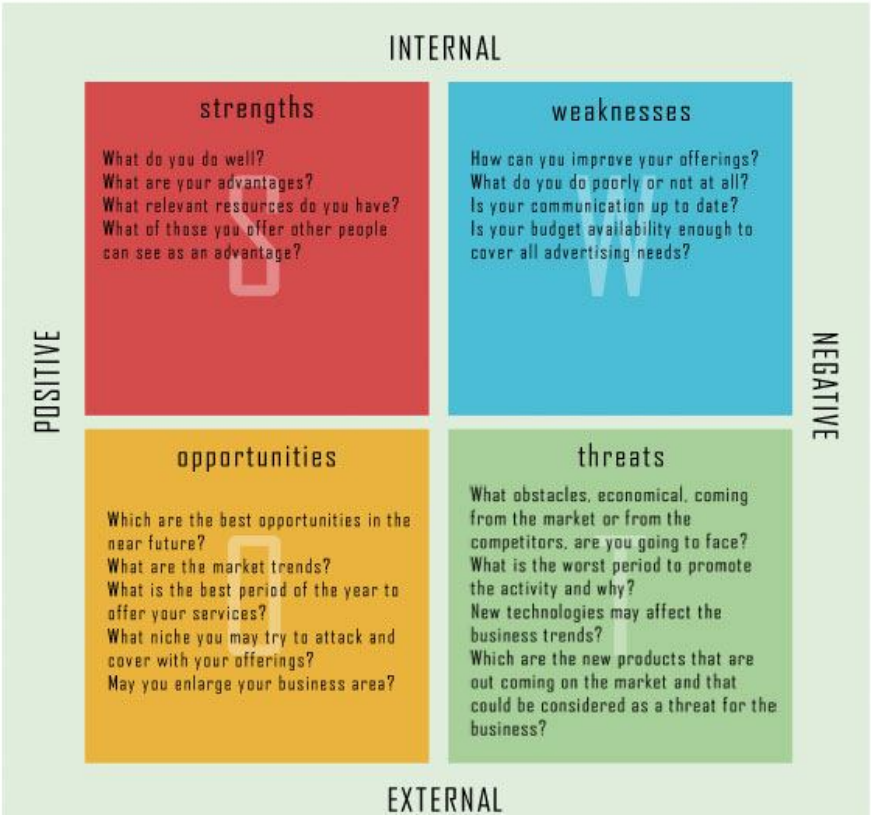


Figure 86: SWOT Analysis

For all the members is important to do the SWOT to find the best approach to analyses in this project. For introduce in the market a new product, that until now it has never proposed, it is important analyses main factors in the SWOT.

5.5.2. Strengths

STRENGTHS	
POSITIVE	INTERNAL
	Wide range
	Renewable resources
	New Product
	Innovative aspects
	Flexibility
	Internet site

Table 26: Strengths

Wide range: The Rent e-bike can be used by a wide range of people. The bicycles can be adjusted in height so it is accessible for all ages. In Horsens a lots of people prefer use the bicycle to move. Not only adults but many young and seniors. The electric bicycle will be transport of the future.

Renewable resources: Renewable resources, due to natural or caused by the cultivation of the human, are renewed in time and, thus, were available for human survival almost indefinitely. Rent e-bicycle use renewable resources it is a matter of sustainability in the natural environment. The group decides to implement solar panels in the roof of the canopy.

New Product: A rent electric bicycle system is a new service in which bicycles are made available for shared use to individuals who do not own them. The central concept is to provide affordable access to electric bicycles for as an alternative to motorized public transportation, to provide a more flexible method to move around the city.
In Horsens there are a lots of bicycle but there are not this product and there are not electrical bicycles.

Innovative aspects: In this project innovative aspects are addressed. It is an innovative urban transport. Before in Horsens does not exist a rent bicycle system and in this area does not develop a lot of electric bicycle. So this project is good solution for the future.

Flexibility: The rent e-bicycle allows you to move within the city in a flexible manner. Using this system you will not have to wait longer, for example, in the bus stop or wait for a taxi after the call.

Internet site: Through the use of a website, it is able to capture new customers. The web site is not only for the advertising but the customers can book the bicycles in a specific station.

5.5.3. Weaknesses

WEAKNESSES	
NEGATIVE	INTERNAL
	To find clients/customers
	Right price
	Places by Municipality propriety

Table 27: Weaknesses

To find clients/customers: The most important initial difficulty is to find interested clients and customers.

Right price: It is very complicated decide a right price. In the market there are a lots of price but to achieve a successful product is important to capture the right price.
Places by Municipality propriety: It is possible implement the rental e-bicycle stations only in a places by municipality is propriety. So this a limit because around Horsens there are a lot of places but most of which are privately owned.

5.5.4. Opportunities

OPPORTUNITIES	
POSITIVE	EXTERNAL
	Adheres to environmental standards
	New technologies
	Solution in absence of own transportation
	Rent product
	Internet site

Table 28: Opportunitties

Adheres to environmental standards: This renting e-bicycle has been designed taking into account all safety regulations and comply with all local laws and regulations policies in order to enter in a new business.

New technologies: Solar panels is a new solution to create electric energy. This new technologies is used to generate electricity for the bicycle.

Solution in absence of own transportation: In Horsens, in VIA University College there are a lots of exchange students. This is a solution for all the people who have not own transportation.

Rent product: The rent production is a opportunities and is a method that reduce the consumptions. In this way is not necessary to buy a new bicycle.

Internet site: Internet site is a opportunities because allows to enter in news market.

5.5.5. Threats

THREATS	
NEGATIVE	EXTERNAL
	Competitor
	Political/ legislative effects
	New product
	Maintenance costs

Table 29: Threats

Competitor: When enter in a new market must always take into consideration the possible competitors. In this case the competitors are other means of transport around Horsens city. The main competitors are cars, taxis, bus, normal bicycle and walking.

Political/ legislative effects: Being able to implement a product in compliance with all regulations and legislative policies in force in the country where it is possible to implement.

New product: Implement a new product is not only a strength but can be a threat. The people don't know the product and in the beginning may not be interested in using it. Moreover, especially in the initial phase, people may not feel the need to choose it instead of other means of transportation.

Maintenance costs: The people will not use the electric bicycle in a right way. Bicycles are damaged and need a lot of cost for repair its.

Conclusion

It is important for define the best strategy to use on the market do the SWOT Analysis. Through it is possible to know the strengths and the weakness of the project but before shall be made the market, stakeholder and competitor's analysis.

The project rotates around the city of Horsens. The stakeholders and competitors could be from this city or from other place in Denmark. For this reason, the analyses were made for all the Denmark. The results from them is that this project could be real because the number of competitor it is not very high but the number of stakeholder interesting in the renting station could be very elevated.

6. Final Product Development

6.1. Introduction

In this chapter the development of the renting station is going into its final stage. Different possibilities of energy storages became analysed in order to evaluate their suitability for this project. Furthermore, different concepts of possible canopies have been invented and were evaluated as well for finding the most fitting solution for the projects purpose.
In the last part of this chapter the canopy as well as the charging column are presented. The charging column and the canopy are the most essential parts of the rent station, which became developed during this project.

6.2. Energy storage (Tobias)

Energy storage is a device, which has the ability to store energy. In this project, the kind of energy, which has to be stored, exists in the form of electricity. The requirements to the storage are, of course, the ability to provide electricity as well as recharge ability.
There are two systems existing, which can serve such a purpose: The battery and the fuel cell. Both are different types of a galvanic cell. Each of these technologies has various advantages and disadvantages, which will also be handled in the following text.

6.2.1. Battery

A battery is a so called galvanic cell, in which chemical reactions lead to accumulation of positive and negative charges at the two electrodes of the battery. These electrodes are called “anode” and “cathode”. Anode is the name for the positively charged electrode, cathode names the negatively charged electrode. The used chemicals vary from one battery type to another, but all of types have the same basic principles in common.

6.2.1.1. How it works

A battery is an electro chemical cell. The energy within is stored in the form of chemical energy. During discharging the chemical energy is converted into electrical energy by a red-ox-reaction within the cell. In this reaction the included chemical compounds (for example a solution of sulphuric acid and water[77]) react with the material of the electrodes. One electrode becomes reduced, the other one becomes oxidized depending on the electrodes material. Possible materials are for example Zink and Copper[78]. By this process the reduced electrode charges negative while the oxidized electrode charges positively. Due to the resulting voltage between the two electrodes an electrical current will result when the electrodes are linked by an electrical conductive material. In order to increase the maximum current of a battery, the electrodes are applied in a sheet like arrangement for increasing the surface (see Figure 87: Components of a car battery)

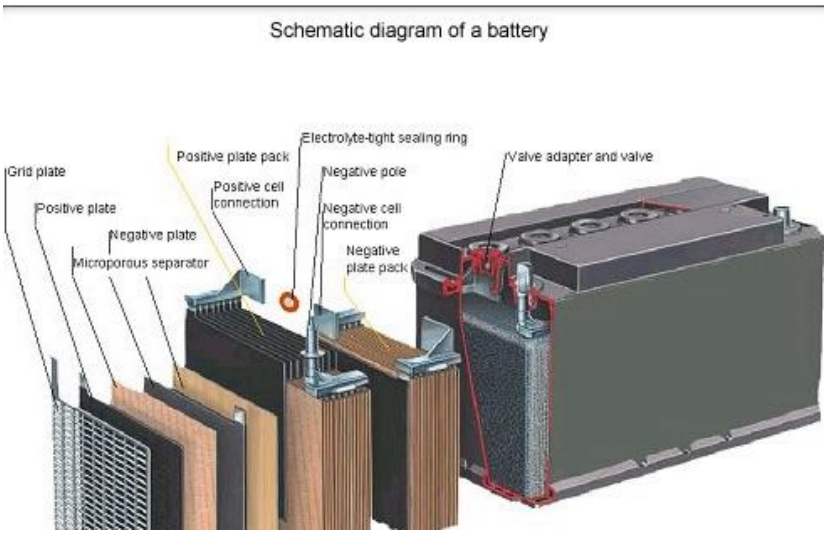


Figure 87: Components of a car battery [76]

The material of which the electrodes are made as well as the chemical compounds inside the battery decide about the voltage, which will be produced by the cell[79].

[76] http://www.eepe.murdoch.edu.au/resources/info/Tech/enabling/index_image001.jpg [09.12.2011]
[77] http://www.batterycouncil.org/LeadAcidBatteries/HowaBatteryWorks/tabid/108/Default.aspx [14.12.2011]
[78] http://de.wikipedia.org/wiki/Galvanische_Zelle#Beispiele [14.12.2011]
[79] http://www.ehow.com/info_8052411_happens-make-voltage-battery.html [14.12.2011]

A battery can be connected in a serial order to another battery (anode of the first battery connected to the cathode of the second one) as well as in parallel combination (anodes of both batteries connected as well as both cathodes). When connected in serial order, the total voltage will raise on a value, which is equal to the sum of each batteries single voltage.
When the batteries are connected parallel to each other, the voltage stays the same as before but the possible maximum current will double because the batteries inner virtual resistor drops to the half (if both batteries are identical).

There are two types of batteries: the “primary cell” and the “secondary cell”. The primary cell is a battery, which only can be used one time. It is not rechargeable. Against the primary cell, the secondary cell is rechargeable. The basic principle, which makes it work is the same as for the primary cell but the chosen materials differ. When suitable materials are used, a battery can be recharged. The only suitable type of battery for our project is the secondary cell. It is also called an “accumulator”.

Batteries are reacting very sensitive to the circumstances under which they become charged. A battery should be, if somehow possible, almost completely discharged before recharging. Otherwise, the so called “memory effect” sets in and lowers the capacity of the battery over the time. Modern types of batteries are meanwhile safe to this effect. But they are also more sensible to wrong charging currents and voltages. The lithium polymer battery technology for example can store huge amounts of electrical energy in small space but when it is used out of its parameters (during charging or discharging), it can catch fire or explode.

6.2.2. Advantages and disadvantages

6.2.2.1. Advantages:

- Cheap
- Available in many different sizes and forms
- Reliable

6.2.2.2. Disadvantages:

- Amount of storable energy is low
- Memory effect
- Often limited life time

6.2.3. Fuel cell:

A fuel cell consists out of two containments. One containment for Oxygen (or another oxidant) and another one for the "fuel"[81]. Most commonly the substance named "fuel" is simple Hydrogen. A fuel cell also works with various other substances and chemical compounds as long as these compounds include a minimum amount of Hydrogen, which can be oxidized in order to produce electricity. The only important requirement, which is posed to the fuel compound (beneath that it contains hydrogen) is that it can be easily transformed into gas state. Due to this fact, a fuel cell can also work with earth gas because it consists in a major part of Hydrogen. The main compound of earth gas is Methane. Its chemical formula is C_1H_4, so there is plenty of Hydrogen included.

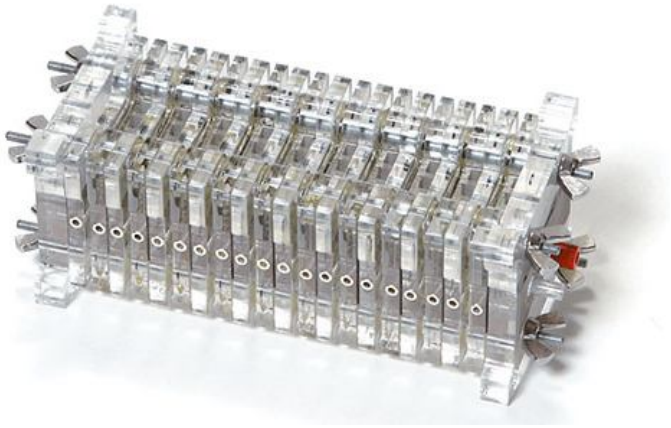


Figure 88: Fuel cell stack[80]

6.2.4. How it works:

A fuel cell system consists of two containments for the fuel (most likely Hydrogen) and the Oxygen as well as a reaction chamber (the fuel cell). The reactive substances are most likely stored in a liquid state under pressure, which will change into gas state when it enters the fuel cell under low pressure. The most important part of a fuel cell is the Proton Exchange Membrane (PEM). This membrane allows only protons to pass As a result Hydrogen atoms have to leave their electron on the one side of a fuel cell before they can pass the PEM. On each side electrode grids are applied to the PEM.

[80] http://www.fuelcellstore.com/en/pc/catalog/2090FuelCellStack10.jpg [09.12.2011]
[81] http://www.nasa.gov/centers/glenn/technology/fuel_cells.html [14.12.2011]

These electrodes provide the possibility to the electrons (when connected) to travel around the PEM and be reunited with the Hydrogen's proton on the other side[82]. The reason why this technology works, lies within the fact, that a system always tries to go into the state with the lowest possible amount of energy. This is a law of nature and one of the basic laws of Thermodynamics. In the case of a fuel cell, the electrons are separating from their atoms cores because the attraction of the Hydrogen core to its oxidant is greater then the attraction of the electron to the core. This difference in the strength of attraction makes the electrons run through a wire in order to reunite with a hydrogen core on the oxidants side where the reunited hydrogen Atoms become oxidized with Oxygen to H_20 or simply: water[83]. By letting this take place in a bigger scale, significant electrical currents can be caused between the two electrodes. This current can be used to drive electrical devices. When electrical voltage is applied to the electrodes, which is bigger then the voltage, which is produced by the cell itself, the process becomes turned into the opposite direction. The water in the fuel cell becomes divided again into hydrogen and oxygen. By this way electrical energy becomes converted into chemical energy, which is stored in the form of separate hydrogen and oxygen.

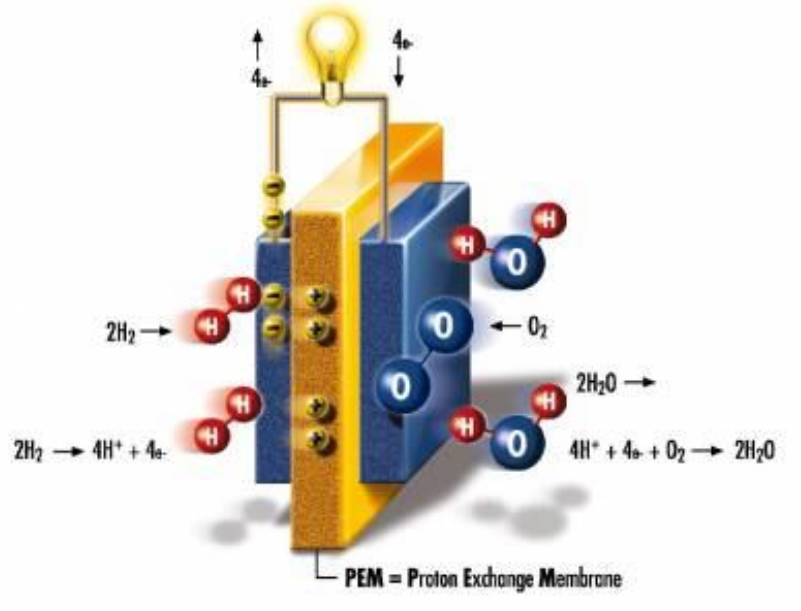


Figure 89: How a fuel cell works[84]

[82] http://www.nasa.gov/centers/glenn/technology/fuel_cells.html [14.12.2011]
[83] http://auto.howstuffworks.com/fuel-efficiency/alternative-fuels/fuel-cell2.htm [14.12.2011]
[84] http://www.odec.ca/projects/2007/truo7j2/fuel_cell_small.JPG [09.12.2011]

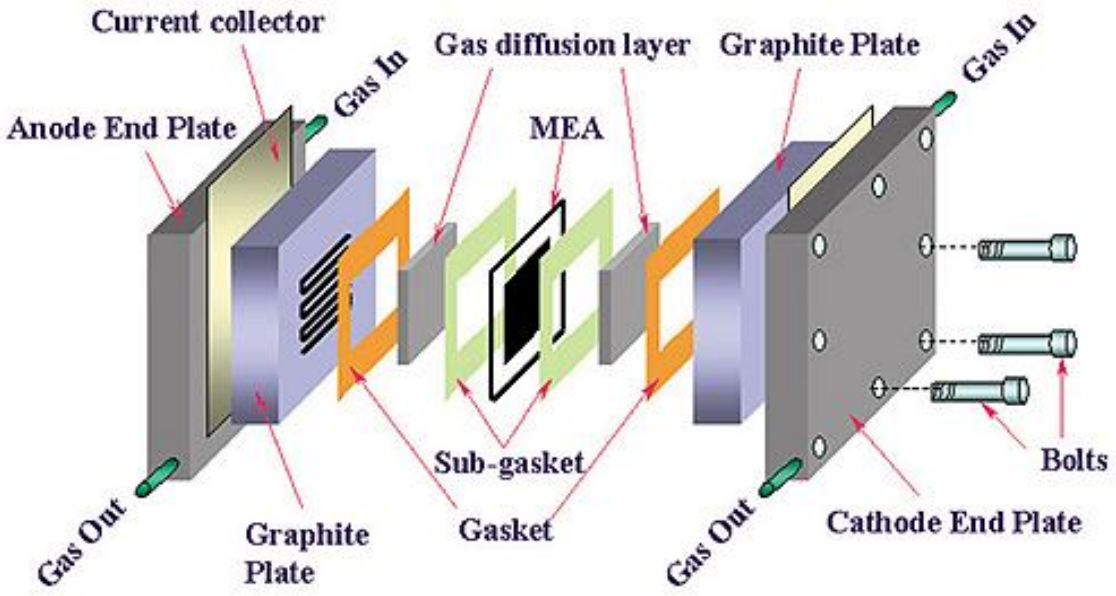


Figure 90: Exploded schematic of a fuel cell[85]

The anode end plate seals the fuel cell at the side of the anode. The current collector works as an electrode in the cell. The graphite plate is routing the gas current along the PEM, which consist out of the gas diffusion layers and the MEA. The graphite plate is also responsible to conduct the charges from the PEM to the electrodes (graphite is conducting electricity). The gaskets prevent the hydrogen and oxygen from leaving the fuel cell.

6.2.5. Advantages and disadvantages:

6.2.5.1. Advantages:

- No memory effect
- No self discharging
- Big capacity (depending on size of storage tanks)

6.2.5.2. Disadvantages:

- Expensive
- Fuel implies danger of explosion
- Technically complicated
- Information about life cycle of modern fuel cells are barely existing

[85] http://www.scientific-computing.com/images/scwjanfeb03fuelcell1.jpg [08.12.2011]

6.2.6. Evaluation:

For in the rent stations, the energy storage has to fulfil a number of requirements.
It has to be:

- Save in operation
- Reliable in operation
- Durable
- Unaffected by heat and cold
- Compact / adaptable form
- Low losses while charging -> high efficiency
- Long estimated life time
- As cheap as possible
- Low maintenance
- High capacity

The fuel cell has a significant advantage when it comes to capacity. During the charging process, the fuel cell has an advantage as well, because the charging current can be very high (and by this fact, more energy can be stored in the same time). In both aspects the fuel cell is advanced over batteries. Therefore, the battery is more durable until it uses chemicals inside which will not freeze when the temperature drops under 0°C. The water, which is produced in a fuel cell will freeze. For working against this problem, the storage and processing chambers would have to be electrically heated which consumes a lot of energy. The heat which is generated by a fuel cell in operation will may not be enough to prevent the water from freezing in a very cold winter night. This critical aspect of limited operation guarantee when it comes to (common) fuel cell systems is a K.O. criterion. Furthermore, fuel cell technology is relatively new technology compared to battery technology so there is almost no reference data for long term operation and the need for maintenance.
When it comes to the price the battery succeeds as well. Due to the fact, that batteries are a mass product, the prices are low compared to fuel cells. They are also less complicated which makes maintenance easier. Last but not least, batteries can be build in all sizes and forms. Fuel cells are limited when it comes to different sizes or forms because of the characteristics of its different components (including the storage containment).

6.2.7. Final result:

The use of a battery is the better choice. Unless it will still be operational in winter without any additional equipment, the battery succeeds over the fuel cell. Furthermore, when it comes to the projects application the battery seems to provide the bigger security in use until it does not contain hydrogen and oxygen, which could lead to an explosion if the storage tanks of the fuel cell have a leak. The lower capacity of batteries can be compensated by using a bigger battery system. Until batteries are cheaper than fuel cells, it would probably still be economic to scale up the battery system.

After evaluating all the facts and properties of both systems, the battery appears to be the better choice.

6.2.8. Addition:

During the projects progress the project team realized, that the storage provides only very limited independency to the rent station. Without the connection to the local grid, the station would be completely depending on its on energy production. This poses various problems. Even if the station is not used for charging the bikes, energy from the storage will be consumed by camera systems, cash system (computer) and light. If the environmental conditions lead to a lack of energy supply (for example: bad cloudy weather over several days) the station probably will run out of stored electrical energy and get out of order. The problem will become even more intense in the short winter days, where the station will may not be able to produce the necessary amount of energy in order to charge the used bikes and run the stations secondary systems. The risk that the average consumption of energy surpasses the average energy production is very high in winter times.

Due to these facts, the concept of a semi independent rent station which can be upgrade to an independent rent station seems not to be feasible, at least not with an economic relation between price and benefits. As a result the final rent station, which will be delivered at the end of this project, will not posses an energy storage.

6.3. Concepts for Construction (Tobias)

6.3.1. Fully integrated rent station

The concept of a fully integrated rent station would include a station in which the systems for energy generation are completely integrated.
The different electric generator systems would be handled as modules so they can be added or left away, but the overall design would aim to “a look like out of one piece”. Solar cells would be placed on the stations roof and the wind turbines would be attached to the top end of the columns, which are carrying the roof. In order to save costs and space, the stations design has to be functional. Therefore, the number of parts should be reduced to a minimum amount. The ground shape of the station would have to be as small as possible while containing the highest possible number of bikes. A computer system would manage the renting process as well as the stations functions.
The electrical systems have to be included in the construction to prevent passengers from touching sensible parts

6.3.1.1. Advantages:

- Better look
- Saves space
- Less material necessary

6.3.1.2. Disadvantages:

- More complex in construction
- More difficult to build

6.3.2. Semi integrated rent station

The concept of a semi integrated rent station includes a design, in which the solar cells are fully integrated on the stations roof, while the wind turbines are separated from the station. They would become installed near to the station and connected by an underground cable. However, this concept is more difficult to realise during the final building process because it affects also the close environment around the station. To be more precisely, for connecting the wind turbines to the station (by the use of an underground cable, the ground would have to be digged up in order to install the cable). In places with asphalt coating or with heavy sidewalk stones, this process has not to be underestimated in its complexity as well as in the causing costs.

6.3.2.1. Advantages:

- No problems of integrating the wind turbines into the building
- Easier in construction

6.3.2.2. Disadvantages:

- Higher space consumption
- Bigger complexity when it comes to connect wind turbines
- Environmental impact (real and perceived size of the station are bigger)

6.3.3. Modular rent station

The concept of the modular rent station includes a complete separation of all the energy generation systems from the station. The station would be build at one spot, the panels with the solar cells as well as the wind turbines directly beneath the station.

6.3.3.1. Advantages:

- Totally independent systems
- Separate construction –> easier in development

6.3.3.2. Disadvantages:

- Huge and ineffective consumption of space
- Separate constructions will increase the price drastically

6.3.4. Final Result:

The fully integrated station is to be the best choice. Due to the fact, that space is a critical factor in inner city areas, the small space consumption of this concept is the most important aspect. Furthermore it will fit better into the city's environment because, against all other concepts, this concept includes a building, which has a look as if it is made out of one piece. The other concepts include solutions with multiple buildings and in most cases this will not harmonize with the cities environment.
Therefore, the final station will be a fully integrated station.

6.4. Canopy (Tobias)

The canopy is the building, which contains all the necessary devices including the e-bikes, which are necessary to provide green mobility to the publicity. The whole construction is thought to be as cheap and as light as possible. Therefore, the number of different parts has been kept as low as possible. The parts itself are also designed in a way that they don't have unnecessary weight. This saves material and thereby costs. The canopy consists out of two main columns, which are carrying a strong pipe. So called "PV panel carriers" are welded on this pipe. As the name says, these carriers are carrying the PV panel, which will provide electrical power from sun light to the station. The standard canopy has twelve PV panels in total. Depending on the customer's request, the station can also become equipped with another type of solar panel. The other version is more expensive but provides higher efficiency in energy production to the station. Due to the fact that the panel size differs from the default panel, the station will be able to carry 14 panels (7x2) of the more efficient panels. The only change to the construction, which becomes necessary by such a change lies within a different distance between the solar panels or to be more precise, its mounts.

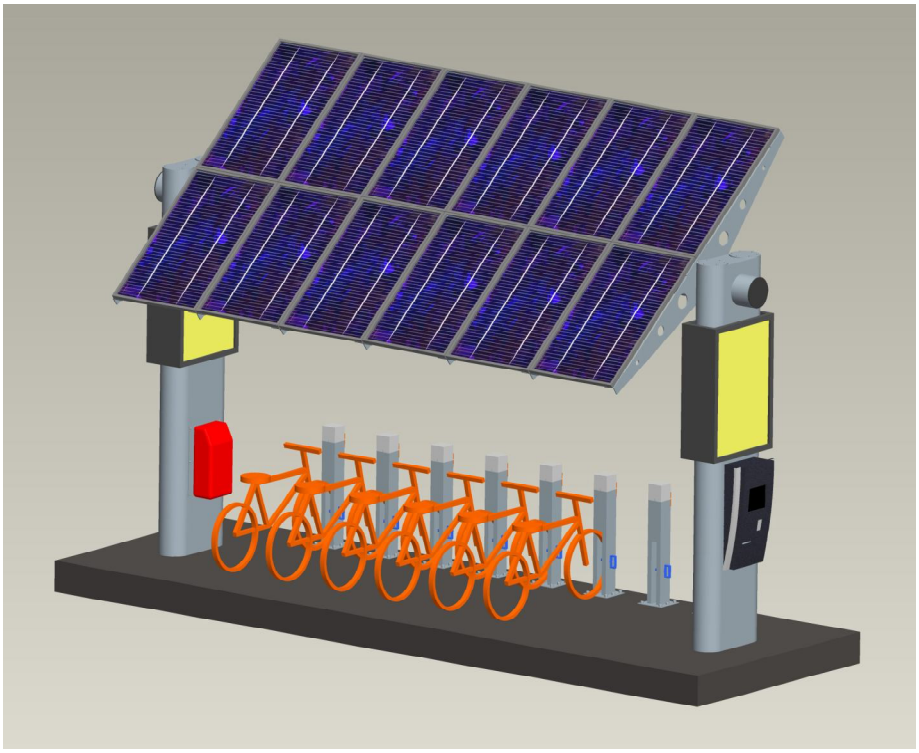


Figure 91: The final canopy with six bikes

They are mounted in a matrix of six by two. The roof, which consists out of the PV panels has an angel of 39 degrees to the horizon. The angel provides us the maximum of possible efficiency in energy generation in Denmark. The angel differs from region to region on the whole world but it can be easily changed during the building process of the canopy. The renting station (the canopy) provides eight recharging columns for the electrical bikes but only six places will be occupied on from the start. The canopy provides the possibility for an upgrade with two vertical wind turbines. The wind turbines can be easily mounted on the top of the main columns. If no wind turbines are mounted, the holes will be sealed by so called "top seal plates". At night the station is illuminated by two strong LED spots, which are installed in the pipe, which is carrying the roof. The choice to use LED spots was triggered by the need to cut energy consumption wherever possible. LED lights are low in energy consumption and therefore ideal for our purpose. The electrical systems of the canopy (including inverter) will be stored in the two main columns. The system will be accessible by an opening in the column, which is usually sealed by a metal sheet. The systems of the canopy, first of all the charging columns, are controlled by a computer terminal, which is mounted on the outside of the right main column. It also provides the renting system including a cash system.

Security through surveillance is provided by a remote controlled surveillance camera. It is mounted close to the roof in order to provide a maximized field of view. In the case of a fire, the canopy also provides a fire extinguisher, which is mounted in a box (see [Figure 91: The final canopy with six bikes], red box) on the inner side of the left main column.

Furthermore, the canopy provides space for advertisement. Two mounts (each can carry two advertisements, see yellow surface) are attached on the upper part of both main columns in order to guarantee maximized visibility. At night the advertisement is illuminated from behind by an energy saving electro florescence foil. For more pictures of the canopy, see appendix under **- II Canopy:**.

6.5. Charging column (Tobias)

6.5.1. Purpose

The charging column serves multiple purposes:
The first purpose lies within the function of a bicycle holder. The charging column provides the possibility to hold the bike upright when it is brought back to the renting station.

The second purpose of the charging column is an issue of safety against theft. The charging column possesses an integrated lock mechanism. This mechanism is controlled by the computer of the renting station. When a customer rents a bike, the computer will unlock the lock by using a coil to generate an electromagnetic field. This electromagnetic field pulls a little metal bolt out of the main lock bolt, which will thereby become movable. After the little metal bolt is pulled out of a notch in the lock bolt, the lock bold, which kept the tire of the bike in the charging column, can be can be pulled to the right side of the charging column in order to release the tire (and the bike). When the lock bolt is not in locking position anymore, the lock recognises this by an optical switch, which becomes blocked, if the lock bolt is in any position which is different from the "locked-position". By using the optical switch the computer knows if a bike is removed from the station after the customer payed for it and the computer unlocked the lock. The computer also can control if the customer locked the bike correctly after he brought it back.

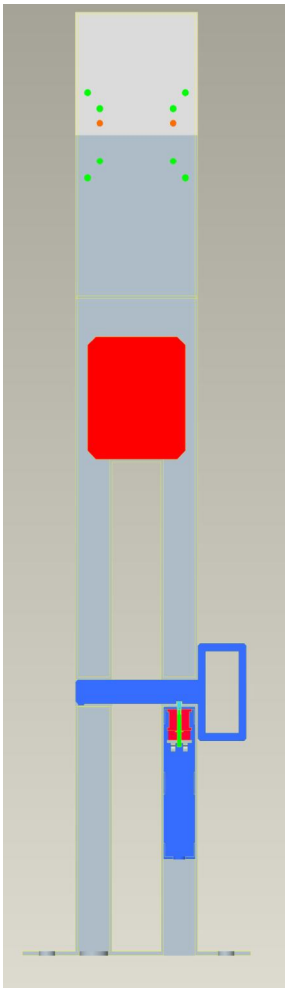


Figure 92: Vertically sliced charging column

The last and maybe most important purpose of the charging column is, as the name already says, to charge the bikes or to be more precise, their batteries. Therefore, a charging device is integrated in the upper part of the column.

It is sealed inside to keep it from getting stolen but the charging cable is easily reachable. In order to connect the cable with the bike, the end cap of the column must be switched open. The cable including its plug is stored in the top part of the columns body. The cable can be easily removed and be attached to the bike. A little notch in the end-cap of the column provides the possibility to close the cap completely even if the cable reaches out of the columns body. When plugged in, the charging process starts. The whole process is controlled by the stations computer. For safety reasons, the charging device is only activated when the computer registers a bike stored in the column. If the column appears empty to the computer, he will deactivate the power supply to the charging device.

6.5.2. Components and mechanics:

The charging column consists of several components. The most important part is the main body (see picture -> part with dark grey colour). It holds all the other components. The big red body, which is visible in the upper middle part of the main body, is the charging device. It transforms the high voltage AC-current from the electrical grid in to low voltage DC-current, which is suitable to recharge the bikes batteries. It also controls the charging process and shuts down when the battery is fully charged. This happens to avoid possible damage to the battery. In order to protect the charging device from environmental impacts or theft, the device is protected by a sealing plate, which is mounted directly over the device. The horizontal blue part in the lower third of the column is the lock bolt. It locks the front tire of the bike in the charging column by being stuck through the front tire. The vertical blue part is the housing for the electromagnetic lock mechanism. It contains four main components. A little metal rod with ferromagnetic properties (light blue), a plastic rod which is attached to the metal rod, the coil module which generates an electromagnetic field when activated and the mount for an optical switch which controls if the lock is locked or unlocked. The both rods are positioned in the coil.

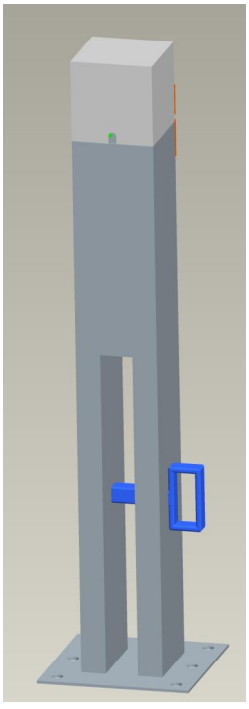


Figure 93: Charging Column

Thereby, the upper part of the combined rod is the metal rod. The plastic rod is going all the way though the coil and leaves it at the bottom side. At the bottom side of the coil module the mount for the optical switch is attached. It carries an infrared led and a phototransistor. If the coil is not activated, the rod is pulled up by a weak feather. The metal part of the rod becomes pulled into a notch in the lock bolt, which becomes fixed in its position (it is “locked”). When the coil is activated the metal part at the top of the rod becomes pulled into the coil and unlocks the lock bolt, which becomes movable. When the rod is pulled down by the magnetic field the optical switch becomes blocked (so it is possible to check the state of the lock). When the coil becomes deactivated, the feather pushes the rod back to the top. If the lock bolt is in “lock position” then the little metal piece will go back into the notch. If the lock bold is not in lock position, the rod is not going back into the notch and remains in the “unlocked position” and continues to block the optical switch. As soon as the lock bolt becomes pushed back into the “locked position” the tiny metal rod snaps back into the notch and the optical switch becomes unblocked. The lock bold is not entirely removable from the column. A tiny metal nose at the end of the lock bold only allows to pull the bold out of the column until the bikes tire is unlocked.

On the top of the columns body, the end cap (bright grey) is mounted. A hinge is connecting the end cap and the columns body, so the cap can be opened. Under the end cap, the charging cable is stored in the columns upper body. If the cap is open the cable can be removed in order to charge the bikes battery.

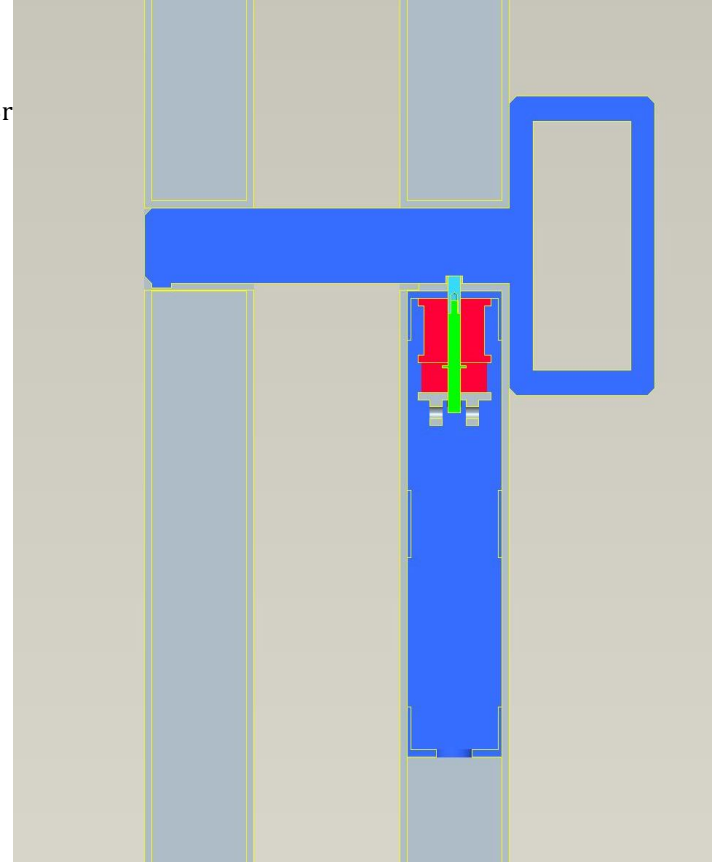


Figure 94: Sliced view of the electromagnetic lock mechanism

Cut through the electromagnetic lock mechanism

Last but not least, the column body is welded on a steel plate, which provides the possibility to mount the column on the ground by using six screws. The cables for providing the electrical current as well as for signal transmission are entering the column from the ground. For more pictures of the charging column, see appendix under **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**

6.6. Technical drawings (Tobias)

In order to do the technical drawings, A CAD program with the name “PROengineer” has been used. This program provides the possibility to the user to generate 3D-modells from simple drawn shapes. These 3D models can be combined in order to to form more complex groups of object. By doing so, the user has the possibility to generate different parts of a device and combine them into the final device. Out of these 3D parts, the user can create technical drawings in a way as they are common in modern engineering science. The drawings can be simple drawings of parts as well as complex assembly drawings. The user interface of this program is shown in Figure 95: User interface of Wildfire PROengineer.

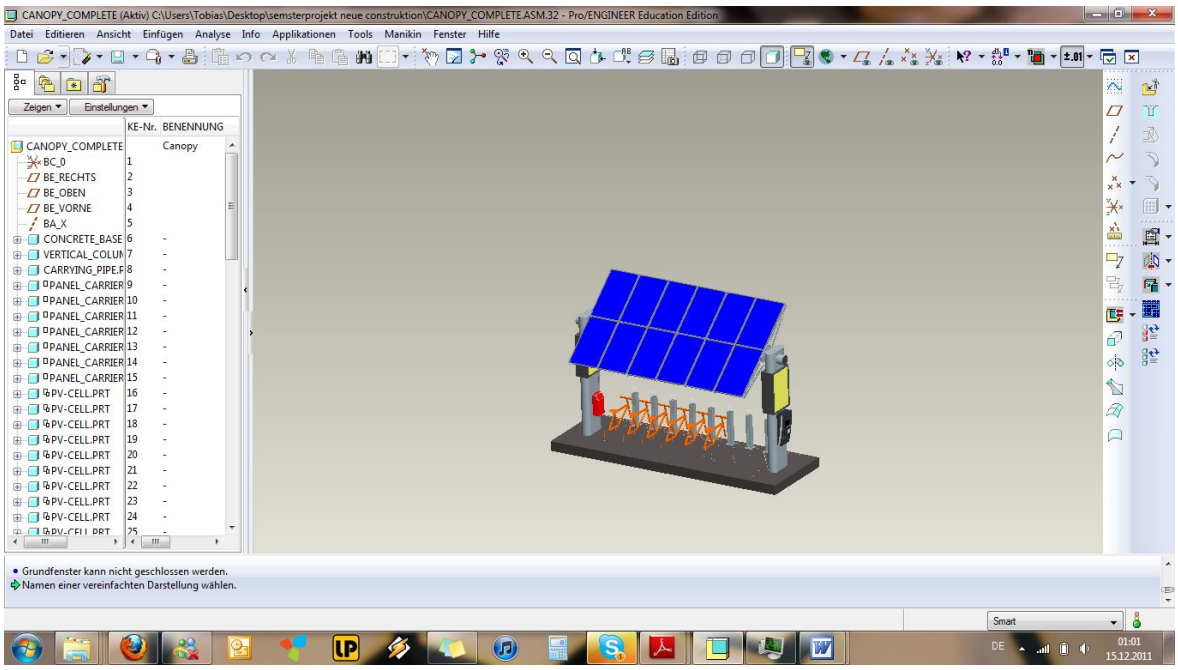


Figure 95: User interface of Wildfire PROengineer

The technical drawings on the following pages show the most important measures of the canopy and the column in a completely assembled state (Figure 96: Technical drawing of the assembled canopyFigure 97: Technical drawing of the charging column).

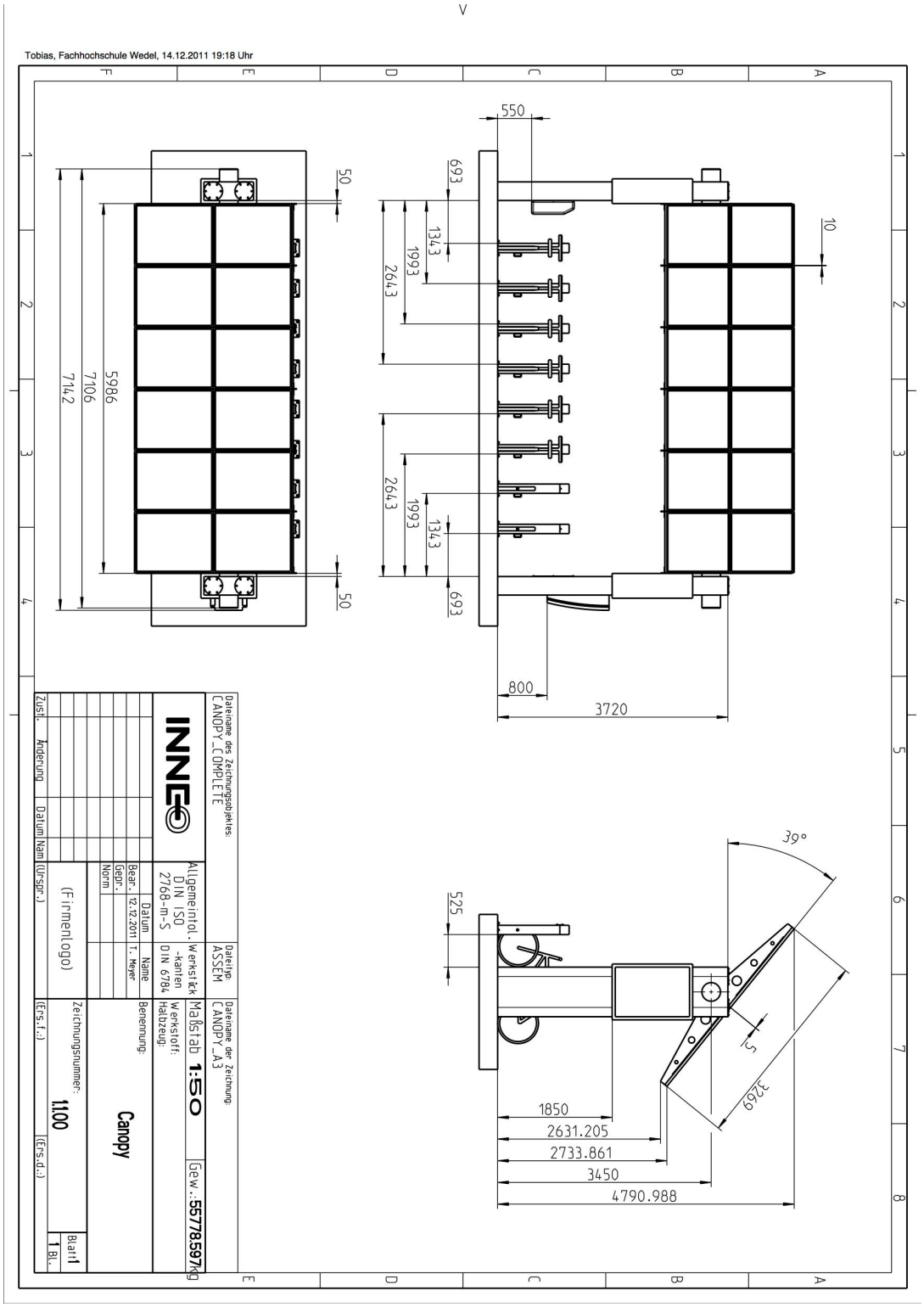


Figure 96: Technical drawing of the assembled canopy

A full scale A4 print is included at the end of the appendix.

(- IV Technical Drawings)

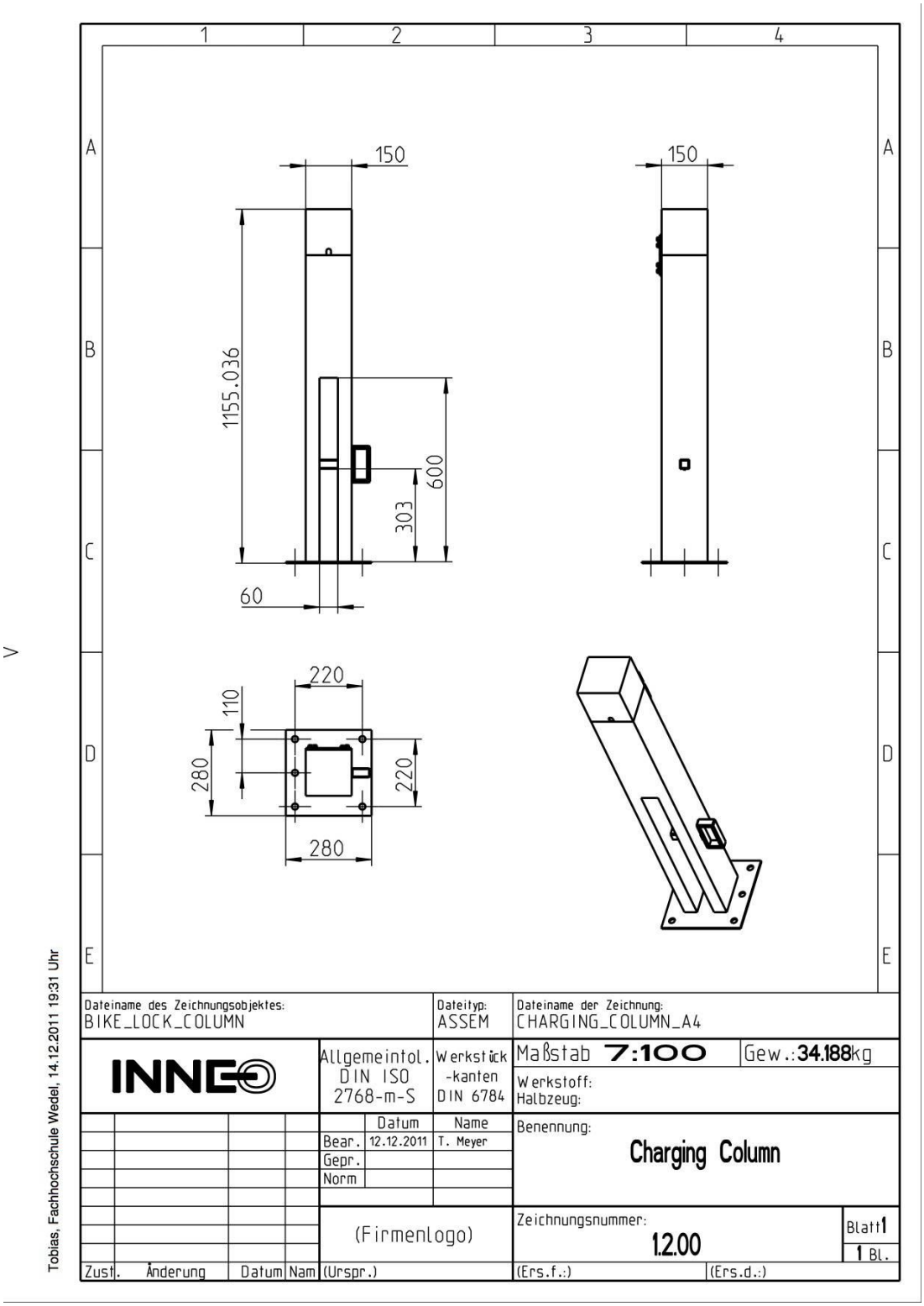


Figure 97: Technical drawing of the charging column

A full scale A4 print is included at the end of the appendix.

(- IV Technical Drawings)

6.7. Conclusion

During the investigations in this chapter, the use of an energy storage which was supposed to provide full independency to the rent station has proven to be unfeasible. The storage system which could provide independency to the station would acquire too much space in order to be truly effective.
Furthermore, the concept for the final rent station has been chosen. The final rent station will follow the concept of a fully integrated rent station, due to the fact that it needs a smaller amount of space and is extendable more easily in order to apply wind turbines for additional energy production. Last but not least, this concept will most likely fit in all areas because of its compact appearance.

Finally, the rent station was designed and constructed. During the construction process, big effort was paid in order to do the station as simple as possible. Therefore, less parts as possible were used. The final station provides the possibility to charge eight electrical bikes simultaneously. Solar panels and (and if needed wind turbines) become applied at the top of the station.
Beneath containing the bikes, the station can also serve to advertisement purposes. In order to do so, the station provides two advertisement carriers. The stations system will be managed by a computer system, which is also responsible for the renting process, including customer interaction.

For more pictures of the canopy and charging column, see appendix- I **Pictures of canopy and charging column:**.

In order to give an impression about the dimensions of the station, technical drawings have been created which show the most important measures. The drawing where created for the canopy and for the charging column.

7. Chapter

7.1. Strategy (Laura B, Laura R)

7.1.1. Introduction

For the project is important define a marketing strategy to minimize the cost. Marketing strategy is a process that can allow an organization to concentrate its limited resources on the greatest opportunities to increase sales and achieve a sustainable competitive advantage.
The team analyses the different strategy in the market, we have include this part in the appendix Strategy. Following the group shows the strategy that decides to apply. After the group decide to analyse the channel distribution and the advertising.

7.1.2. Strategy applied

After analyzing improvement methods for planning and management system it is possible choose the best methods to be applied at the strategy for the product.
The team purpose is utilizing one method that allows us to minimize application cost. The method that the members decided to apply is JIT (Just in time) because it's a cheaper solution. It is needed to build a warehouse to store items to be sure that products are available when needed. The group members decided to include in the warehouse all the materials needed to build the canopy and the products necessary for the safety. (Products are in the chapter 4). It is necessary the warehouse because when the suppliers deliver the products that it is necessary to order, they deliver also some spare parts.

7.1.3. Bill of material: Charging column and Canopy

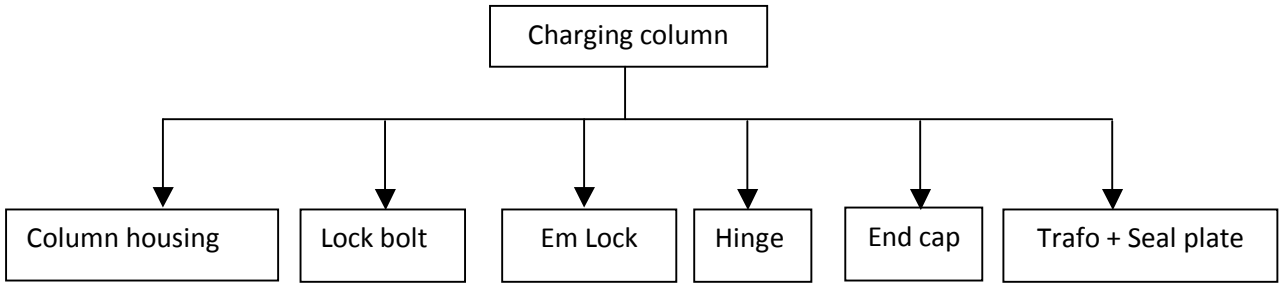
The member of the team decided that is better to design the canopy and the charging column. It is necessary decide what are the components that compose each single item. This part is related at the mechanical part (Chapter 6) and this particular components are explain in the product part(Chapter 4).

7.1.4. Charging Columns

Below it is possible to see the bill of material necessary to build the charging column. Churching column is a particular column able to provide energy to the electric bicycles.

The bill refers to the production of one unit. It is necessary is to inform the manufacturer how many units of product you want to produce. In this case there are in total 7 bicycle stations around Horsens and in each station the team decides to insert 8 charging columns, so in total for all the project are require 56 charging columns.

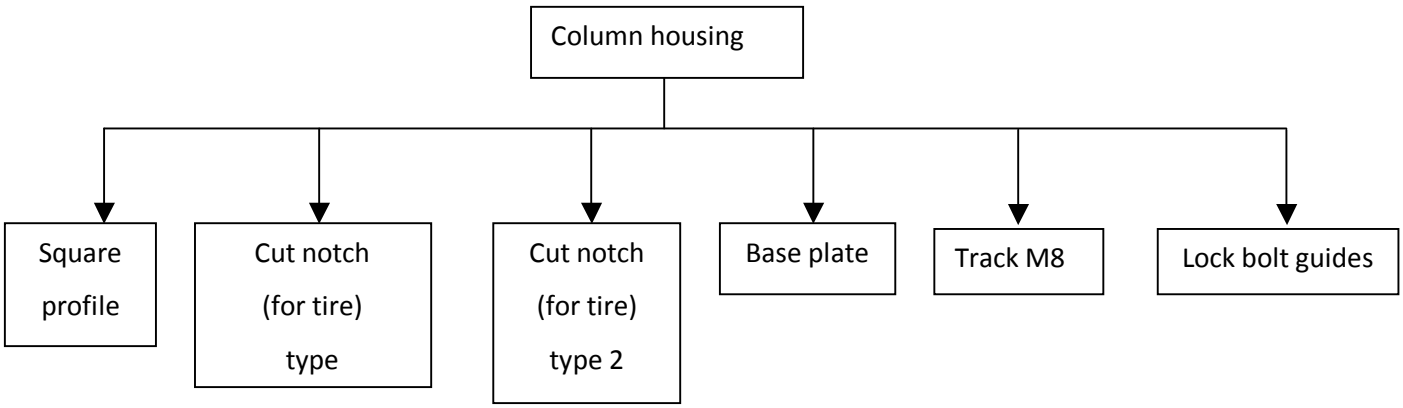
Each bill contains tables showing the level at which belong in each component and the required amount with the respective measures.



MATERIAL	LEVEL
Column housing	1
Lock bolt	1
Em Lock	1
Hinge	1
End cap	1
Trafo + Seal plate	1

Table 30: Level Charging Column

7.1.4.1. Column housing



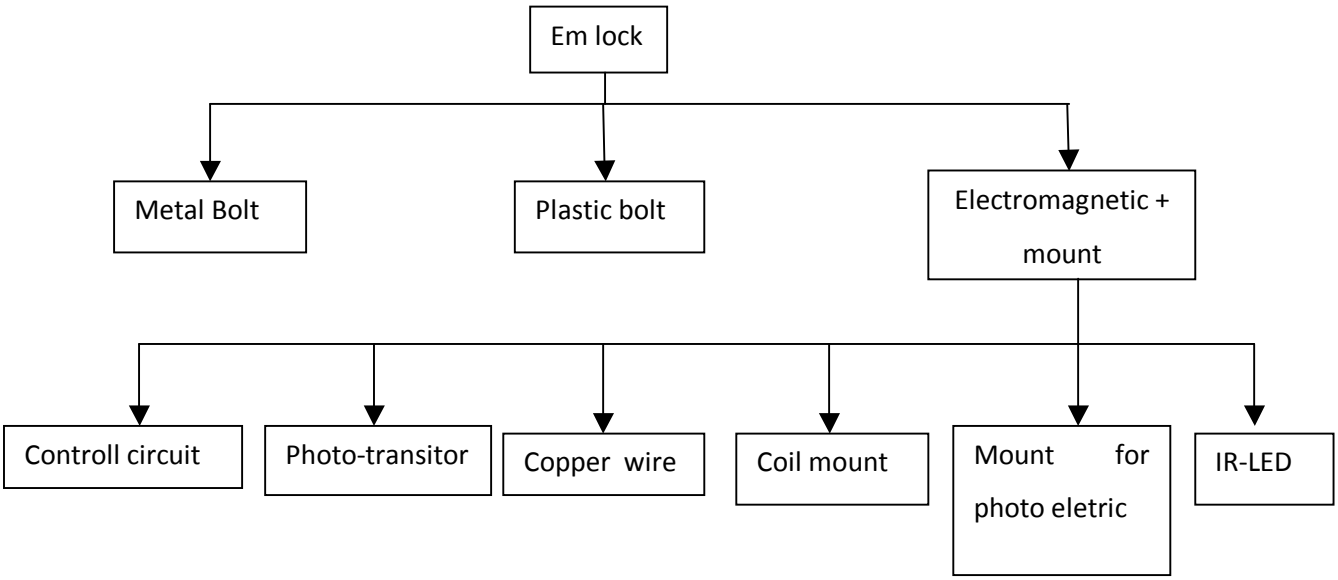
MATERIAL	LEVEL
Column housing	1
Square profile	2
Cut notch (for tire) type 1	2
Cut notch (for tire) type 2	2
Base plate	2
Track M8	2
Lock bolt guides	2

Table 31: Level Column housing

MATERIAL	NUMBER	DIMENSION
Square profile	1	[150 x 150 x 1000] cm^3
Cut notch (for tire) type 1	2	[150 x 600 x 3] cm^3
Cut notch (for tire) type 2	1	[150 x 60 x 3] cm^3
Base plate	1	[5 x 280 x 280] cm^3
Track M8	1	[15 x 40 x 20] cm^3

Table 32: Dimensions Charging Column

7.1.4.2. Em lock

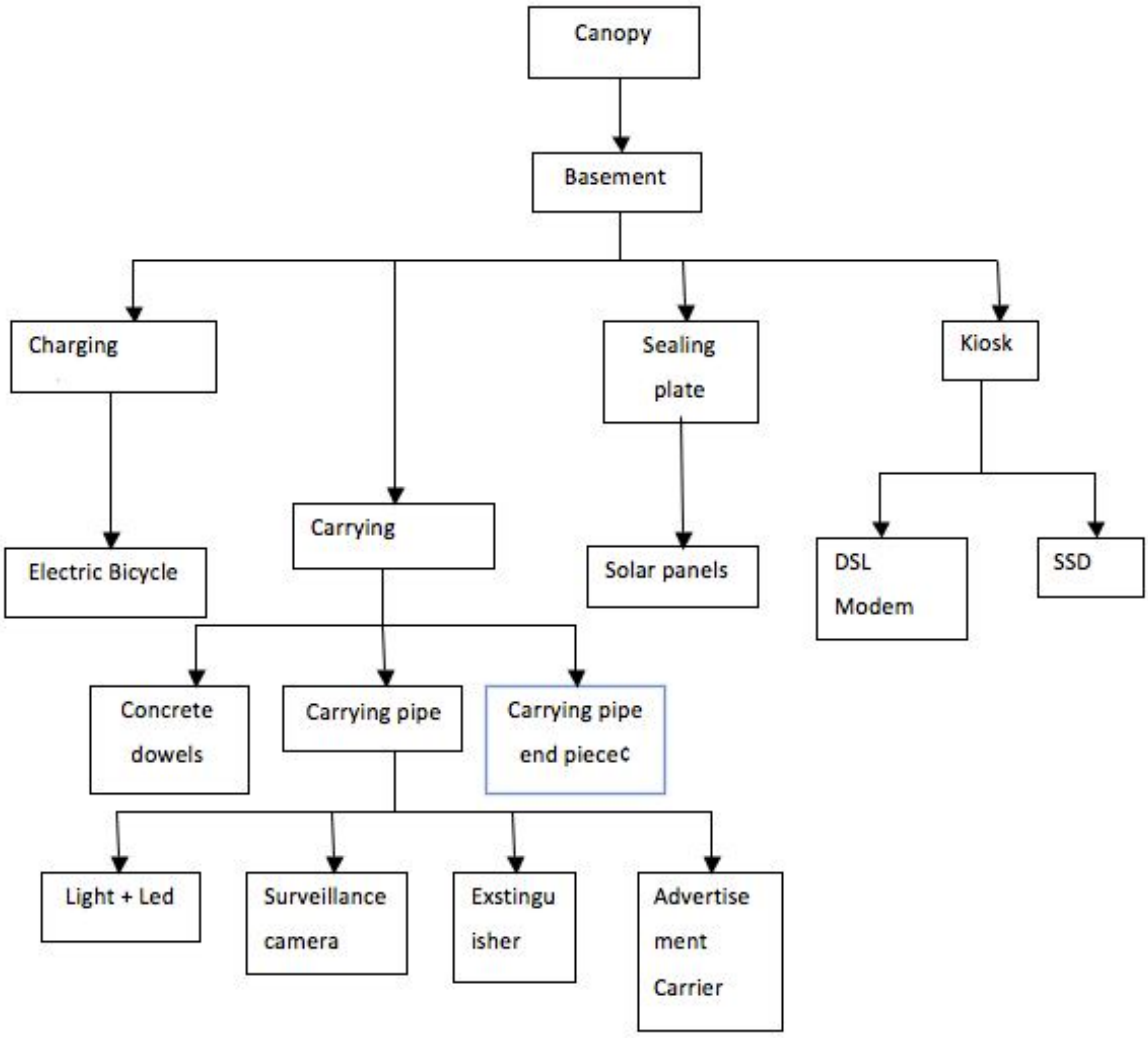


MATERIAL	LEVEL
Em lock	1
Metal Bolt	2
Plastic bolt	2
Electromagnetic +mount	2
Controll circuit	3
Photo-transitor	3
Copper wire	3
Coil mount	3
Mount for photo eletric	3

Table 33: Level EM Lock

7.1.5. Canopy

The canopy is the structure that hosts the electric bicycle. The member of the team decides to implement 7 canopy around Horsens (Paragraph Place in the chapter 4). In the following is what are the main components that constitute a canopy. Each diagram refers to the components of a single canopy. To find the total number of total component it is necessary multiply the bill of material for 7.



MATERIAL	LEVEL
Basement	1
Charging Column	2
Kiosk	2
Carrying Column	2
Top Sealing plate	2
Sealing plate	2
Carrying pipe end piece	3
Solar panels: cell carrier	3
Solar panel: cell carrier end piece	3
Solar panel: cell	3
Electric Bicycle	3
DSL modem	3
carrying pipe	3
SSD	3
Concrete dowels	3
Light	4
Led	4
Surveillance Camera	4
Extinguisher	4

Table 34: Level Canopy

MATERIAL	NUMBER	DIMENSION
Basement	1	[6,3 m x 2 m]
Charging Column	8	[4,7 m x 0,3 m]
Carrying pipe end piece	2	[shape: L40 R150]
Kiosk	1	/
Surveillance Camera	1	/
Exstinguisher	1	/
Solar panels: pv-cell carrier	5	/
Solar panel: pv-cell carrier end piece	2	/
Solar panel: pv-cell	12	/
Carrying Column	2	[sharpe: L4020 W800 D300 S15]
Electric Bicycle	6	/
DSL modem	1	/
SSD	1	/
Light	2	[L150 R67 S5]
Led	2	/
carrying pipe	1	[L7086 R150 S20]
Top Sealing plate	4	[L10 R150]
Sealing plate	2	[L680 W480 D5]
Advertisement carrier	2	/
Concrete dowels	2	[L200 R12,5 Ri (M20)]

Table 35: Dimensions Canopy

LEGEND	
D	Depth
R	Radius
Ri	Inner Radius
S	Strength
m	meters

Table 36: Legend for "Dimensions Canopy"

7.2. CHANNEL DISTRIBUTION (Laura R.)

The channel decision is very important. The decision that the team members take is to design their product as standardized as possible but they will offer also personalized solutions for their customers. The weather conditions are different for each place and so important is to implement in the final product the best solar panel for the city of the customers and also the best wind turbine. But the electric bikes, the canopy and the other component are the same in each station.

Considering the cost of this product they choice is not to sell it on-line or by e-mail. It is important to meet the customer for know his needs and offer the best solution.

For these reasons the group thought to sell their product in a office where is possible to meet all the people who are interesting in the renting stations, both customers or stakeholders. In this project the focus is on Horsens, so the position of their first office in this city.

For meet customers, they offer also the service of salespersons. Of course, the team members are the best salespersons of this product because it grew in their hands. But if the market expands, they will not exclude to train some persons to sell the renting station.

In the web site the customers can find the contact of the group components and the address of their office.

7.3. ADVERTISING (Laura R.)

Advertising is a form of communication used to persuade people to buy products or to make known services. Most commonly, the desired result is to drive consumer behaviour with respect to a commercial offering, although political and ideological advertising is also common. Advertising messages are usually paid by sponsors and viewed via various traditional media: newspaper, magazine, television commercial, radio advertisement, outdoor advertising, e-mail web site or text message.

The TV commercial is generally considered the most effective mass-market advertising format. The market of the project is Denmark so the follow analysis is about the possibility to advertise the renting station on Danish television. An "ads by Google" wrote by Marguerite R. Plummer86 shows these data:

Number of television Station	25
Number of television set	3.121.000
Television Consumption (Minutes per days - average value)	174
Number of cable subscribers	1.403.440
Number of satellite subscribers	800.000

Table 37: Television Data

In Denmark there is one television every two persons (the population is 5.352.815 persons from this research). The television consumption is an average of 3 hours a day. A research from "The economist"[87], weekly newspaper where there are articles with information from all the word published in London, shows the number of televisions per 100 families in the following places:

[86] http://www.pressreference.com/Co-Fa/Denmark.html#b
[87] http://gandalf.it/storia/storia09.htm

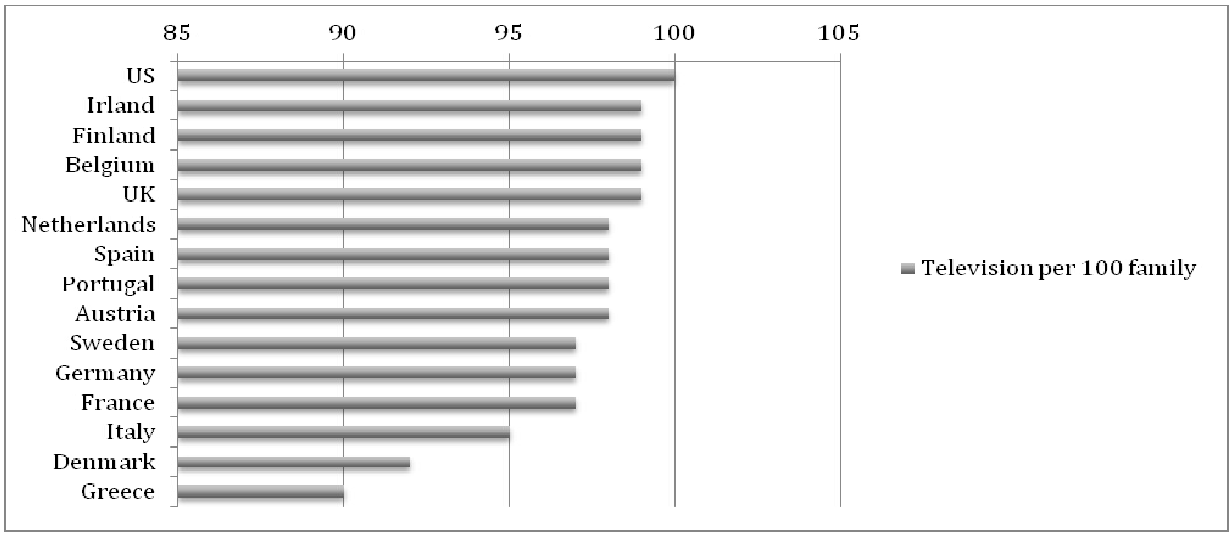


Figure 98: Number of televisions per 100 families [2003]

These data show that Denmark is at the last positions. The Danish DR-channels do not show any advertisements at all because they are funded by a television license88. TV2, another Danish television network, shows advertisements only in blocks between the programs. These can take from two minutes to ten minutes depending on the time to the next show. The cost of commercial advertising time on TV2 can range from $100 (555,92 DKK) to many thousand depending on the length of the advertising and the time its screens[89]. Commercial breaks in Denmark are strictly prohibited and advertising targeted to children is restricted. Channels like as Kanal 5 and TV3 are allowed to interrupt programs, as these channels are being broadcast via satellite from the United Kingdom.

For all these reasons, the decision that the team members take is to do not use the television for advertising: it is expensive and it does not give the necessary visibility. In future, if the business generates a profit, it will be possible use also the television to support it.

The data from Marguerite R. Plummer's research show a similar analysis for the radio advertising.

Number of radio station	357
Number of radio receivers	6.020.000
Radio consumption (minute per day)	128

Table 38: Radio Data

[88] http://en.wikipedia.org/wiki/Television_advertisement#Denmark
[89] http://tvnz.co.nz/view/page/816460/869419#howmuchad

In Denmark there are more then one-radio receiver for person and a consumption average of two hours. The number of station is high and for a successful advertising it will be important choose the right channel. The negative characteristic that has the radio is that there is not station that can be listen everywhere. The channels in Copenhagen are different from the channels in Horsens. For these reason the choice was to invest the money in other types of advertising.

In Denmark there are 55 different newspapers: 16 national ones and 39 regional[90]. To make known the product in all the Denmark, important is to analyse the national newspaper. The largest-selling of newspaper with 120.000 copies is a record of Jyllands-Posten[91]. Its main competitors are the broadsheet Politiken and compact Berlingske Tidende. All these newspapers are also on-line so they have a lot of visibility. Invest in these ones for the advertising and also in some business newspapers, like us Dagbladet Børsen, could be interesting.

The personal web site designed by Federico, a team member, is helpful to promote the product and the stakeholders could advertise themselves. For this reason there are two columns free.

Figure 99: Advertisement on web site

Of course, also in the bike stations there are some places for the stakeholder advertising and for the project one.

[90] http://en.wikipedia.org/wiki/List_of_newspapers_in_Denmark
[91] http://en.wikipedia.org/wiki/Jyllands-Posten#cite_note-2

Through brochure, billboards in the cities and leaflets it is possible publicize the renting points. The need that has the group is to find a specialist to make the design for their adverting. In Denmark there are more then 500 advertising-agencies92, but the initial budget is limited. For these reason the decision that the team take is to entrust the work to the company that offer the better solution in term of cost and quality.

Conclusion

After analyzing this chapter it is possible to conclude that it is very important to choose the correct marketing strategy to be adopted. In this part it was important analyzed the bill of materials for each canopy because it fundamental know from what the final product is composed. Designing new components and offering a new product, it was necessary to study the distribution channel and the necessary advertising to ensure that the product is well known.

[92] http://www.denmark.net/business/category/advertising-agencies

8. Chapter

8.1. SECURITY (Laura R. Laura B. Federico)

8.1.1. INTRODUCTION

Security can be defined as the knowledge that the evolution of the product will not produce undesirable states. It is important the control for do not cause damage for the people that work on the renting station, like as assembly team, and for the people that will decide to use it.

8.1.2. THEORY OF SECURITY

8.1.2.1. AMMOUNT OF RISK (R)

Risk assessment is one of the main tools used to ensure and implement proper training and information for individuals exposed to risk and to safeguard the health and safety, and one of the stages of risk management. Assess the risk involves measuring the amount (R) that affect on it: the size of the potential loss (L) and the probability (p) that the loss should actually be supported.
The formula is the following[93]:

$$Ri = Li\ p(Li)$$

Where,
R: is the amount of risk
L: potential loss
p: probability
i: is the event for which e calculate R.

For every risk (i) it was calculate the amount and at the end the total risk:

$$R_{total} = \sum_i [(L_i) * p(L_i)]$$

[93] www.wikipedia.it

Risk assessment is often the most important step in the process of Risk Management and can also be the most difficult and prone to error. Once the risks have been identified and evaluated, the steps to manage them appropriately may be easier to spot.

Part of the difficulty of risk management depends on the fact that the measurement of two quantities that determine the risk assessment can be very difficult. The uncertainty in the measurement is often significant. In addition, risk management would be simpler if a single metric could incorporate all the information involved in the measurement. Instead, since there are two types of quantities that are measured, this is not possible. A risk with a large potential loss and a low probability of occurrence must be treated differently from one with a low potential loss but a high probability of occurrence. In theory, both would be managed with the same priority, but in practice this can be very difficult when you are having to do with the scarcity of resources, especially the resource-time, assigned to the process of risk management.

8.1.2.2. RISK ASSESMENT IN THE WORKPLACE

The risk assessment consists in the determination of risks (physical, chemical, biological, cargo movement, from computer screens, fire, indoor, outdoor etc.) to which the workers could be subjected, by quantifying the probability that there will be a damaging effect to the workers (P= probability) and assessing the seriousness of this event (M=magnitude).

$$R = P * M$$

The range for the probability and the magnitude is from 1 to 5 and so for the amount of risk from 1 to 25[94]. If R is more than 10, immediate actions are required. Every company can decide which range using, but the most common range is the one that the team choose.

The main goal of risk assessment is to prevent two types of risk:

1. Risk of incurring in damages in the workplace during the work hours.
2. Risk of damage due to prolonged exposure to high levels and a chemical, physical, biological, causing damages r after some time.

[94] slides from Security Course

In the risk assessment involves several steps that require the contribution of different disciplines. The assessment must also take into account the type of work environment, the processes involved in it and their complexity. However, it is possible to summarize the assessment process in the following steps:

1. Identification of sources of danger: it aims to identify the factors that could cause an adverse effect.
2. Identification of exposed subjects: it aims to identify persons who may be exposed to a particular risk, taking into account differences in gender, age, ethnicity and so on. In fact, in our project, it is possible to identify as potential workers, strong men for the phases of assembly and women for office work.
3. Prioritize risk: results of the two phases are then combined to produce an estimate of risk (Risk Assessment). This way you can draw up a ranking on the basis of establishment of the order of operations to be performed.
4. Choice of intervention: according to the priorities set out above, there is to choose interventions to be effective, efficient and appropriate to the context in which they are applied, making an assessment and cost-effective.
5. Implement control measures on the operations: when it was put into practice interventions, it should be checked periodically to their actual capabilities.

8.1.2.3. ISO RISK CURVE

The amount of risk could be represent on e iso-risk curve, which is a rectangular hyperbola.

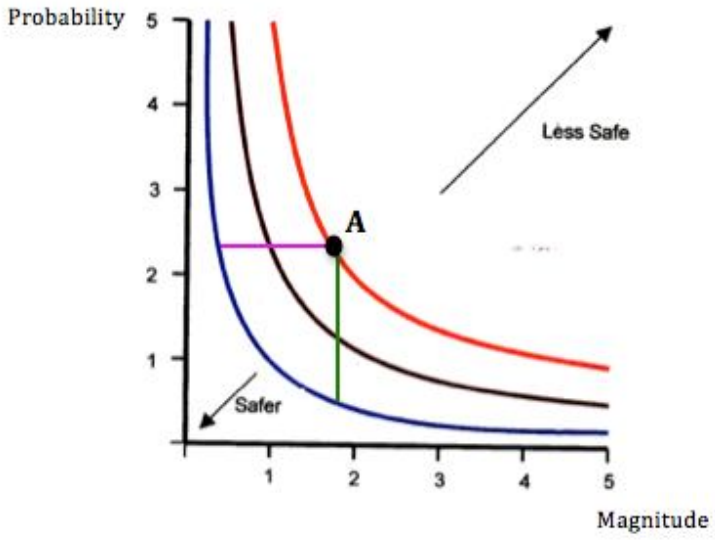


Figure 100: ISO-risk curve

In the horizontal axe there is the magnitude (M), in the vertical axe there is the probability (P). Moving ward the red curve, the risk increases. Assuming that the point A is the current situation, moving along the green line the prevention action was done, instead along the purple line is the protection action that was done. These two different actions are for decrease the risk.

8.1.2.4. COST-EFFICACY CURVE

The basic principle of the intervention consists of two basic guidelines:

1. Design your facilities for safety (prevention).
2. Designing the security of facilities (protection).

Firstly, designing safe means to follow during the design all the rules, suggestions and information provided by the experience, from knowledge and scientific techniques to the law, so the likelihood of risk events is reduced to negligible levels. Secondly, designing the security means to organize an efficient structure of man and procedures, so the adverse events are limited as possible.

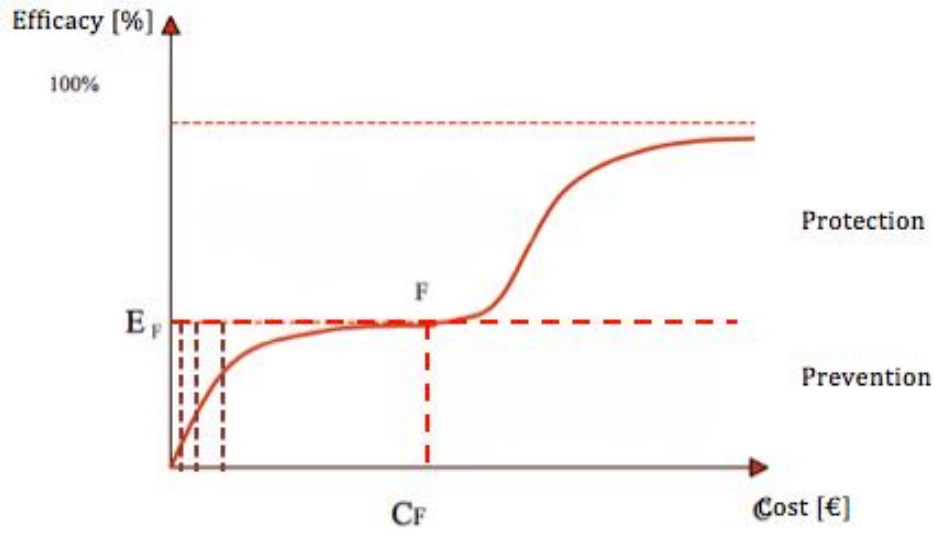


Figure 101: Cost-efficiency-curve

The point F is the limit of convenience of safe operations. In the horizontal axe there is the cost and in the vertical axe there is the efficacy.

Every operation has implementation cost. During the implementation part there are less costs and the efficacy is higher during the first operations. This is the prevention part. The situation is repeated over the horizontal asymptote after the point F, in the protection part, but here the cost and the efficacy are higher than the first situation.

Concluding, prevention is less expensive then protection.

8.1.2.5. RISKS ANALYSIS

This part analyse the different risks, at which the people who will assemble the renting stations and the users are subject. In particular the workers are could be injured doing wrong movement (mechanical risk). Both the customers and the assemble teams risk of getting hurt in case of fire, it is for this reason that the group thought to give them all the possible means and tools to avoid it. Moreover, there are many electrical parts in the stations, which could cause damage if they are not protected.

In this paragraph there is the analysis of the mechanical risk, the fire risk and the electrical risk to prevent injuries. Was missed the analysis about the other types of risk (biologic, chemical, fulmination, sound, vibration) because they have a low amount of risk in this project.

8.1.2.6. MECHANICAL RISK

The mechanical risk could be generated by forklift motors, manual handling of loads, repeated efforts and mechanized handling of loads. The most significant of these for the project is the manual handling of loads because the assemble team works manually for 90% of the time, moving products that are not so light. In fact, “manual handling of loads” means transport operations or support of loads by one or more workers, including the actions of lift, lay down, push, pull, carry or move a load. An improper movement can result in distortions, back pain, acute low back pain, and muscle strain until serious injury. These are risk associated with activities, but there are also risks due to carry load: it could fall down, causing fractures; or due to the dimensions of it, the worker could not see steps or something on the floor and then fall down. These are risk that is important to prevent and educate the staff about them.

For the movements of the body that the worker:

- Must stay in an upright position on the move

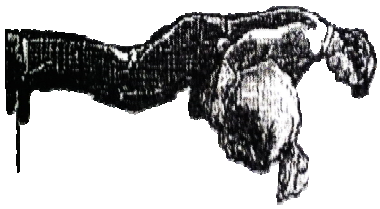


Figure 102: Right position of the back

- Should not stand on his toes
- Should not extend up the arms above head
- Should always avoid twisting

Figure 103: Wrong and right movements

- Must avoid sudden movements

The load instead:

- Must be kept s close as possible to the body
- Must be lifted and placed n the floor with the back straight

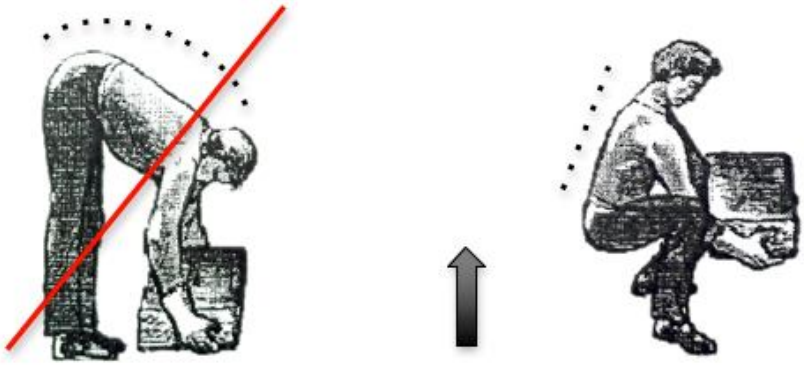


Figure 104: Wrong and right movements to lift a load

- Should be grasped with the alms of hand
- Should be distributed symmetrical and balanced

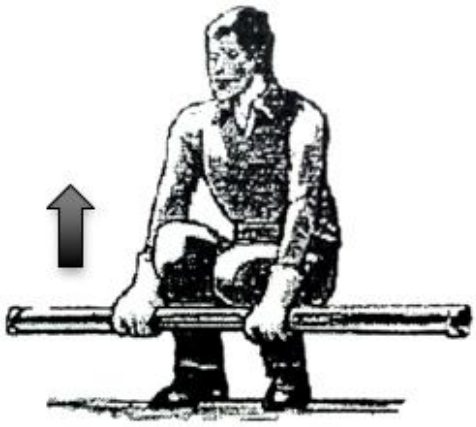


Figure 105: Right position of the load

- The movement should be at a height between e knees d head

When two or more people involve together to lift, transport, lay down one load, their movement should be coordinated and simultaneously. The transportation of load on the shoulder is not recommended because the back takes the wrong position, but if it is the only one possible solution the movement must be don in this way:

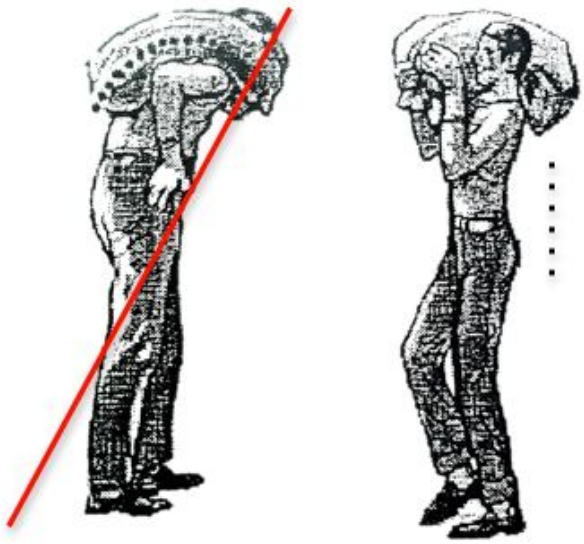


Figure 106: Wrong and Right way for the transportation of load on the shoulder

PROBABILITY	MAGNITUDE	AMOUNT OF RISK
3	2	6

Table 39: Amount of mechanical risk

The amount of mechanical risk in this project is 6/25. The workers do a lot of manual work so it could be possible that they incurring in injures.

8.1.2.7. ELECTRICAL RISK

Electrical risks resulting from the damaging effects that the electricity could produce on the human body both for direct and indirect actions. The direct action consists in the passage of electrical current through the human body that consist in the contact of two points with different potential. The passage of electricity through the body could produce a simple shock, without consequences, or severe muscle contraction that could cause death. The effects depend on the intensity of current that flow, on its curse and on the time that e current persist in the body. The indirect action, which is generated, is a consequence of the electric arc. The electric arc could be produced by short-circuit or by an interruption with improper means of circuit with strong currents. The electric arc could be produce burns, dazzles, conjunctivitis, projections of incandescent parts and fire.

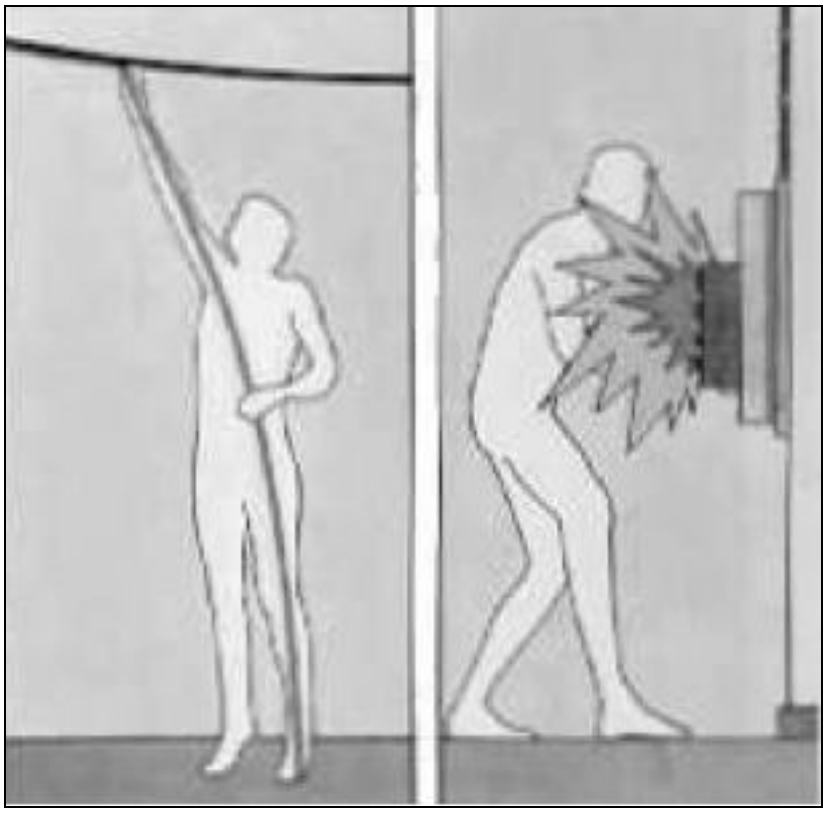


Figure 107: Indirect and direct Actions

To prevent this risk the workers who have to deal with the electrical pert, have to wear the insulated gloves, helmet and clothes that do not leave uncovered body parts. They have also to use insulated tools.

PROBABILITY	MAGNITUDE	AMOUNT OF RISK
1	4	4

Table 40: Amount of electrical risk

In this case, the amount of risk is 4/25. The probability that happen this risk is not so high but the consequences that it could produce are big for the worker and customers. This value is less than the other one because the probability that happen some electrical problem is less then the probability that happen some mechanical problem.

8.1.2.8. FIRE RISK

A fire is a burning uncontrolled. The combustion is a chemical reaction of a combustible substance with oxygen, accompanied by evolution of heat. In order for combustion, it must be true e following three conditions:

1. Presence of oxygen
2. Presence of fuel (wood, tissue, hydrocarbon, paper…)
3. Appropriate temperatures

It is possible categorise the fire in four classes:

1. CLASS A: Fire of solid materials, usually organic ones. Their combustion normally consists in the production of embers. In this category there is the wood, paper and rags.
2. CLASS B: Fire of liquid or solid that could liquefy. In this category there is gasoline, alcohol, paints and oil.
3. CLASS C: Fire of gas. This is the category of methane, propane, hydrogen, and acetylene.
4. CLASS D: Fire of metal. This is the class in which it is possible to identify the main risk for our worker and our users.

The workers have to know the three different ways to extinguish the fire. There are three possible actions: action of separation, that consist in a separation of the fuel, which is not yet affects by fire burning form which is already burning; action of suffocations, this means elimination f contact between fuel and oxidising; action cooling that is the reduction of fuel temperature below the ignition with the use of

carbon dioxide. The carbon dioxide that comes out from the extinguisher is -78 degrees (-78°C).

The high temperature could be a big risk for the people. In fact, it can cause burns, heat shock and dehydration. The oxygen deficiency could cause difficult movements, collapse, respiration ceases and in six minute the death for asphyxiation. The fumes could cause burning eyes and mucous membranes of the respiratory tract.

It is for the serious damage that the fire could produce on the people and the products that the team decided to implement the system with extinguisher and appropriate signals that are described in the Chapter 4 Paragraph Product.

PROBABILITY	MAGNITUDE	AMOUNT OF RISK
1	5	**5**

Table 41: Amount of fire risk

The value of amount of fire risk is 5/25. The probability that happen a fire is low but if it happen the consequences on the station's owner could be important because it could damage the product and the people.

Conclusion

The renting stations are not risky because even value of the amount calculated is upon the 10, which is the thresholds over which are necessary several controls. The risk with the higher value is the mechanical one, so the worker has to be carful during their manual works and the organization has to plan the working place and the distribution of materials on it to prevent the injuries.

9. Chapter

9.1. Business plan (Federico, Laura B, Laura R)

A business plan is a formal statement of a set of business goals, the reasons why they are believed attainable, and the plan for reaching those goals.

Two different business plan were analysed the difference regarding the type of solar panels used: one with LG 235M1C-G2 and one with Sanyo HIT N235SE-10.

The first one, with the LG solar panels that has less efficiency, is studied to ensure that the energy produced is enough only for charge the electric bicycle and the other devices.

The second one, with the Sanyo solar panels that has more efficiency, is designed for the customers who want to get a profit selling the energy to the Local Grid because the energy that these panels produce is more than the energy required by each station.

The follow table shows the cost analysis for one canopy with the LG solar panels:

Cost Analysis LG			
	Number	PRICE [Euro per unit]	Total
Number of structure	1		
Structure			**€ 10.000,00**
Canopy	1	€ 6.000,00	€ 6.000,00
Charger column	8	€ 500,00	€ 4.000,00
Energy Installations			**€ 6.320,44**
Solar panel (LG)	12	€ 318,37	€ 3.820,44
Inverter	1	€ 2.500,00	€ 2.500,00
Renting Service			**€ 3.396,40**
Electric Bicycle	6	€ 442,00	€ 2.652,00
GPS system	6	€ 69,90	€ 419,40
Display (seven segments)	1	€ 25,00	€ 25,00
Electrical equipment (lamps, cable etc.)	2	€ 150,00	€ 300,00
Payment System			**€ 1.340,00**
Cash machine	1	€ 1.300,00	€ 1.300,00
Modem	1	€ 40,00	€ 40,00
Security System			**€ 155,00**
Fire Extinguisher	1	€ 84,22	€ 84,22
ABS Deposit Extinguisher	1	€ 67,73	€ 67,73
Extinguisher's sign	1	€ 3,05	€ 3,05
TOTAL [€]			**€ 21.211,84**
TOTAL [DKK]			**kr. 158.028,21**

Table 42: Cost Analysis LG for one canopy

Instead, the follow one shows the cost analysis for one canopy with the Sanyo solar panels:

Cost Analysis Sanyo			
	Number	**PRICE [Euro per unit]**	**Total**
Number of structure	1		
Structure			**€ 10.000,00**
Canopy	1	€ 6.000,00	€ 6.000,00
Charger column	8	€ 500,00	€ 4.000,00
Energy Installations			**€ 8.260,00**
Solar panel (Sanyo)	12	€ 480,00	€ 5.760,00
Inverter	1	€ 2.500,00	€ 2.500,00
Renting Service			**€ 3.396,40**
Electric Bicycle	6	€ 442,00	€ 2.652,00
GPS system	6	€ 69,90	€ 419,40
Display (seven segments)	1	€ 25,00	€ 25,00
Electrical equipment (lamps, cable etc.)	2	€ 150,00	€ 300,00
Payment System			**€ 1.340,00**
Cash machine	1	€ 1.300,00	€ 1.300,00
Modem	1	€ 40,00	€ 40,00
Security System			**€ 155,00**
Fire Extinguisher	1	€ 84,22	€ 84,22
ABS Deposit Extinguisher	1	€ 67,73	€ 67,73
Extinguisher's sign	1	€ 3,05	€ 3,05
TOTAL [€]			**€ 23.151,40**
TOTAL [DKK]			**kr. 172.477,93**

Table 43: Cost Analysis Sanyo for one canopy

The difference between the two cost analysis is 1939,84€. The team decided to increment this value to a 30% more.

The decision is to implement seven stations around Horsens (Chapter 4 paragraph Place) so all the costs are multiplied for seven.

Selling Price			
Sanyo		**LG**	
Materials Cost for 1 canopy	€ 23.151,40	Materials Cost for 1 canopy	€ 21.211,84
Assembly Cost for 1 canopy	€ 1.000,00	Assembly Cost for 1 canopy	€ 1.000,00
Transport Cost for 1 canopy	€ 500,00	Transport Cost for 1 canopy	€ 500,00
Total Cost for 1 canopy	€ 24.651,40	Total Cost for 1 canopy	€ 22.711,84
Percentage of Gain	30,00%	Percentage of Gain	30,00%
Selling Price for 1 canopy	€ 32.046,82	**Selling Price for 1 canopy**	€ 29.525,39
Web-site	€ 500,00	Web-site	€ 500,00
Cost for 7 canopy	€ 172.559,80	**Cost for 7 canopy**	€ 158.982,88
Selling price for 7 canopy	€ 224.827,74	**Selling price for 7 canopy**	€ 207.177,74
Profit	**€ 52.267,94**	**Profit**	**€ 48.194,86**

Table 44: Selling price and profit

As you can see the price of the type of solar panels radically change the amount of the total cost. In fact, if our customers decide to buy the cheaper panels, they will save € 17.650,00.

The assembly, the transport and the web-site costs are supposed thanks to a market research.

The product with Sanyo solar panel is more expensive but this system is able to produce more energy that could be sell to the local grid at the price of 2 DKK/kwh. The customer who will buy this product can gain money also from selling energy and not only renting the bike.

For more information about the energy produced by the two different types see the Chapter 2.

Conclusion

The business plan offers two different solutions. The first, more expensive, is thought for a private customer and the second, cheaper, is thought for the municipality.

10. Chapter

10.1. Final Conclusion

The purpose of the project was to give a solution for the mobility problem in the city of Horsens. For that reason, the decision was made to implement a system of renting stations for the electrical bikes.
The system is composed by seven stations with six bikes in each one. The electricity to recharge the electric bikes is provided by the solar panels installed on the roof.
Thanks to this service the people are able to move into the city without their car or any other air polluting transport vehicle, this is useful for reduce the traffic jam.
Using renewable energy in the stations is also useful in order to reduce the emission of Carbon of Dioxide. According the calculations done during the analysis in the project, the stations are able to produce the needed energy.
The product that is offered is a good deal between quality and price. This system was thought to be implemented also in other cities. It is standardized and the customers could choose to install wind turbine without doing many changes to the stations.
That system could be implemented in reality as well because Denmark is affiliated to eco-energy. Also the mentality of the people is opened towards the new types of eco-mobility.

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12. Appendices

Appendix: Web-Site

To create some pages like the login page or the registration page, or pages that have at their internal some function that calls a database, it was necessary to create java classes inside the main folder. These classes are files with the extension ".java" and serve to create a special database which records all the data that we join with the form in the html pages, for example when is filled out the registration form to register is going to insert data in the database created by the page ".java". Below is possible to see the RegistrationBean.java created specifically for the website.

*RegistrationBean.java

```
package main;
import java.io.Serializable;
public class RegistrationBean implements Serializable {
    private String name;
    private String surname;
    private String email;
    private String username;
    private String password1;
    private String password2;

    public String getName() {
        return name;}
    public void setName(String name) {
        this.name = name;}
    public String getSurname() {
        return surname;}
    public void setSurname(String surname) {
        this.surname = surname;}
    public String getEmail() {
        return email;}
    public void setEmail(String email) {
        this.email = email;}
    public String getUsername() {
        return username;}
    public void setUsername(String username) {
        this.username = username;}
    public String getPassword1() {
        return password1;}
    public void setPassword1(String password1) {
        this.password1 = password1;}
    public String getPassword2() {
        return password2;}
    public void setPassword2(String password2) {
        this.password2 = password2;}
    public String store() {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        if ((password1.equals(password2)) && (email.contains("@"))) {
            User u = new User(name, surname, email, username, password1);
            pm.makePersistent(u);
            pm.close();
            return "Registration completed!<br>"
                    + "<a href=\"log1.jsp\">Home</a>";
        } else
            return "Registration not completed!<br/><a href=\"reg.html\">Back to the registration!</a>";}
    public String read() {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        User u = null;
        try {
            u = pm.getObjectById(User.class, name + surname);
        } catch (Exception e) {
            System.out.println(e);}
        pm.close();
        if (u != null)
            return u.toString();
        return "User non trovato";}
    public String delete() {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        User u = null;
        try {
            u = pm.getObjectById(User.class, name + surname);
            pm.deletePersistent(u);
        } catch (Exception e) {
            System.out.println(e);}
        pm.close();
        if (u != null)
            return "Deleted user!";
        return "User not found!";}
    public String readAll() {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        String query = "select from " + User.class.getName();
        List users = (List) pm.newQuery(query).execute();
        String result = "";
        int i;
        for (i = 0; i < users.size(); i++) {
            User u = (User) users.get(i);
            result = result + u.toString() + "<br>\n";}
        pm.close();
        return result;}
    public String Print() {
        return name + " " + surname + " " + email;}
    public boolean check(String username, String password) {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        User u = null;
        try {
            u = pm.getObjectById(User.class, name + surname);
        } catch (Exception e) {
            System.out.println(e);}
        pm.close();
        if (u != null)
            return true;
        return false;}
}
```

Figure 108: RegistrationBean.java

After creating the database through private and public strings were created other public strings to do some operations in the database:

- Public string read():
  allows you to search a user inside the database;

- Public string delete(): allows you to delete a user inside the database;
- Public string readall(): allows you to search all user inside the database;
- Public string print(): allows you to see what you have searched in the database;

The LoginBean

The page for the login is a page written by Java language such as the registrationbean. The function of this page is to search in the database of the registration part if the username and password entered by the user who is trying to enter in the private area exists or not.

*LoginBean.java

```
package main;
import java.io.*;
public class LoginBean implements Serializable {
    private String username;
    private String password;
    private boolean logged = false;
    private RegistrationBean registration;

    public LoginBean()  {
    }
    public void setRegistrationBean(RegistrationBean registration)  {
        this.registration = registration;
    }
    public String getUsername() {
        return username;
    }
    public void setUsername(String username) {
        this.username = username;
    }
    public String getPassword() {
        return password;
    }
    public void setPassword(String password) {
        this.password = password;
    }
    public String doLogin() {
        logged = registration.check(username,password);
        if (logged==true)
            return "Welcome in the Private Area"+"<br/>" + "<a href=\"log1.jsp\">Go to Home</a>";
        else
            return "Log failed!"+"<br/>"+"<a href=\"index.html\">Return to Index</a>"
                    +"<br/>"+"<a href=\"login.html\">Retry to login</a>";}
    public boolean getLogged()  {
        return logged;
    }
    public String doLogout()    {
        logged = false;
        return "You have left the Private Area!";
    }

}
```

Figure 109: LoginBean.java

If the username and the password entered exist the login page sends you in the private area, otherwise you should write them again or effect the registering.

The RentingBean

```
*RentingBean.java
package main;
import java.io.Serializable;
public class RentingBean implements Serializable{
    private String name;
    private String surname;
    private String station;
    private String date;
    private String hour;
    private String hhmin;
    private String hhmax;

    public String getHhmin() {
        return hhmin;}
    public void setHhmin(String hhmin) {
        this.hhmin = hhmin;}
    public String getHhmax() {
        return hhmax;}
    public void setHhmax(String hhmax) {
        this.hhmax = hhmax;}
    public String getName() {
        return name;}
    public void setName(String name) {
        this.name = name;}
    public String getSurname() {
        return surname;}
    public void setSurname(String surname) {
        this.surname = surname;}
    public String getStation() {
        return station;}
    public void setStation(String station) {
        this.station = station;}
    public String getDate() {
        return date;}
    public void setDate(String date) {
        this.date = date;}
    public String getHour() {
        return hour;}
    public void setHour(String hour) {
        this.hour = hour;}

    public String store() {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        if (name != null) {
            Rent r = new Rent(name, surname, date, station, hour);
            pm.makePersistent(r);
            pm.close();
            return "Bike rental is complete!<br>Go to the station where you rented the bike!<br>"
                    + "<a href=\"vedi.jsp\">See the list of rentals!</a>";
        } else
            return "Bike rental is not completed!<br/><a href=\"aggiungi.html\">Try again!</a>";}
    public String read() {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        Rent r = null;
        try {
            r = pm.getObjectById(Rent.class, name + surname);
        } catch (Exception e) {
            System.out.println(e);}
        pm.close();
        if (r != null)
            return r.toString();
        return "Rental not found";}
    public String delete() {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        Rent r = null;
        try {
            r = pm.getObjectById(Rent.class, name + surname);
            pm.deletePersistent(r);
        } catch (Exception e) {
            System.out.println(e);}
        pm.close();
        if (r != null)
            return "Rental deleted from the Database!";
        return "Rental not found from the Database!";}

    public String readAll() {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        String query = "select from " + Rent.class.getName();
        List Rents = (List) pm.newQuery(query).execute();
        String result = "";
        int i;
        for (i = 0; i < Rents.size(); i++) {
            Rent r = (Rent) Rents.get(i);
            result = result + r.toString() + "<br>\n";}
        pm.close();
        return result;}
    public String Print() {
        return name + " " + surname + " " + station + " " + date + " " + hour;}
    public boolean check(String Name, String Surname) {
        PersistenceManager pm = PMF.get().getPersistenceManager();
        Rent r = null;
        try {
            r = pm.getObjectById(Rent.class, surname + date);
        } catch (Exception e) {
            System.out.println(e);}
        pm.close();
        if (r !=null)
            return true;
        return false;}
    public String search(){
        PersistenceManager pm = PMF.get().getPersistenceManager();
        String query = "select from " + Rent.class.getName();
        List Rents = (List) pm.newQuery(query).execute();
        String result = "";
        int i;
        for (i = 0; i < Rents.size(); i++) {
            Rent r = (Rent) Rents.get(i);
            int x=Integer.parseInt(hhmin);
            int y=Integer.parseInt(hhmax);
            int z=Integer.parseInt(r.hour);
            if ( z >= x && z <= y)
             result = result + r.toString() + "<br>\n";}
        pm.close();
        return result;}
}
```

Figure 110: RentingBean.java

The rentingbean page serves to rent the bikes, has a function similar to the registrationbean page. The page creates a database that stores the information given by the user about the station and time of hire. This database is also consulted by the computers in the stations so you can rent the bike in the stations in real-time.

The Rent.java

Rent.java

```
package main;
import java.io.*;

@PersistenceCapable
public class Rent implements Serializable {

    @PrimaryKey
    private String key;
    @Persistent
    public String name;
    @Persistent
    public String surname;
    @Persistent
    public String station;
    @Persistent
    public String date;
    @Persistent
    public String hour;

    public Rent(String name, String surname, String station, String date, String hour)  {
        this.key = name + surname;
        this.name = name;
        this.surname = surname;
        this.station = station;
        this.date = date;
        this.hour = hour;
    }

    public String toString()    {
        return "<p>"+name+" "+surname+" "+station+" "+date+" "+hour+"</p>";
    }
}
```

Figure 111: RentBean.java

The rentbean page is made to retrieve and publish all rentals in the page vedi.jsp.

The User.java

User.java

```
package main;
import java.io.*;

@PersistenceCapable
public class User implements Serializable {

    @PrimaryKey
    private String key;
    @Persistent
    public String name;
    @Persistent
    public String surname;
    @Persistent
    public String email;
    @Persistent
    public String username;
    @Persistent
    public String password;

    public User(String name, String surname, String email, String username, String password)    {
        this.key = name + surname;
        this.name = name;
        this.surname = surname;
        this.email = email;
        this.username = username;
        this.password = password;
    }

    public String toString()    {
        return "<p>"+name+" "+surname+": "+username+ "</p>";
    }
}
```

Figure 112: User.java

The User page is made to retrieve and publish all User registered in the page utenti.jsp.

The Persistence Manager Factory

PMF.java

```
package main;
import javax.jdo.JDOHelper;

public class PMF {

    private static final PersistenceManagerFactory pmfInstance =
    JDOHelper.getPersistenceManagerFactory("transactions-optional");

    private PMF() {}

    public static PersistenceManagerFactory get() {

        return pmfInstance;
    }


}
```

Figure 113: PMF.java

Using Persistence Manager Factory (PMF) the objects can be saved, found and deleted from the database. It also monitors the database transaction and the aspects of the persistent object cache.

Appendix: Italian e-mail (Federico)

We contact the Italian company Giulio Barbieri S.p.A for a quote for their product. The e-mail that we wrote is in Italian so we translate it:
"Hi,

I am student of the University of Modena and Reggio Emilia, in the Erasmus at the VIA

University in Denmark, we are working on project to install in this city bike rental system with electric charging stations equipped with solar panels and wind turbines. Seeing your site I would be very happy to use your system in our project, clearly now we are not talking about any purchase, only a project, but maybe in the future if they are interesting in it they could carry forward it. I would ask for a quote or if you have even a price list for complete stations with all their shares and prices of each component.
Thanks you very much!
Yours sincerely
Federico Sassi"

Their answers was:

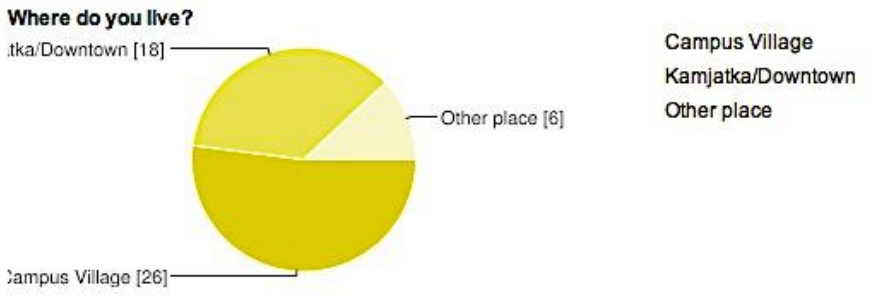
"Dear Federico,
Our solution ENERGY SELF, the island of charging for electric vehicles, issue of a Stand Alone and then provided with batteries for storage of energy produced by photovoltaic panels. Self Energy is managed by an intelligent system that provides management control of the energy available and that required to recharge the vehicles. If the request is greater than that produced by the electrical network is interested in the link provided.
We designed the electrical and electronic components inside watertight containers, easy wiring.
The monocrystalline panels used are from the German Bosch while the inverter is from the company SMA.
The Self Energy is equipped with all the certifications required by law.The cost of the island ranges from 19,500 to 21,000 photovoltaic (EXCLUDING VAT) depending on the version with one or two units of charge and according to which you want to install optional equipment such as wind turbine.
I attach a leaflet and brochures.
The following is the link where you can view the installation phases of the structure:
http://www.youtube.com/watch?feature=player_embedded&v=TeUMSm0pd3o
Remaining at your disposition for further information and clarification,
I offer cordial greetings.
Yours sincerely"

Appendix: Costumer's questionnaire and result (Laura R.)

The questionnaire that the team send to the students of VIA University College in Horsens and the results are the follow.
It is important underline that some people do not answer at all the questions, it is for this reason that sometime the calculations are strange.
At the beginning of questionnaire there was write a little description about the project:

> "We are a group of students, who are doing a project about green mobility.
> Therefore, we want to create a renting system, which will consist out of several independent renting stations, which will be spread over Horsens, where people are able to rent electric bikes. The renting stations will also be used to recharge the batteries of the electric bikes.
> The renting stations will also be used to recharge the batteries of the electric bikes. Furthermore, they will produce the biggest part of needed electricity by their selves, using green energy sources, like wind and solar power. In order to collect the needed information for our project, we ask you to participate in this small survey, it will only take five minutes of your time".

The first questions are about **general information** to know the customers.
The first ones is about where they live in Horsens. All the respondents are student so the team make three different choices: Student Village, Kamjatka/Downtown and other places. This is important to understand how many people will move with renting bikes and from/to which places.



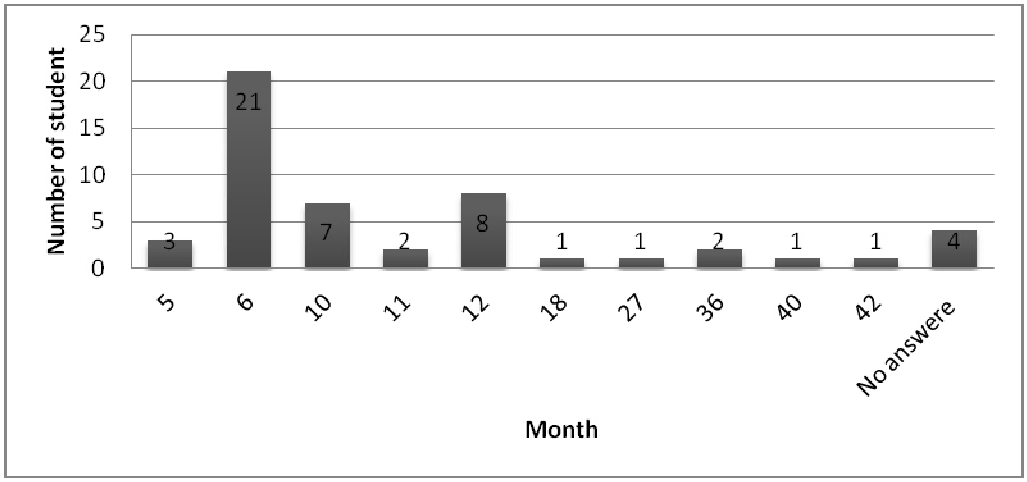
26	51%
18	35%
6	12%

The second question was about how many months they study in Horsens. This data is important to know the real need of the people that study at VIA University College.

How long will you study in Horsens?

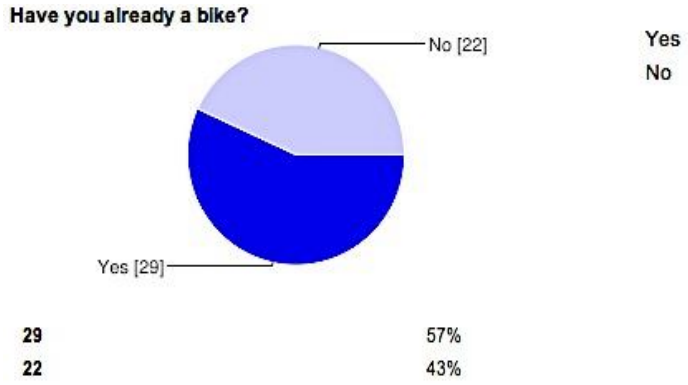
6 | 6 6 6 6 27 5 11 36 18 10 42 40 6 6 6 6 | 6 5 6 10 6 | 6 6 5 6 6 12 6 months 10 10 11 10 10 months 6 6 12 month 12 6 10 36 12 month 12 12 month 6 6 12 12 month 6

A summary of these data is in the follow diagram:

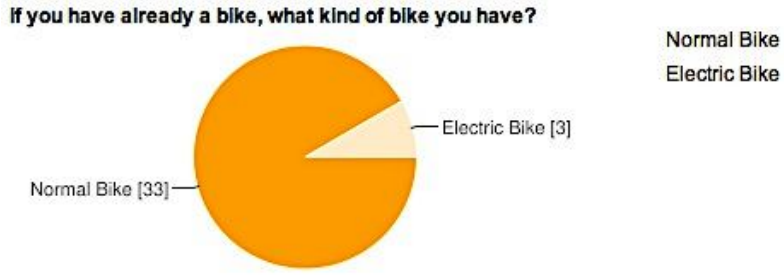


Then the **specific questions** important for this project.

The first one was about if they have a bike in Horsens.

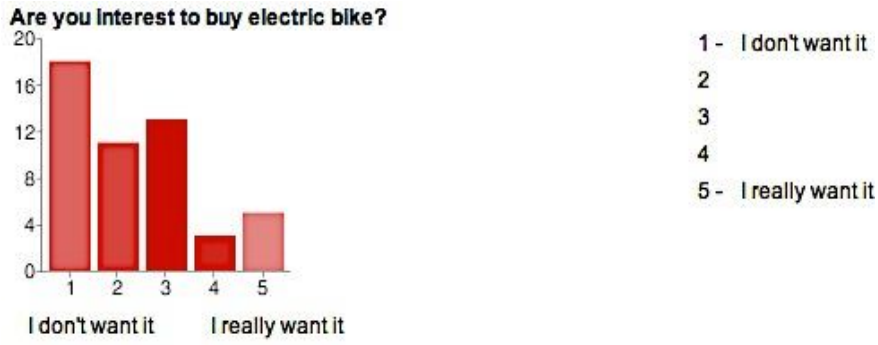


The other question was about the type of bike that the people have.



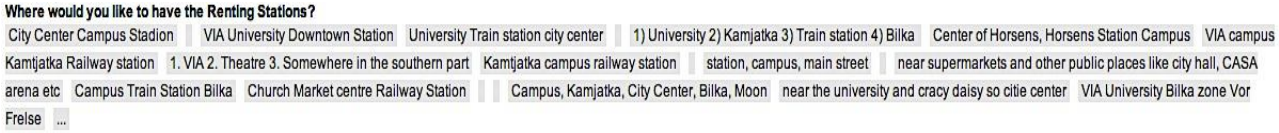
33	65%
3	6%

After it was asked if they are interesting to buy an electrical bike. For this question there were a scale of five values: from 1 (I do not want it) to 5 (I really want it).

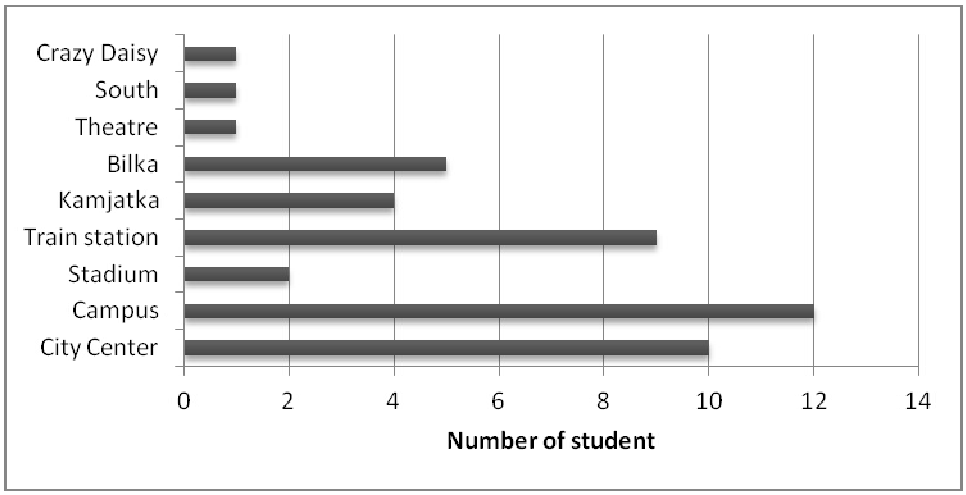


18	35%
11	22%
13	25%
3	6%
5	10%

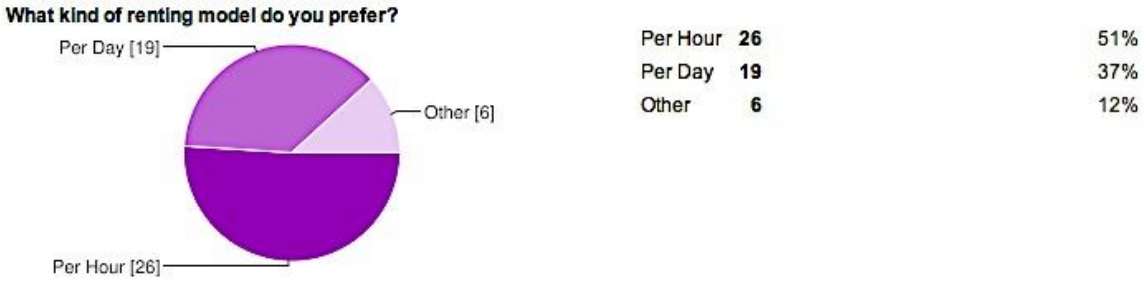
Then the question was about the places where they would like to find the stations.



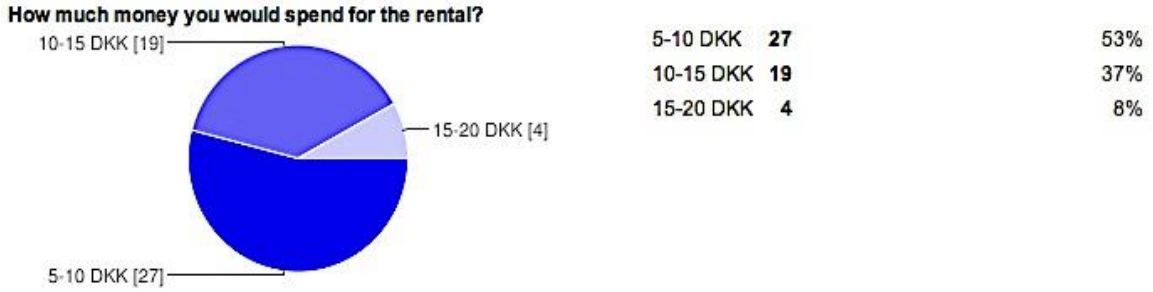
A summary of the data is in the follow chart:



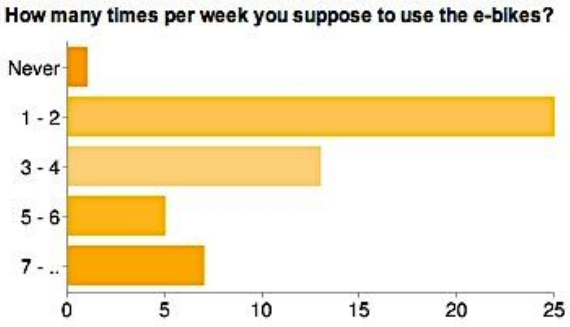
The seventh ones was about which kind of renting model they prefer. The different choices are: per day, per hour or other.



Then how many money they could spend for rental the electric bike per hour.

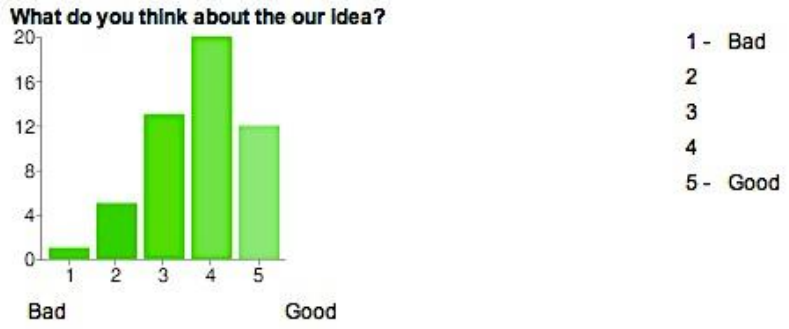


The next question was about how many times per week they suppose to use the e-bikes.



1	2%
25	49%
13	25%
5	10%
7	14%

At the end the team asked to the people what they things about their idea. The scale that they proposed to them has five values: from 1 (bad idea) to 5(good idea).



1	2%
5	10%
13	25%
20	39%
12	24%

It is possible to see the result also in this table:

Timestamp	Where do you live?	How long will you study in Horsens?	What do you think about the our idea?	Where would you like to have the Renting Stations?		How much money you would spend for the rental?	How many times per week you suppose to use the e-bikes?	Have you already a bike?	If you have already a bike, what kind of bike you have?	Are you interest to buy electric bike?	What kind of renting model do you prefer?
10/27/2011 18:56:12	Campus Village	6	3	City Center Campus Station		5-10 DKK	1 - 2	No		1	Per Hour
10/27/2011 18:59:40	Campus Village		5			15-20 DKK	7 - ..	Yes	Normal Bike	5	Per Day
10/27/2011 19:05:46	Campus Village	6	3	VIA University Downtown Station		5-10 DKK	1 - 2	No	Normal Bike	2	Per Day
10/27/2011 19:06:59	Campus Village	6	3	University Train station city center		10-15 DKK	1 - 2	No	Normal Bike	3	Per Day
10/27/2011 19:08:26	Kamjatka/Downtow	6	2			5-10 DKK	3 - 4	Yes	Normal Bike	1	Per Hour
10/27/2011 19:21:21	Campus Village	27	4	1) University 2) Kamjatka 3) Train station 4) Bilka		5-10 DKK	3 - 4	Yes	Normal Bike	1	Both possibilities will be ok; maybe the Day rental could be a little cheaper
10/27/2011 19:22:34	Kamjatka/Downtow	5	3	Center of Horsens, Horsens Station Campus		10-15 DKK	3 - 4	Yes	Normal Bike	2	Per Day
10/27/2011 19:23:16	Kamjatka/Downtow	11	3	VIA campus Kamjatka Railway station		5-10 DKK	Never	Yes	Normal Bike	1	Per Hour
10/27/2011 19:26:44	Kamjatka/Downtow	38	5	1. VIA 2. Theatre 3. Somewhere in the southern part		10-15 DKK	3 - 4	Yes	Normal Bike	3	Both should be available
10/27/2011 19:31:23	Kamjatka/Downtow	18	3	Kamjatka campus railway station		10-15 DKK	1 - 2	Yes	Normal Bike	1	Per Hour
10/27/2011 19:33:30	Kamjatka/Downtow	10	2			10-15 DKK	1 - 2	Yes	Normal Bike	1	Per Day
10/27/2011 19:35:42	Other place	42	2	station, campus, main street			5 - 6	Yes	Normal Bike	1	sponsored by the city hall
10/27/2011 19:56:55	Campus Village	40	3			10-15 DKK	1 - 2	No		3	Per Hour
10/27/2011 20:40:46	Kamjatka/Downtow	6	3	near supermarkets and other public places like city hall, CASA arena etc		5-10 DKK	1 - 2	Yes	Normal Bike	1	Per Hour
10/27/2011 21:13:06	Campus Village	6	4	Campus Train Station Bilka		5-10 DKK	7 - ..	No		2	Per Hour
10/27/2011 21:34:00	Campus Village	6	2	Church Market centre Railway Station		5-10 DKK	1 - 2	Yes	Normal Bike	2	Per Hour
10/27/2011 23:12:07	Kamjatka/Downtow	6	1			5-10 DKK	1 - 2	Yes	Normal Bike	1	Per Hour
10/27/2011 23:20:30	Campus Village		2			5-10 DKK	1 - 2	No	Normal Bike	1	Per Day
10/28/2011 0:08:59	Campus Village	6	5	Campus, Kamjatka, City Center, Bilka, Moon		15-20 DKK	3 - 4	No	Electric Bike	5	20kr deposit like the bikes in copenhagen
10/28/2011 0:21:37	Campus Village	5	3	near the university and cracy daisy so citie center		10-15 DKK	3 - 4	No		1	Per Hour

Timestamp	Where do you live?	How long will you study in Horsens?	What do you think about the our idea?	Where would you like to have the Renting Stations?		How much money you would spend for the rental?	How many times per week you suppose to use the e-bikes?	Have you already a bike?	If you have already a bike, what kind of bike you have?	Are you interest to buy electric bike?	What kind of renting model do you prefer?
10/28/2011 2:33:59	Other place	6	4	VIA University Bilka zone Vor Frelsers Kirke		5-10 DKK	1 - 2	Yes	Normal Bike	3	Per Day
10/28/2011 10:58:42	Campus Village	10	4			5-10 DKK	7 - ..	No	Normal Bike	3	Per Day
10/28/2011 14:36:41	Campus Village	6	3	VIA university Kamjatka Station		5-10 DKK	1 - 2	Yes	Normal Bike	2	Per Day
10/28/2011 23:43:41	Other place		5			15-20 DKK	7 - ..	Yes	Normal Bike	5	Per Hour
10/29/2011 14:19:29	Kamjatka/Downtow	6	4	at the beach, at campus, at kamjatka, downtown in the city center, at the supermarkets		5-10 DKK	1 - 2	Yes	Normal Bike	4	Per Hour
10/30/2011 0:36:58	Campus Village	6	4			5-10 DKK	1 - 2	No		3	Per Day
10/30/2011 17:16:41	Campus Village	5	4	Campus,Crazy Daisy, Train station		5-10 DKK	1 - 2	No	Normal Bike	2	Per Day
10/30/2011 17:28:56	Campus Village	6	5	Campus Village, Bilka, train station		10-15 DKK	3 - 4	No	Electric Bike	3	Per Hour
10/30/2011 17:33:51	Campus Village	6	4	1. Campus 2. Kamtjatka 3. Downtown (near shopping area)		10-15 DKK	1 - 2	Yes	Normal Bike	3	Per Day
10/30/2011 18:11:22	Other place	12	4	railway station		5-10 DKK	3 - 4	Yes	Normal Bike	1	Per Hour
10/31/2011 1:25:32		6 months	4	near the campus		5-10 DKK	1 - 2	No	Normal Bike	1	Per Hour
10/31/2011 9:55:08	Campus Village	10	4	Campus Village, Kamjakla, Beach, Down Town.		10-15 DKK	1 - 2	No		3	Per Hour
10/31/2011 12:28:07	Campus Village	10	4	Campus, Station, Kamjatka		10-15 DKK	1 - 2	Yes	Normal Bike	2	Per Hour
11/2/2011 19:35:57	Campus Village	11	4	In Campus, Train station and the main square downtown where you have all bars and interesting places in Horsens		5-10 DKK	3 - 4	Yes	Normal Bike	1	Per Day
11/2/2011 22:03:54	Kamjatka/Downtow	10	5			10-15 DKK	7 - ..	Yes	Normal Bike	4	Per year
11/8/2011 19:42:05	Kamjatka/Downtow	10 months	5	In the center		5-10 DKK	5 - 6	Yes	Normal Bike	1	Per Day
11/29/2011 18:43:05	Campus Village	6	4	Bilka University train station		10-15 DKK	1 - 2	Yes	Normal Bike	4	Per Hour
11/29/2011 18:43:48	Campus Village	6	5	VIA Bilka Centre city Train Station Forumhoteers		10-15 DKK	7 - ..	No		1	Per Hour

Timestamp	Where do you live?	How long will you study in Horsens?	What do you think about the our idea?	Where would you like to have the Renting Stations?		How much money you would spend for the rental?	How many times per week you suppose to use the e-bikes?	Have you already a bike?	If you have already a bike, what kind of bike you have?	Are you interest to buy electric bike?	What kind of renting model do you prefer?
11/29/2011 18:43:54	Campus Village	12 month	3	Bilka University Train station		10-15 DKK	3 - 4	Yes	Normal Bike	2	both
11/29/2011 18:44:44	Kamjatka/Downtow	12	4	Gym, center, university, station		10-15 DKK	3 - 4	No		2	Per Day
11/29/2011 18:44:58	Kamjatka/Downtow	6	4	kamjatka university centre		5-10 DKK	1 - 2	No		3	Per Day
11/29/2011 18:45:20	Kamjatka/Downtow	10	4	near the center University near the stadium		15-20 DKK	5 - 6	No		5	Per Day
11/29/2011 18:45:37	Kamjatka/Downtow	36	5	VIA, station, centre		10-15 DKK	3 - 4	Yes		1	Per Day
11/29/2011 18:46:13	Other place	12 month	3	Centre Station VIA		5-10 DKK	1 - 2	No		2	Per Hour
11/29/2011 18:46:51	Campus Village	12	4	center university bilka		10-15 DKK	1 - 2	No		3	Per Hour
11/29/2011 18:47:41	Campus Village	12 month	5	VIA Bilka Train Station		10-15 DKK	5 - 6	Yes	Normal Bike	3	Per Hour
11/29/2011 18:47:46	Kamjatka/Downtow	6	5	center station university		5-10 DKK	1 - 2	Yes	Normal Bike		Per Hour
11/29/2011 18:48:11	Kamjatka/Downtow	6	3	stadium train station university		5-10 DKK	5 - 6	No		5	Per Hour
11/29/2011 18:49:00	Kamjatka/Downtow	12	5	Via Kamjatka Center		5-10 DKK	7 - ...	No		1	Per Day
11/29/2011 18:49:16	Other place	12 month	4	VIA Centre Bilka		5-10 DKK	3 - 4	Yes	Electric Bike	3	Per Hour
11/29/2011 18:53:16	Campus Village	6	4	School Crazy Daisy Bilka		5-10 DKK	1 - 2	Yes	Normal Bike	2	Per Hour

Appendix: Interview Municipality (Laura R.)

On Monday 7th November Laura, Federico and Nikos had a meeting with Niels Christian Mikkelsen and Ole Helboe Nielsen. Both of them work in the Municipality of Horsens.
Niels Christian Mikkelsen is a worker of the department of engineering. Before to start the meeting, he calls also Ole Helboe Nielsen to support him during the meeting.
The team members try to meet also the liberal politicians, Hans Bang Hansen, chairman of the technical committee at the municipality. They wrote an e-mail to him but he did not answer. So with the help of their supervisor, Jens Eybye, they come in contact with him and they received an answer. He said to the supervisor, that he referred to the department staff, which the student already talked to, and he was inline with them.
So in the meeting, at first they spoke about the possible product and they created a dialogue in which they try to answer at the question that they had prepared before.

1. How many tourists for year?
2. In which criteria you calculate the public transportation?
3. We choose as interest point to apply our renting station:
    - VIA University
    - Train/Bus Station
    - Centre City (2 Points)
    - Stadium
    - Bilka Markets
    - Hospital
    - We would like to ask you if you agree that point and if you have to suggest as other point.
4. How many Square metres could we have to apply our stations?
5. Which criteria you use to decide the renting cost?
6. Have you already spoke about “Green Mobility”?
7. Are there any laws that affect our project?
8. Do you have any records about the emissions data for the last five years?
9. Do you have any problem about the traffic jam?
10. Would you be interested to invest in our project? In which amount you are interested to invest or which criteria you use to calculate the amount of the investment?

Answer:

1. For this data you have to contact:
    a. City Horsens: Bojsens Gård, Søndergade 47, 8700 Horsens. Tif 75 62 47 22
    b. City chef: Pernille Perigaard. Mobil 30 35 43 54

c. Eventkoordinator: Lykke Veel Jeppe. Mobil 40 18 00 12

2. To answer at this question they give to the students the document that they scanned and are follow:

Servicemål for kollektiv trafik

1. Nuværende servicemål
– regional kørsel

Vejle Amts Trafikselskab (VAT) har udarbejdet servicemål for betjening af bysamfundene.

Ved optælling af antal ture lægges følgende til grund
- Der skal være tale om afgange til kommunecenter/anden større relevant by.
- Er der en sådan betjening til flere byer, tælles alle afgange med.
- Lokalruter (skoleruter) tælles ikke med.
- Ved optællingen af ture tælles ture i begge retninger med.
- Der regnes med max. gangafstand på 1 km.

For byer over 200 indbyggere gælder som servicemål
- Det skal være muligt at møde på gymnasium, handelsskole eller teknisk skole max. 30 minutter før normal mødetid.
- Det skal være muligt at komme hjem fra gymnasium, handelsskole eller teknisk skole til normal sluttid med en maksimal ventetid på 1 time.
- Det skal to gange dagligt på hverdage være muligt at komme til læge, kommunekontor, bibliotek eller posthus inden for disses åbningstid. Der skal være mulighed for at komme retur 2 – 3 timer senere.

De opstillede servicemål er bl.a. betinget af
- at der ved mindre end 4 passagerer pr. tur anvendes teletaxi
- at der er minimumskrav til antal passagerer pr. teletaxitur (1,25) og antal benyttede afgange (min. 10 %) – ellers nedlægges turen.

For byer i følgende størrelser er der opstillet følgende servicemål

Antal indbyggere	Antal afgange hverdage/heraf aften/weekend
0 – 200	0 / 0 / 0
200 – 500	10 / 0 / 4
500 – 1000	16 / 2 / 6
1000 – 2000	22 / 2 / 8
2000 – 10.000	24-28 / 4-6 / 8-12
– skoleruter	

Skoler med 1 – 2 spor (max. 20 – 22 klasser)
- 5 ture dagligt (i alt 25 ture pr. uge)

Skoler med 3 spor eller mere
- 6 ture dagligt (i alt 30 ture ugentligt)

2 eller flere skoler betjenes af samme rute
- ved 3 - 4 spor: 6 ture dagligt (30 ture pr. uge)
- ved 5 eller flere spor: 7 ture dagligt (35 ture pr. uge)

2. Status og nye servicemål for regionale ruter mv.

Nedenfor er for hver by med over 200 indbyggere beskrevet antal afgange på: hverdage/heraf aften/ lørdag/søndag (står der to tal, f.eks. 3-4, betyder det 3 afgange den ene retning og 4 den anden).
Afgange i begge retninger tælles med, når det skal vurderes om servicemål er opfyldte.
Det betyder så f.eks., at Søvind har 32 ture på hverdage, heraf 8 om aftenen, 16 om lørdagen og 12 om søndagen.

Byer med 2000 – 10.000 indbyggere

Brædstrup
Betjenes af rute 110 Horsens – Silkeborg
Antal afgange: 19/3-4/8/8
Betjenes af rute 209 Brædstrup – Rask Mølle – Vejle
Antal afgange: 4-5/0/3-4/3
Betjenes af rute 502 Brædstrup – Voerladegård – Skanderborg
Antal afgange: 11/2/2/2
Servicemål er opfyldt.

Byer med 1000 – 2000 indbyggere

Søvind
Betjenes af rute 306 Horsens – Odder
Antal afgange: 16/4/8/6
Servicemål er opfyldt.

Hovedgård
Betjenes af rute 202 Horsens – Århus
Antal afgange: 17/2-5/9/7-8
Servicemål er opfyldt.

Gedved
Betjenes af rute 107 Horsens – Skanderborg – Århus
Antal afgange: 21/3-4/8/5
Betjenes af rute 112 Horsens – Østbirk – Voerladegård
Antal afgange: 9-10/2/5/4
Servicemål er opfyldt.

Egebjerg
Betjenes af rute 107 Horsens – Skanderborg – Århus
Antal afgange: 21/3-4/8/5
Betjenes af rute 112 Horsens – Østbirk – Voerladegård
Antal afgange: 14/2/5/4
Servicemål er opfyldt.

Østbirk
Betjenes af rute 112 Horsens – Østbirk – Voerladegård
Antal afgange: 14/2/5/4
Servicemål er opfyldt.

Lund
Betjenes af rute 110 Horsens – Silkeborg
Antal afgange: 19/3-4/8/8
Betjenes af rute 116 Horsens – Herning
Antal afgange: 13/2-3/4/5
Betjenes af rute 114 Horsens – Rask Mølle – Tørring
Antal afgange: 6-7/0/0/0
Servicemål er opfyldt.

Hatting
Betjenes af rute 108 Horsens – Løsning – Vejle
Antal afgange: 9-10/2/7/7
Betjenes af rute 117 Horsens – Billund
Antal afgange: 11/1/3/3
Servicemål er opfyldt.

Byer med 500 – 1000 indbyggere

Følgende byer foreslås placeret i størrelsen 500 – 1000 indbyggere, selv om begge byer har lige under 500 indbyggere pr. 1/1 2007

Tvingstrup
Betjenes af rute 202 Horsens – Århus
Antal afgange: 17/2-5/9/7-8
Servicemål er opfyldt.

Nim
Betjenes af rute 110 Horsens – Silkeborg
Antal afgange: 19/3-4/8/8
Servicemål er opfyldt.

Byer med 200 – 500 indbyggere

Haldrup
Betjenes af rute 306 Horsens – Odder
Antal afgange: 16/4/8/6
Servicemål er opfyldt.

Grumstrup
Betjenes af rute 202 Horsens – Århus
Antal afgange: 17/2-5/9/7-8
Servicemål er opfyldt.

Vestbirk
Betjenes af rute 112 Horsens – Østbirk – Voerladegård
Antal afgange: 13-14/2/5/4
Servicemål er opfyldt.

Sønder Vissing
Betjenes af rute 502 Brædstrup – Voerladegård – Skanderborg
Antal afgange: 11/2/2/2
Servicemål er opfyldt.

Sejet
Betjenes af rute 103 Horsens – Juelsminde
Antal afgange: 14/3/6/6
Servicemål er opfyldt.

Øvrige ruter
Herudover betjenes Horsens af følgende to ruter
Rute 105 Horsens – Hornsyld – Juelsminde
Antal afgange: 14/3/5/5-6

Rute 202 Horsens – Vejle
Antal afgange: 25-26/5/12/12

Endvidere betjenes Brædstrup af følgende to ruter
Rute 509 Ejstrupholm – Nr. Snede – Brædstrup
Antal afgange: 1 dobbelttur mellem Brædstrup og Tørring

Rute 523 Brædstrup – Tørring
Antal afgange: 3 dobbeltture på skoledage

Begge ruter betjener primært Tørring Gymnasium for de elever, der bor i Horsens Kommune.

Alle nævnte ruter hører under Region Midtjylland med undtagelse af rute 112 Horsens – Østbirk – Voerladegård, som hører under Horsens Kommune og er medfinansieret af Skanderborg Kommune.

Forslag til evt. nye servicemål

½ times drift i myldretid morgen og eftermiddag på de mest trafikerede ruter.
½ times drift i myldretid vil være en væsentlig forbedring for især pendlerne og være med til at nedbringe spildtid i forbindelse med kørsel til og fra arbejde.
½ times drift svarer til niveauet for bybusser i villakvarterer i Horsens.

Følgende ruter er de mest oplagte

- Rute 110 Horsens – Brædstrup – Silkeborg
  Opgraderingen kan enten ske for hele ruten eller kun Horsens – Brædstrup.
  Det vil betyde en væsentlig bedre betjening mellem kommunens to største byer samt to af mest hurtigtvoksende mindre byer – Lund og Nim.
- Rute 107 Horsens – Skanderborg – Århus
  Der er allerede i dag ½ times drift om eftermiddagen - ½ times drift om morgenen vurderes.
  Ruten betjener den nordlige del af Horsens by, Egebjerg og Gedved.
- Rute 306 Horsens – Odder
  Fra Odder er der forbindelse med tog eller bus til Århus, herunder de store boligområder og byer syd for Århus.
  Ruten betjener to af de største regionale mål i Horsens, nemlig sygehus og VIA.
  Man kan evt. lade nogle af busserne mellem Århus og Odder fortsætte til Horsens.
  Herved undgås et skift i Odder.
  Ruten betjener Stensballe, Haldrup og Søvind.

"Markedet" bør også undersøges for følgende ruter

- Rute 202 Horsens – Hovedgård – Århus
  Ruten har i dag et ringe underlag i Århus Kommune. Dette kan der måske ændres på i forbindelse med regionens og Århus Kommunes planlægning af busbetjeningen.
  Ruten betjener også Serridslev og Tvingstrup.
- Rute 202 Horsens – Vejle
  I Horsens Kommune betjener ruten primært Horsens by samt Oens.
  Udover Horsens ligger "markedet" primært i Hedensted Kommune samt i Vejle.
  Mellem Horsens og Vejle er der tog, hvoraf ét tog i timen også stopper i Hedensted.
- Rute 112 Horsens – Østbirk.
  Ruten er lokalrute og betjener primært Østbirk og Egebjerg. Der er formentlig ikke så stort et kundepotentiale.
- Rute 117 Horsens – Tørring – Give – Billund
  Ruten betjener Hatting.
  Kundepotentialet er formentlig begrænset, men en hurtigrute via Diagonalvejen og med stop alene i de større byer kunne være interessant.
- Rute 103 Horsens – Glud – Juelsminde
  Ruten betjener Sejet og Endelavefærgen i Snaptun.
  Kundepotentialet er formentlig begrænset, bl.a. fordi rute 105 Horsens – Hornsyld – Juelsminde også betjener de to store mål i begge ender af ruterne.

Det anbefales, at den kollektive trafik primært mellem de store byer opgraderes til ½ times drift i myldretid morgen og eftermiddag.
I første omgang vurderes ruterne 110, 107 og 306.

3. Status og nye servicemål for lokalruter og skoleruter

I afsnittet om regionale ruter er betjeningen af bysamfundene udførligt beskrevet. Her er også rute 112 – Horsens – Østbirk – Voerladegård beskrevet.

Horsens Kommune har fra sommeren 2008 herudover 2 lokalruter og 14 skolebusruter.

Rute 501 Brædstrup – Østbirk
Antal afgange: 2/3 på hverdage
Ruten er en tidligere regional rute, som Horsens Kommune har overtaget sommeren 2008.
Ruten betjener endvidere Tønning, Gammelstrup og Vestbirk samt skoler.

Rute 518 Brædstrup – Træden – Torp (- Horsens)
Antal afgange mellem Brædstrup og Torp: 4/5 på skoledage
Antal afgange mellem Horsens og Lund: 1/3 på skoledage (teletaxi)
Antal afgange mellem Brædstrup og Horsens: 4-5/2/2 på ikke-skoledage/lørdage/søn- og helligdage (teletaxi).
Ruten er "resterne" af en tidligere regional rute mellem Horsens og Brædstrup.
Det primære formål er at betjene Torp, Underup, Træden og Tønning i forhold til Brædstrup, hvor der er korrespondance med rute 110 Horsens – Brædstrup – Silkeborg.

Brædstrup skole – 2-3 spor
betjenes af rute 620 med 1 afgang dagligt.
betjenes af rute 621 med 3 afgange dagligt.
betjenes af rute 622 med 5 afgange dagligt.
betjenes af rute 624 med 5(7) afgange dagligt.

Nim skole - 1 spor
betjenes af rute 621 med 5 afgange dagligt.
betjenes af rute 623 med 3 afgange dagligt.

Sønder Vissing skole – 1-2 spor
betjenes af rute 621 med 3 afgange
betjenes af rute 623 med 1 afgang
betjenes af rute 624 med 4 afgange dagligt.
betjenes af rute 625 med 4 afgange dagligt.

Gedved skole – 1-2 spor
betjenes af rute 630 med 5 ture dagligt.
betjenes af rute 633 med 6 ture dagligt.

Hovedgård skole – 2-3 spor
betjenes af rute 633 med 7 ture dagligt.
betjenes af rute 635 med 6 ture dagligt.

Søvind skole – 1 spor
betjenes af rute 633 med 7 ture dagligt.

Østbirk skole – 2 spor
betjenes af rute 630 med 5 ture dagligt.
betjenes af rute 631 med 4 ture dagligt.

Egebjergskolen – 2-3 spor
betjenes af rute 671 med 7 ture dagligt.

Højvangskolen – 3 spor
betjenes af rute 673 med 7 ture dagligt.

Lundskolen – 2 spor
betjenes af rute 670 med 3 – 5 ture dagligt.

Stensballeskolen – 3-4 spor
betjenes af rute 674 med 7 ture dagligt.

Servicemålene for skolerne er stort set opfyldte og må i praksis anses som opfyldte, da kørslen er tilrettelagt efter skolernes ringetider.
Ved Brædstrup, Nim og Sønder Vissing skoler ligger antal afgange på de enkelte ruter under normen, men "billedet" kompliceres af de mange ruter. Samlet set har alle tre skoler mange afgange.

Forslag til evt. nye servicemål
De nuværende servicemål foreslås uændrede, dog tilstræbes – af økonomiske grunde – at skolernes ringetider afpasses så der er behov for færrest mulige ture.

4. Bybusser

Nuværende servicemål
Servicemålene fra Vejle Amts Trafikselskab har været

- max. 400 m til stoppested i etagebyggeri og tæt byggeri
- max 600 m til stoppested i øvrige områder
- kørsel hverdage kl. 5.00 – 22.30, lørdage kl. 7.30 – 22.30 og søn- og helligdage kl. 9.00 – 21.30. Aftenkørsel starter kl. 18.00.

Vejreglers anbefalinger
Vejregler anbefaler følgende

- 300 – 400 m til stoppested i tæt bebyggelse - i centrale byområder dog ned til 200 m
- max. 500 m (400 – 800 m) til stoppested i øvrige områder
- afstand mellem stoppesteder i tæt by 200 – 400 m
- afstand mellem stoppesteder i øvrige områder 400 – 600 m
- "maskevidde" i rutenettet ca. 800 m
- i større byer arbejdes med en frekvens (antal afgange pr. time) på 4 i myldretid og 2 i øvrig dagtid.

Status
Fra sommeren 2008 træder et nyt rutenet og køreplan i kraft. De væsentligste forskelle i forhold til den nuværende køreplan er betjening af Østerhåb og bedre betjening af området omkring Bilka og Horsens Hus.
Under gennemgangen af rutenettet viste det sig umuligt at få busserne ud i de yderste boligkvarterer i Sydbyen, hvis de nuværende principper for betjening skulle opretholdes (busser kører tur/retur mellem Centrum og bydelen på lidt under ½ time).
Ellers vurderes, at VATs servicemål stort set er opfyldt for Horsens byområde.
I dagtimerne har de fleste områder 2 afgange pr. time, men området omkring Bakkesvinget, Sundvej har 4 afgange pr. time (linje 1 og 2).

Forslag til evt. nye servicemål
De nuværende mål vedr. gangafstande vurderes at være passende og i overensstemmelse med anbefalingerne.
Ved en udbygning af den kollektive trafik kan denne blive et bedre alternativ til bilen og kan således være med til at begrænse biltrafikken og forsinkelserne i trafikken.
Flere afgange specielt i myldretid kan være aktuelt.
For nogle områder kan man overveje f.eks. 3 afgange pr. time med 20 minutters interval, hvilket vil betyde, at bussen også kan nå ud i de yderste boligområder.
Andre steder kan det overvejes, om der skal være 4 afgange pr. time i myldretid.
Der skal foreligge et detaljeret materiale om nuværende rejsemønstre samt en vurdering af mulighederne for at tiltrække flere kunder.

3. They said that some of these areas are private, like as Via University, Stadium, Bilka and Hospital, and some of them maybe are not interesting to give them some of their private area. They also suggest at the teams to put their system in the nearest public area.

4. For the square meters they said that the members can decide and use the place that they need, of course they have to do a reasoned proposal.

5. The renting cost is decided in this ways: if the needed area is for a commercial activity, they ask us the 1% of the profit; if the necessary area is not for a commercial activity, it is free.

6. They spoke about green mobility, but not green e-bikes. This is a new idea for them, because they say that in Denmark have become used only for a few years.

7. They think that there are not laws that affect this project.

8. No, they did not have.

9. They are doing now a map to know where is the problem in city streets. The hours that they found more traffic is from 7.30 a.m. to 8 a.m., and form 3 p.m. to 5 p.m.

10. They like very much this project but for say if it possible implements it in Horsens they need more specifications, like as lifetime of solar panel etc. Important is to know that they are already do a similar service for electric cars, and they said: “why not for e-bikes?”.

Appendix: Stakeholder questionnaire (LAURA R.)

For this project was made the stakeholder analysis, so it was important talk with them. The stakeholders that the team had the pleasure to meet or only to listen by e-mail are:

Municipality

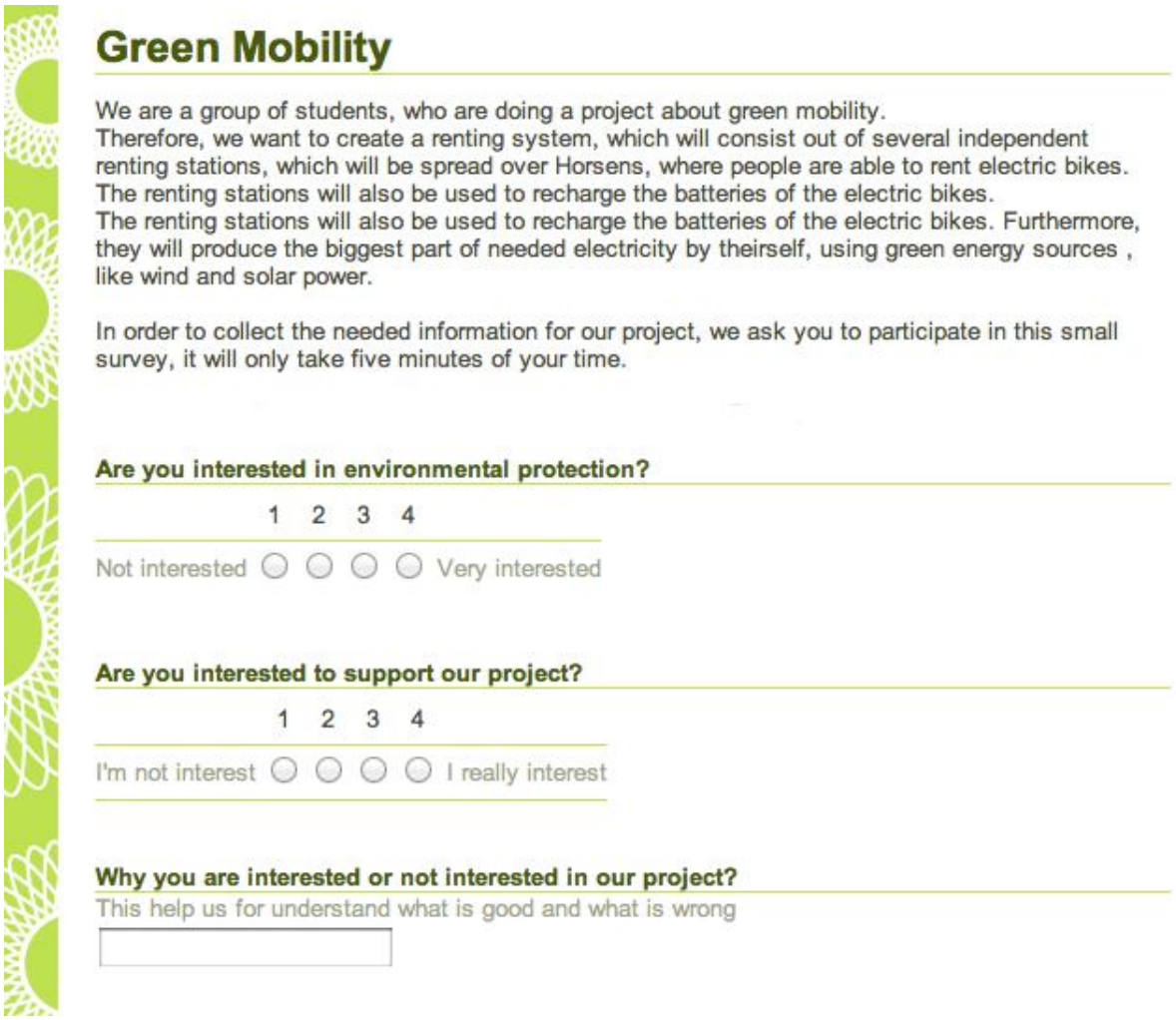
For the sport centres:

- Forum Horsens
- Fitness gym
- Equinox Horsens
- Butterly Waman

For the local communities:

- Visit Horsens
- Horsens Sund by

Knowing that they could not have time for a meeting, the members of the group send to them a questionnaire for collect information and data important for the project.
The questionnaire starts with a little introduction about the project and an explanation about the important of their help.



Green Mobility

We are a group of students, who are doing a project about green mobility.
Therefore, we want to create a renting system, which will consist out of several independent renting stations, which will be spread over Horsens, where people are able to rent electric bikes.
The renting stations will also be used to recharge the batteries of the electric bikes.
The renting stations will also be used to recharge the batteries of the electric bikes. Furthermore, they will produce the biggest part of needed electricity by theirself, using green energy sources , like wind and solar power.

In order to collect the needed information for our project, we ask you to participate in this small survey, it will only take five minutes of your time.

Are you interested in environmental protection?

1 2 3 4

Not interested ○ ○ ○ ○ Very interested

Are you interested to support our project?

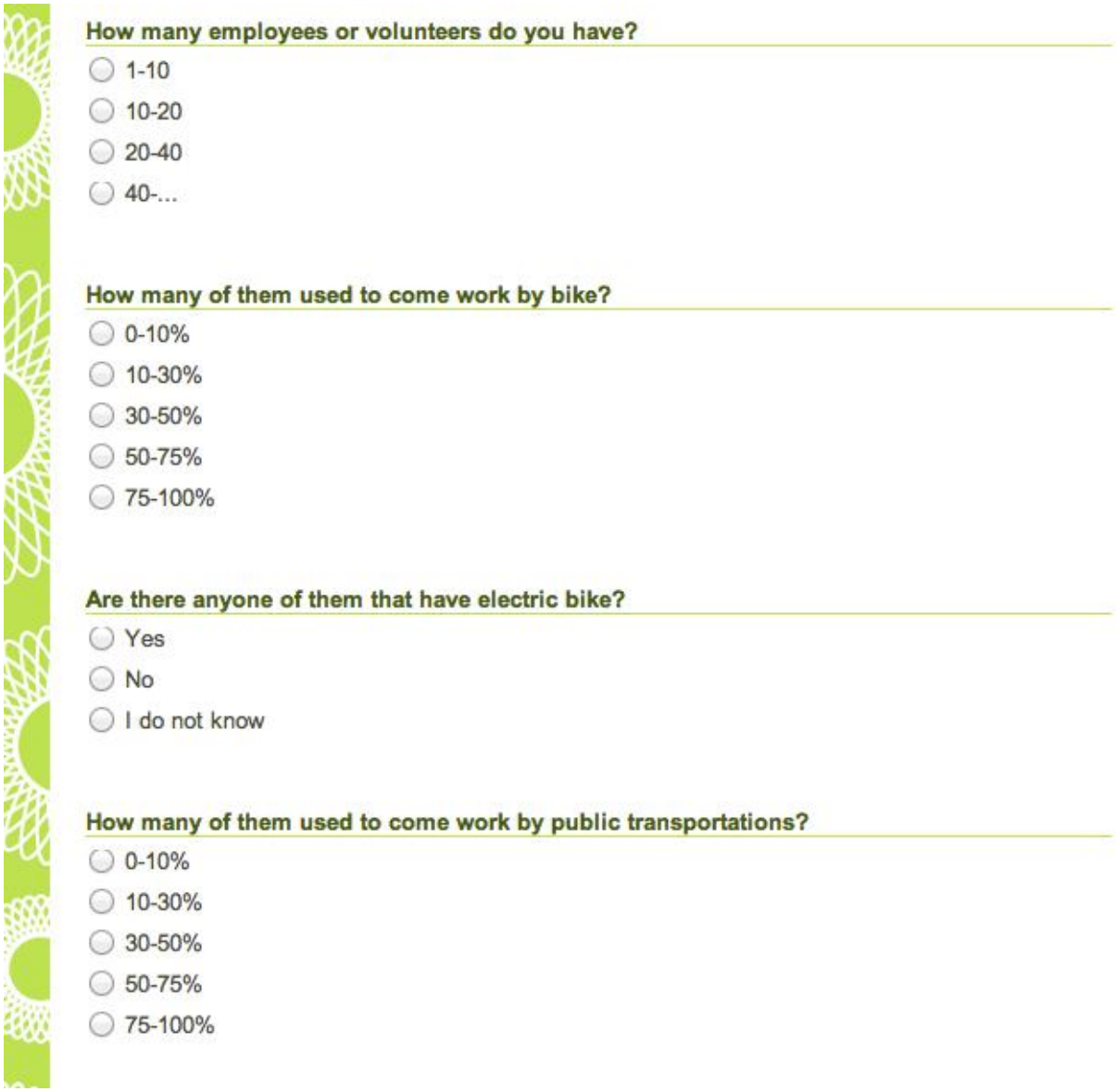
1 2 3 4

I'm not interest ○ ○ ○ ○ I really interest

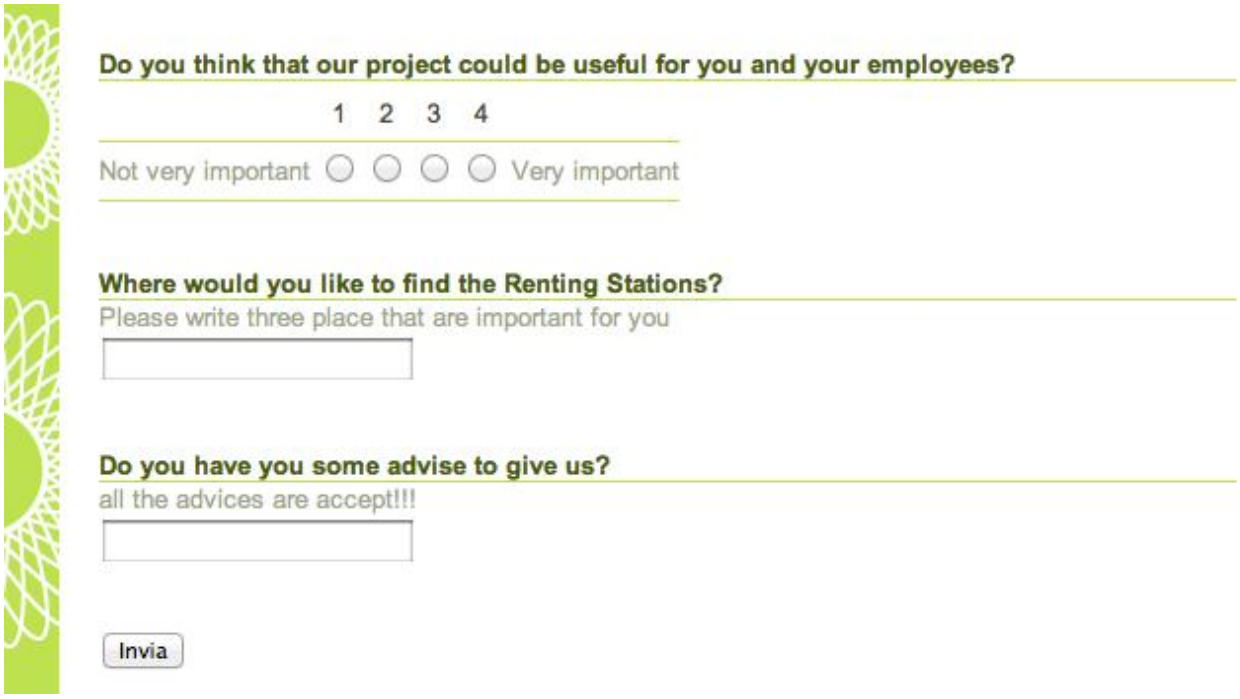
Why you are interested or not interested in our project?

This help us for understand what is good and what is wrong

The first question is about their attention in the environmental protections because if they are not interested, probably they will not invest in the renting stations. There are also other cases: they are interest in the environmental protection but they will not in this system, or they are really interest in this topic and so very happy for the group's project.
The second question is about their interest in the project and then it was asked a little comment about their answer: their critics or compliments could be very useful for understand what the team have to change or not.



These questions are about their company or organization, in particular about their transports. The purpose of this part was try to collect data about their habits in order to make a specific analysis.



This last question was to understand their interest in the Green Mobiity's project.

The text of e-mail sent is equal for each organization and it is the follow:

> "Dear xxx (name of organization),
> We are a group of students from VIA University College and we are working on a student project about eco-mobility. Due to the work in this project, we would like to collect information about the local circumstances. In order to do so, we would like to meet you in person to discuss a few questions, which are relevant to our project. Would it be possible to meet you? If it is not possible, can you help us answered at this questionnaire? You spend only two minutes to do it and for us it is very important.
>
> Thank you very much!
> Best regards"

Laura R., Federico and Laura B. sent all the e-mails but nobody answer them.

Appendix: Interview University (Laura B.)

Meeting with VIA Research Director

On wednesday 2nd November Laura B. and Tobias had meeting with Soren Gytz Olese, Executive Director at University College VIA.

Who is Soren Gytz Olese?

The Director has the overall academic, educational, administrative and financial responsibility for the division's activities, under the annually adopted budget. This includes responsibility for

• Implementation of VIA's strategy, values, policies and work plans in the area and with reference to the Board's decisions

• Implementation of VIA's leadership base within the division's auspices in the form of a good climate of cooperation and respect for the individual employee's professional welfare and development
• The Development Division is an essential part of VIA's external action and offers on development and research in relation to cooperation with the region, large municipalities, universities and industry players director works with the directors of the professional colleges and CVT-division on the concrete implementation of the tasks.
The team asked to meet him because is responsible for the evaluation of research and development so he could be able to answer some of our questions and suggest feedback. After having introduced our project, the group members asked a series of questions.
Questions

1. Would you be interested to be our client or our customer?
2. Do you think that it will be a good investment for advertising?
3. Would you invest in our project as education example for the student?
4. Where would you like to find the renting stations?
5. What do you think the our idea?
6. Do you have you some advice to give us?

Answers

1. Soren thinks that University college VIA (Horsens) might be interested in becoming clients.
2. Soren thinks that this project will be a good investment for advertising. Place on a bicycle, which is in constant motion, an advertising logo is definitely a good solution propagation. In Horsens a lot of people use a bicycle so is a good idea.
3. Soren thinks that our project is very interesting for many points of views. One of this is a education example for the future student.
4. Is important to place the ranting station in parts of the city frequented daily by people. Soren has advised us to place in the University, near the town centre and in the train station.
5. Soren thinks that our idea is very attractive because it's faster use the bike so may be a service widely used and appreciated.
6. Soren has pointed out two problems. The fist is that people might steal your bike so you have to place a surveillance system in the stations and a system to know where the bikes are parked when not in the stations. The second is the maintenance of bicycle.

   Soren advice to us to test the busiest points of the city to highlight the speed of a bike trip than for example a car or tram.

Strategy (Laura B, Laura R)

Abschnitt 1.01 Developing a marketing strategy

Marketing strategies serves as the fundamental underpinning of marketing plans designed to fill market needs and reach marketing objectives. Plans and objectives are generally tested for measurable results. Marketing strategies are developed as multi-year plans, with a tactical plan detailing specific actions to be accomplished in the current year. Time horizons covered by the marketing plan vary by company, by industry, and by nation, however, time horizons are becoming shorter as the speed of change in the environment increases. Marketing strategies are dynamic and interactive. They are partially planned and partially unplanned.

Marketing strategy involves careful scanning of the internal and external environments. Internal environmental factors include the marketing mix, plus performance analysis and strategic constraints. External environmental factors include customer analysis, competitor analysis, target market analysis, as well as evaluation of any elements of the technological, economic, cultural or political/legal environment likely to impact success. A key component of marketing strategy is often to keep marketing in line with a company's overarching mission statement.

Once a thorough environmental scan is complete, a strategic plan can be constructed to identify business alternatives, establish challenging goals, determine the optimal marketing mix to attain these goals, and detail implementation. A final step in developing a marketing strategy is to create a plan to monitor progress and a set of contingencies if problems arise in the implementation of the plan.

Abschnitt 1.02 Planning and management system: improvement methods

Define the best strategy and choose between improvement methods is fundamental to determine the best politics.

(a) Material requirements planning

A material requirement planning (MRP) is a production planning and inventory control system used to manage manufacturing processes. Most MRP systems are software-based, while it is possible to conduct MRP by hand as well.

An MRP system is intended to simultaneously meet three objectives:

- Ensure materials are available for production and products are available for delivery to customers.
- Maintain the lowest possible material and product levels in store
- Plan manufacturing activities, delivery schedules and purchasing activities.

The basic function of MRP system includes inventory control, bill of material processing and elementary scheduling. MRP helps organizations to maintain low inventory levels. It is used to plan manufacturing, purchasing and delivering activities.
Companies need to control the types and quantities of materials they purchase, plan which products are to be produced and in what quantities and ensure that they are able to meet current and future customer demand, all at the lowest possible cost. Making a bad decision in any of these areas will make the company lose money.
It provides answers for several questions:

- What items are required?
- How many are required?
-

MRP can be applied both to items that are purchased from outside suppliers and to sub-assemblies, produced internally, that are components of more complex items.

(b) Just in time (Business)

Just in Time (JIT) is an industrial philosophy that has converted the "old way" of producing finished products for the warehouse waiting to be sold (the system known as "push ") in "pull " system, for which it should produce only what has been sold or is expected to sell quickly.
In other words, is a policy that uses inventory management methods aimed at improving the production process, not trying to optimize both production stages upstream, to lighten up stocks of raw materials and semi finished goods needed for production.
The Just in Time combines elements such as reliability, lower inventory and lead times, increased quality and customer service. This will greatly reduce the costs of storage, handling, loading and unloading of stock.
JIT is a production strategy that strives to improve a business return on investment by reducing in-process inventory and associated carrying costs. Just-in-time production method is also called the Toyota Production System. To meet JIT objectives, the process relies on signals or Kanban between different points in the process, which tell production when to make the next part. Kanban are usually 'tickets' but can be simple visual signals, such as the presence or absence of a part on a shelf. Implemented correctly, JIT focuses on continuous improvement and can improve a manufacturing organization's return on investment, quality, and efficiency. To achieve continuous improvement key areas of focus could be flow, employee involvement and quality.
The system Just-In-Time Inventory System (JIT) can provide many benefits. The main benefits of JIT are:

- The preparation time is greatly reduced in the warehouse. Reduce preparation time allows the company to be more productive to improve profits in order to appear more efficient and spend time on other areas that may need improvement.
- The flow of goods from the warehouse to the shelf improves. Doing that workers be focused on specific areas allows them to quickly process the merchandise and not to get too many jobs doing at the same time.

- Employees who have multiple skills (that are flexible) are used more effectively. Training employees to work on different phases of the inventory system allows the company to use in situations where operators are used when there is a lack of workers and a high demand for a product.
- JIT provides a better planning and greater consistency of working hours. If there is no current demand for a product, the workers must not work. This means that the company save money, when you do not even have to pay the workers.
- The emphasis on the relationship with the supplier increases. A company without stocks do not want problems in its logistics system, problems that would create a lack of available stocks. This means that the relationship between the company and the supplier is very important.
- Stocks arriving 24 hours a day taking operators and production company focused on sales. Having management focused on meeting deadlines motivate employees to work well to achieve the objectives of the company and then get benefits in terms of job satisfaction, a promotion or a pay rise.

(c) KANBAN method

Kanban is a method for developing products with an emphasis on just-in-time delivery while not overloading the developers. It emphasizes that developers pull work from a queue, and the process, from definition of a task to its delivery to the customer, is displayed for participants to see.

The Japanese word for kanban, translates as "signboard". Kanban traces back to the early days of the Toyota production system. Taiichi Onho developed 1940/1950 kanbans to control production between precesses and to implement Just n Time (JIT) manufacturing at Toyota manufacturing plants in Japan. The Kanban Method as formulated by David J. Anderson is an approach to incremental, evolutionary process and systems change for organizations[95]. It uses a work-in-progress limited pull system as the core mechanism to expose system operation (or process) problems and stimulate collaboration to continuously improving the system. One example of such a pull system, is a kanban system, and it is after this popular form of a work-in-progress limited pull system that the method is named.

The Kanban Method is rooted in these basic principles:

- Start with what you do now
- The Kanban Method does not prescribe a specific set of roles or process steps. There is no such thing as the Kanban Software Development Process or the Kanban Project Management Method. The Kanban Method starts with the roles and processes you have and stimulates continuous, incremental and evolutionary changes to your system.
- Agree to pursue incremental, evolutionary change

The organization (or team) must agree that continuous, incremental and evolutionary change is the way to make system improvements and making them stick. Sweeping changes may seem more effective but more often than not fail due to resistance and fear in the organization. The Kanban Method encourages continuous small incremental and evolutionary changes to your current system.

Respect the current process, roles, responsibilities & titles

[95] http://agilemanagement.net /the_principles_of_the_kanban_method/

It is likely that what the organization currently does has some elements that work acceptably and are worth preserving. We must also seek to drive out fear in order to facilitate future change. By agreeing to respect current roles, responsibilities and job titles we eliminate initial fears. This should enable us to gain broader support for our Kanban initiative. Perhaps presenting Kanban against an alternative more sweeping approach that would lead to changes in titles, roles, responsibilities and perhaps the wholesale removal of certain positions will help individuals to realize the benefits.

(d) CONWIP system

Production control systems can be classified as pull and push systems. In a push system, the production order is scheduled and the material is pushed into the production line. In a pull system, the start of each product assembly process is triggered by the completion of another at the end of production line. One variant of a pull system is the CONWIP(CONstant Work in Process) system (Spearman et al. 1990) which is known for its ease of implementation[96].
CONWIP is a kind of single-stage Kanban system and is also a hybrid push-pull system. While Kanban systems maintain tighter control of system WIP through the individual cards at each workstation, CONWIP systems are easier to implement and adjust, since only one set of system cards is used to manage system WIP. CONWIP uses cards to control the number of WIPs. For example, no part is allowed to enter the system without a card (authority). After a finished part is completed at the last workstation, a card is transferred to the first workstation and a new part is pushed into the sequential process route. In their paper, Spearman et al. (1990) used a simulation to make a comparison among the CONWIP, kanban and push systems, and found that CONWIP systems can achieve a lower WIP level than kanban systems.

(e) Theory of Constraint

The analytic approach with TOC comes from the contention that any manageable system is limited in achieving more of its goals by a very small number of constraints, and that there is always at least one constraint. Hence the TOC process seeks to identify the constraint and restructure the rest of the organization around it, through the use of five focusing steps.
The underlying premise of Theory of Constraints is that organizations can be measured and controlled by variations on three measures: throughput, operational expense, and inventory. Throughput is the rate at which the system generates money through sales. Inventory is all the money that the system has invested in purchasing things which it intends to sell. Operational expense is all the money the system spends in order to turn inventory into throughput.
The goal itself is to make money. All other benefits are derived, in one way or another, from that single primary goal.
Theory of Constraints is based on the premise that the rate of goal achievement is limited by at least one constraining process. Only by increasing flow through the constraint can overall throughput be increased.
Assuming the goal of the organization has been articulated, the steps are:

- Identify the constraint (the resource or policy that prevents the organization from obtaining more of the goal)
- Decide how to exploit the constraint (get the most capacity out of the constrained process)

[96]http://webuser.bus.umich.edu/whopp/reprints/CONWIP%20%20A%20Pull%20Alternative%20to%20Kanban

- Subordinate all other processes to above decision (align the whole system or organization to support the decision made above)
- Elevate the constraint (make other major changes needed to break the constraint)
- If, as a result of these steps, the constraint has moved, return to Step 1. Don't let inertia become the constraint.

The five focusing steps aim to ensure ongoing improvement efforts are centered around the organization's constraints.

Abschnitt 1.03 Bill of material

A bill of materials (BOM) is the set of all components, subcomponents and raw materials needed to produce an object.
The BOM is represented graphically as a tree, whose root is the finished product.
A bill is organized hierarchically, with a root that indicates the finished product from which the branches to represent all its components in greater detail.
The bills are important, because without them there would be analytically possible to know what and in what quantities are required to build a product and, therefore, what and in what quantities to produce it must be purchased (Materials Requirements Planning).
A bill then defines a product as it is designed, as built or as it is maintained, representing different views of product structure. Consequently, there are various types of bills of materials available and then the set of attributes associated with individual items. For our project is important analyze the Manufacturing Bill of Material because is structured according to the order of construction or installation project, contains information useful to the production.

(a) Manufacturing Bill of Material

The bill of material production is a business planning document.
Manufacturing bill of material describes a hierarchy of processes (cycles/stages) an indication of the relative uses of the material. Each material is used according to a coefficient of use, which specifies how much material is required to produce one unit of product.
The hierarchy of cycles needed to make these materials indicates which processes/assembly operations are used to make the product.

(b) Managing and utilization

Usually the bill of production is handled by the production unit (factory/plant/line) and is generated and handled by the Times & Methods or from engineering process, starting from the bill of materials technique instead is generated and handled by the technical office.
Each phase/processing cycle is timed and can return attributes that map or assign processing to specific processes or equipment. The bill of materials is also used to move production to automatically store the materials at the end of semi-finished products of excellence are "paid", declared that existing. This can be done manually on the lot, or to feed a system of automatic detection. The information system in context download the materials used according to the coefficients reported in the bill.

The most important steps in history written in an article by "Niki Nixon" in the Guardian at Friday 17 October 2008

Figure 3. A steel-bladed water pumping windmill

July 1887, Glasgow, Scotland [97]

The first windmill for electricity production is built by Professor James Blyth of Anderson's College, Glasgow (now Strathclyde University). The professor experiments with three different turbine designs, the last of which is said to have powered his Scottish home for 25 years.

Winter 1887 – Ohio, US
Professor Charles F. Brush builds a 12kW wind turbine to charge 408 batteries stored in the cellar of his mansion. The turbine, which ran for 20 years, had a rotor diameter of 50m and 144 rotor blades.

1890s – Askov, Denmark
Scientist Poul la Cour begins his wind turbine tests in a bid to bring electricity to the rural population of Denmark. In 1903, Poul la Cour founded the Society of Wind Electricians and in 1904 the society held the first course in wind electricity. La Cour was the first to discover that fast rotating wind turbines with fewer rotor blades were most efficient in generating electricity production.

1920s
The first vertical axis wind turbine, the Darrieus turbine, is invented by Frenchman George Darrieus who in 1931 has it patented in the US. The design, often referred to as the "eggbeater windmill", due to the appearance of its two or three blades, is still used today.

1927 – Minneapolis, US
Joe and Marcellus Jacobs open the Jacobs Wind factory, producing wind turbine generators. The generators are used on farms to charge batteries and power lighting.

1931 – Yalta, former USSR
A precursor to the modern horizontal wind generator is used in Yalta, generating 100kW. The turbine has a 30m tower and a 32% load factor, meaning it provides 32% of its potential energy output, pretty good even by today's standards.

1941 – Vermont, US
The world's first megawatt wind turbine is built and connected to the power grid in Castleton, Vermont. The turbine has 75-foot blades and weighs 240 tons.

1956 – Gedser, Denmark
The Gedser wind turbine is built by Johannes Juul, a former student of Poul la Cour. The 200kW, three-bladed turbine inspired many later turbine designs, and Juul's

[97] http://www.guardian.co.uk/environment/2008/oct/17/wind-power-renewable-energy

invention - emergency aerodynamic tip breaks – is still used in turbines today. The turbine operated until 1967 and was refurbished in the mid 1970s at the request of Nasa.

1970s – Ohio, US
The United States government, led by Nasa, begins research into large commercial wind turbines. Thirteen experimental turbines are put into operation and the research paves the way for many of the multi-megawatt technologies used today.

1980 – New Hampshire, US
The world's first windfarm consisting of 20 turbines is built in New Hampshire. The windfarm however, is a failure as the turbines break down and the developers overestimate the wind resource.

1981 – Washington and Hawaii, US
In 1981 the 7.5mW Mod-2 is build by Nasa, followed in 1987 by the 3.2mW, two-blade wind turbine Mod-5B. Both turbines break records for diameter and energy output.

1991 – Vindeby, Denmark
In 1991 Denmark became the first country in the world to take wind turbines out to sea with 11 x 450 kW turbines in the Vindeby offshore wind farm

1991 – Cornwall, UK
The UK's first onshore windfarm is opened in Delabole, Cornwall. The farm consists of 10 turbines and produces enough energy for 2,700 homes.

2003 – north Wales, UK

The UK's first offshore windfarm is opened. North Hoyle offshore windfarm is located 7-8km off the north Wales coast between Prestatyn and Rhyl and consists of 30 2mW turbines.

2007 - Stirling, UK
Installed capacity of wind power in the UK reaches 2GW, with the opening of the Braes O'Doune windfarm, in Scotland, which produces 72MW of power.

2008 – UK
There are currently 186 operational wind farms in the UK (both onshore and offshore) with 2,120 turbines creating enough energy to power the equivalent of 1,523,052 homes and saving 6,156,175 tones of carbon. There are 42 in construction, with a further 134 consented and 268 in planning

2009 – Denmark
With 660 MW offshore wind turbines connected to the electricity grid in 2009, Denmark is still one of the largest developers of offshore wind farms.

2009 -2012 Denmark

A total of 400 MW offshore wind turbine capacity is being tendered out and is expected to be put into operation in 2012 (the Anholt project)

Figure 4 Wind turbine of 21th century

PVGIS radiation databases[98]

PVGIS needs data on solar radiation in order to make estimates of the performance of PV systems and to do the other calculations possible in the web application. There exist a number of different sources of solar radiation data, but none of them are perfect, so it is important to understand the strengths and weaknesses of each data source. In the new version of PVGIS (autumn 2010), we have for the first time included a choice of solar radiation databases for some regions. For this reason we will here describe each of the databases that the user can choose.

NOTE: Below we will talk about the differences between the old version (PVGIS-3) and the new version (PVGIS-CMSAF). However, the old database is still available in the user interface. In some regions the old database is still the only choice.

Types of solar radiation data sources

The two main sources of data on solar radiation at the surface of the earth are:

Ground measurements

Calculations based on satellite data

Ground measurements of solar radiation

Direct measurements of the solar radiation at ground level can be made with a number of different instruments. One widely used instrument is the pyranometer. Typically, the instrument measures all the radiation coming from the sun and from the sky or clouds. When you want to know the solar radiation at a specific place, ground station measurements give the best results. It is also possible to measure with a high time resolution, typically every minute or even more often.

Possible problems with the measurements, apart from failure in the measurement system itself, is that the sensor may be covered with dirt, frost, or snow, or that the sensor is shadowed by nearby trees or buildings for some of the time during the year. These problems can be removed by careful siting and maintenance, but it makes it more uncertain to use data where you don't have direct experience with the measurements. Most of these potential problems will cause the measurement readings to be too low.

When there are no direct measurements at a given place, it is still possible to estimate the solar radiation from mesurements made nearby. Of course the quality of the estimate will decrease as the distance to the measurement site increases. It is also possible to combine data from several different measurement locations to make an estimate for the solar radiation in a place somewhere between the measurement sites. This method is used in the original PVGIS solar radiation database for Europe. The methods used in PVGIS are described in references 1&2 (see below).

Solar radiation estimates from satellite

Abschnitt 1.01 [98]

http://re.jrc.ec.europa.eu/pvgis/apps4/databasehelp_en.html

There are a number of methods to estimate the solar radiation at ground level using data from satellites. Typically the satellites measure the light (visible or infrared) coming from the Earth. This light is mainly the light reflected from the ground or from clouds. The calculation of the solar radiation at ground level must therefore be able to take into account the radiation absorbed by the atmosphere as well as that reflected by clouds.

Different types of satellites can be used to estimate solar radiation. *Geostationary* weather satllites take pictures of the Earth at short intervals (every 15 or 30 minutes) so have a very good time resolution. However, each pixel in the picture typically represents a rectangle a few km on each side, so the estimate of solar radiation for each pixel will be the average of such an area. *Polar-orbiting* satellites fly closer to the Earth, so the space resolution is better. However, they don't stay permanently above a particular area, so they are normally able to take only a couple of pictures a day of a given area. The data used for PVGIS come mainly from geostationary satellites.

The main advantage of satellite-based methods is that they give a fairly uniform coverage of large areas while ground stations are often very far apart. On the other hand, there are potential problems also with the satellite methods:

Snow on the ground is a special problem for satellite methods, since snow will look very much like clouds in the satellite images. There are methods to overcome this problem, but the uncertainty is higher in areas with snow.

In mountain areas one pixel may cover an area with strongly varying altitude. The solar radiation dependence on altitude is not well represented in the satellite-based calculations.

When the sun is very low in the sky the calculation from satellite data becomes very difficult. This can cause problems, in particular in winter at high latitudes.

The quality of satellite-based estimates must be checked by comparison with high-quality ground station measurements.

Radiation databases for PVGIS

The existing PVGIS databases are based on the following types of data:

Original PVGIS Europe

The original PV database for Europe is based on an interpolation of ground station measurements as described in Ref. 2. The ground station measurement data are long-term monthly average of global and diffuse irradiation on a horizontal plane. The data were originally part of the European Solar Radiation Atlas (Ref. 3). The time period of data is 10 years, from 1981 to 1990.

Original PVGIS Africa

This database is from satellite-based calculations performed at MINES ParisTech, France, using data from the first generation of the Meteosat series of satellites. The spatial resolution of the original calculation is 15 arc-minutes, or about 28km right below the satellite (at the equator, 0° W). The data cover the period 1985-2004.

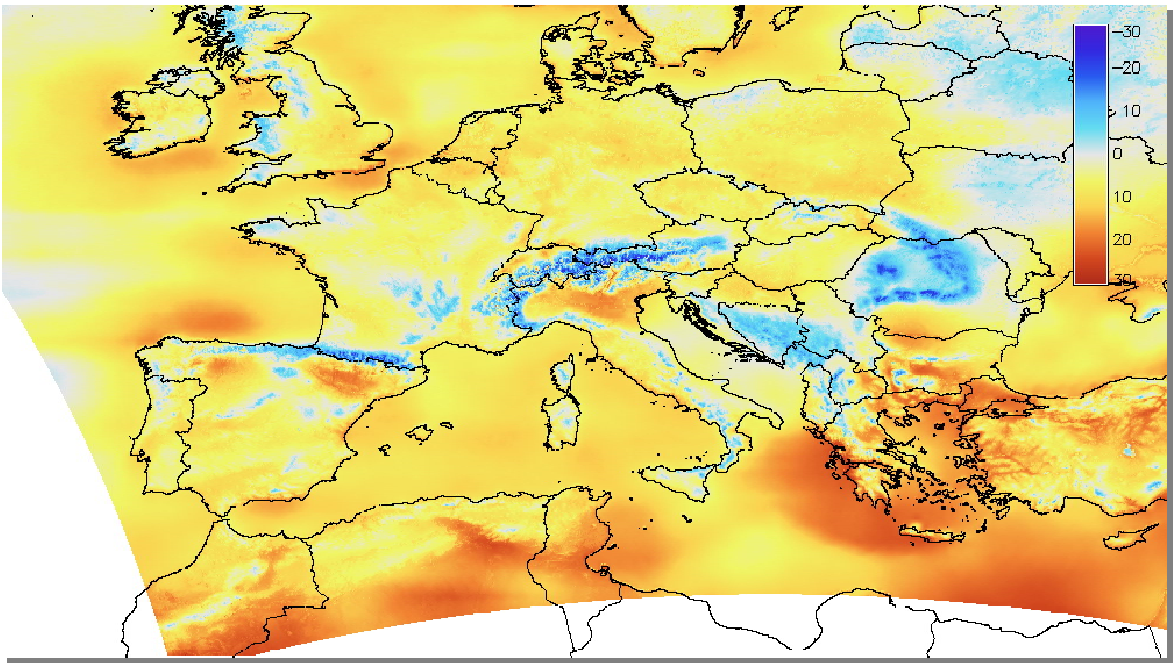
New CM-SAF - PVGIS database for Europe and Northern Africa

These data are based on calculations from satellite images performed by CM-SAF (see also references 4 and 5). The database represents a total of 12 years of data. From the first generation of Meteosat satellites (Meteosat 5-7), known as MFG, there are data from 1998 to 2005 and from the second-generation Meteosat satellites (known as MSG) there are data from June 2006 to May 2010. The spatial resolution is 1.5 arc-minutes (about 3km right below the satellite at 0° N, 0° W). The coverage extends from 0° N (equator) to 58° N and from 15° W to 35° E.

PVGIS-3 to PVGIS-CMSAF: change in the radiation values from the old databases to the new CM-SAF database

The change in global horizontal irradiation from PVGIS-3 to PVGIS-CMSAF is shown in Fig. 1 (for Europe) and Fig. 2 (for Africa). The differences are in percent between PVGIS-CMSAF and PVGIS-3. Yellow and red means the PVGIS-CMSAF gives higher values, blue means PVGIS-CMSAF gives lower values than the older PVGIS-3. The map only gives a genral overview. To see the difference of the results from PVGIS-3 to PVGIS-CMSAF, you can always try it out for the point you are interested in.

Figure 114 Relative difference (in percent) between the new CMSAF based database and the traditional PVGIS database for Europe.



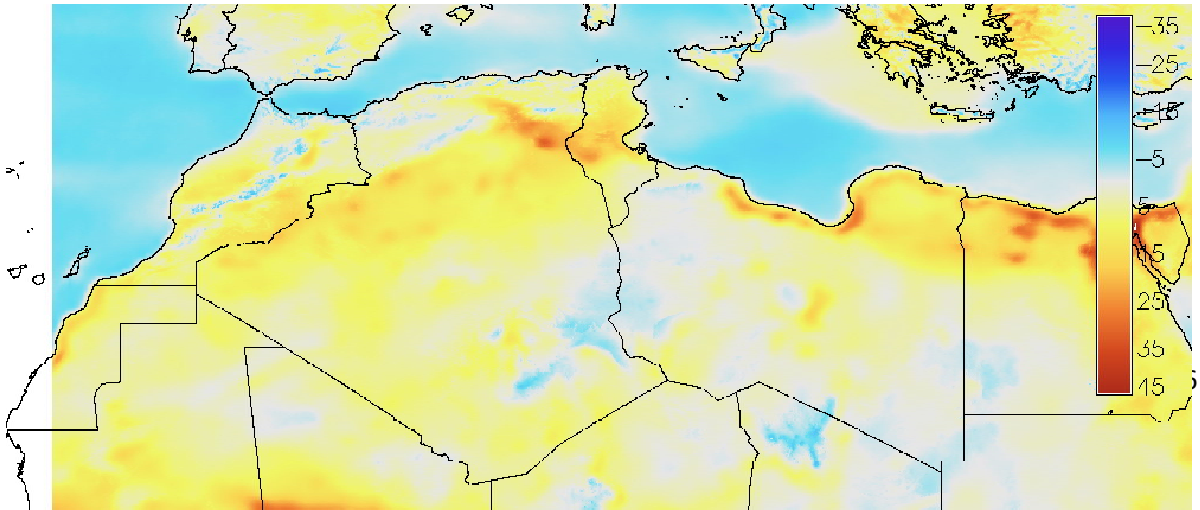


Figure 115 Aative difference (in percent) between the new CMSAF based database and the traditional PVGIS database for Africa.

The new CM-SAF data set has been tested extensively against high-quality measurements on the ground(see documentation at the CM-SAF site). Generally the overall error for the whole year is quite small. A list of ground stations and the yearly error (bias) is shown in the table below. In nearly all places the error is less than 5%. In many places the difference between PVGIS-3 and PVGIS-CMSAF are larger than that. For this reason we are convinced that in most places the new data set is an improvement.

Location	Latitude	Longitude	MSG bias (%)	MFG bias (%)	Relative difference between PVGIS-CMSAF and PVGIS-3 (%)
Lindenberg (DE)	51° 35'N	12° 7'20''E	-3.4	-3.0	+6.9
Cabauw (NL)	51° 58'16''N	4° 55'24''E	+0.4	+1.5	+11.6
Carpentras (FR)	44° 5'N	5° 5'32''E	+2.1	+5.1	+9.0
Payerne (CH)	46° 48'54''N	6° 56'38''E	-3.0	+3.7	+13.2
Camborne (UK)	50° 13'N	5° 19'W	-	+6.2	+8.4
Ispra (IT)	45° 48'37''N	8° 37'4''E	+8.0	-	+15.0

Milano (IT)	45° 28'34''N	9° 15'40''E	-0.5	-	+13.0

Table 1: Comparison of the new PVGIS-CMSAF database with ground station measurements and with the old PVGIS-3 database. Positive bias means that the PVGIS-CMSAF database estimates higher are than the measured values.

Why is the old data set then wrong?

For Europe, the PVGIS-3 data set is based on measurements made on the ground which are then interpolated between points to get radiation values at any point. As we see in Fig. 1, the old values are generally lower than the new values. The interpolation procedure is not perfect, but it will not give values that are too low or high over large areas such as we see in Fig. 1. So the difference must be in the ground station measurements themselves. There are then two possibilities:

The measurements were wrong

The climate has changed so the irradiation is higher for the new data set (1998-2010) than for the old data set (1981-1990)

It is likely that the overall difference is caused by both these effects. When you make radiation measurements there are a number of things that can go wrong. Most of these faults will make the measured value too low. For instance, the sensor can be covered with dirt, snow or frost. There may also be shadows from trees and buildings, and the shadows from trees tend to get larger over the years as the trees grow. Overall, this could lead to too low values in many places. Still, it is unlikely that the effect would be so similar for many stations.

On the other hand, research has shown that the amount of solar radiation has increased over Europe in the last 30 years(see for example Ref. 6). This agrees quite well with the differences between PVGIS-3 and PVGIS-CMSAF.

For the new database for Africa the number of solar radiation measurement stations is very low. We have tried to check both the old and the new database against data from 4 different stations. The results are shown in Table 2. Note that two of these stations are outside the area of the new database as implemented in PVGIS right now, though these areas (Africa south of the Equator, the Arabian Peninsula) will become available in the next few months. From this comparison, we can see that while both databases do reasonably well for the two stations in Africa, the old PVGIS-3 database shows significant underestimation for the two stations in the Middle East. The difference between PVGIS-3 and PVGIS-CMSAF is shown in Fig. 2. The most clear difference is in southwest Sahara where the new PVGIS-CMSAF has significantly higher values than the older PVGIS-3. It is not completely clear why this is the case, and there are no measurement stations in the area. However, we think that it may be due to a problem with the calculation method used for the old data set. The ground in this area is very bright and it may have caused the calculation to mistake the white ground for clouds, so calculating too low radiation values. The same effect may be the reason why the PVGIS-3 values are too low in desert areas of the Middle East.

Location	**Latitude**	**Longitude**	**PVGIS-CMSAF bias (%)**	**PVGIS-3 bias (%)**

Tamanrasset (DZ)	22° 46'48''N	5° 30'36''E	-0.4	-6.0
Sde Boqer (IL)	30° 54'18''N	34° 46'55''E	+4.0	-13.9
De Aar (ZA)	30° 40'S	23° 59'35''E	+2.2	-1.8
Solar Village (SA)	24° 54'36''N	46° 24'36''E	+3.2	-14.8

Table 2: Comparison of the old PVGIS-3 and the new PVGIS-CMSAF database with ground station measurements in Africa and the Middle East. Positive bias means that the databases estimates higher are than the measured values.

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Performance of Grid-connected PV[99]

Contents

[99] http://re.jrc.ec.europa.eu/pvgis/apps4/PVcalchelp_en.html

1. A Caution

We have made this PV performance calculator available online to help give users an idea of the potential of PV as an energy source. We have tried to make it as accurate as possible and to remove all errors, to the best of our capabilities and limited resources. However, there are a number of reasons why the results we show could contain errors. Among these are:

Error in user inputs. If you don't really understand what you are doing when you enter numbers and choose options, you may end up with silly results. Section 1 and Section 2 gives information on how to use the PV calculator.

Uncertainties in the estimation of PV performance depending on PV technology and local conditions. This is an active field of research, and there is by no means universal agreement between researchers. We describe the methods we use in Section 3

Uncertainties and errors in the underlying radiation (and temperature) data. Some of these are due to our calculations and we have tried to calculate the uncertainty from our treatment of the data. But the underlying data themselves (whether from ground stations or satellite) have their own uncertainty which we often do not know. More on this in Section 4

Plain old bugs. If you find something suspicious we would be very happy to hear about it.

In short: the fact that this web site was made available by the European Commission does not mean that the calculations are necessarily correct, nor that they are in any way "official". We are also not the only provider of such services. A number of other organizations and companies offer data and guidance on solar radiation and design and set-up of PV systems. Some are free, while others provide their services for a fee. A more detailed investigation can produce more accurate results than our rather generic approach, but at a cost in time and/or money.

For people interested in the details of all these studies, please see our list of publications.

Please also see our Legal Notice.

2. How to use the online calculator

The estimation of the power output from a given PV installation can be calculated if you supply a bit of information about the installation:

PV technology

The performance of PV modules depends on the temperature and on the solar irradiance, but the exact dependence varies between different types of PV modules. At the moment we can estimate the losses due to temperature and irradiance effects for the following types of modules:

- crystalline silicon cells

- thin film modules made from CIS or CIGS

- thin film modules made from Cadmium Telluride (CdTe)

For other technologies (especially various amorphous technologies), this correction cannot be calculated here. If you choose one of the first two options here the calculation of performance will take into account the temperature dependence of the performance of the chosen technology. If you choose the other option (other/unknown), the calculation will assume a loss of 8% of power due to temperature effects (a generic value which has found to be reasonable for temperate climates). If the database does not have any temperature data the option to choose PV technology will not appear, and the estimated loss due to temperature will always be 8% for all technologies.

Peak power, or array nominal installed power

This is the power that the manufacturer declares that the PV array can produce under standard test conditions, which are a constant 1000W of solar irradiation per square meter in the plane of the array, at an array temperature of 25ï¿½C. If you do not know the declared peak power of your modules but instead know the area of the modules and the declared conversion efficiency (in percent), you can calculate the peak power as power=area * efficiency / 100. See more explanation here

Estimated system losses

The estimated system losses are all the losses in the system, which cause the power actually delivered to the electricity grid to be lower than the power produced by the PV modules. There are several causes for this loss, such as losses in cables, power inverters, dirt (sometimes snow) on the modules and so on. We have given a default value of 14%. If you have a good idea that your value will be different (maybe due to a really high-efficiency inverter) you may reduce this value a little.

Mounting position

For fixed (non-tracking) systems the way the modules are mounted will have an influence on the temperature of the module, which in turn affects the efficiency (see above). Experiments have shown that if the movement of air behind the modules is

restricted, the modules can get considerably hotter (up to 15ï¿½C at 1000W/m2 of sunlight). In the application there are two possibilities: free-standing, meaning that the modules are mounted on a rack with air flowing freely behind the modules; and building-integrated, which means that the modules are completely built into the structure of the wall or roof of a building, with no air movement behind the modules. Some types of mounting are in between these to extremes, for instance if the modules are mounted on a roof with curved roof tiles, allowing air to move behind the modules. In such cases, the performance will be somewhere between the results of the two calculations that are possible here.

Inclination angle

This is the angle of the PV modules from the horizontal plane, for a fixed (non-tracking) mounting

Orientation angle

This is the angle of the PV modules relative to the direction due South. -90 deg. is East, 0 deg. is South and 90 deg. is West.

For some applications the inclination and orientation angles will already be known, for instance if the PV modules are to be built into an existing roof. However, if you have the possibility to choose the inclination and/or orientation, this application can also calculate for you the optimal values for inclination and orientation (assuming fixed angles for the entire year).

Tracking options

The previous options assume that the modules are mounted in a fixed position at a given slope and azimuth (orientation). However, there exist systems that can move the PV modules to allow them to follow (track) the movement of the sun in the sky. In this way we can increase the amount of sunlight arriving at the PV modules. This movement can be made in several different ways. Here we give three options:

- Vertical axis: The modules are mounted on a vertical rotating axis, at an angle. It is assumed that the axis rotates during the day such that the angle to the sun is always as small as possible (this means that it will not rotate at constant speed during the day). The angle of the modules relative to the ground can be given, or you can ask to calculate the optimal angle for your location.

- Inclined axis: The modules are mounted on an axis that forms an angle with the ground and points in the north-south direction. The plane of the modules is assumed to be parallel to the axis of rotation. It is assumed that the axis rotates during the day such that the angle to the sun is always as small as possible (this means that it will not

rotate at constant speed during the day). The angle of the axis relative to the ground can be given, or you can ask to calculate the optimal angle for your location.

- Two-axis tracker: The modules are mounted on a system that can move the modules in the east-west direction and also tilt them at an angle from the ground, so that the modules always point at the sun. Note that the calculation still assumes that the modules do not concentrate the light directly from the sun, but can use all the light falling on the modules, both that coming directly from the sun and that coming from the rest of the sky.

User-defined horizon

PVGIS includes a database of the horizon height around each point you can choose in the region. In this way, the calculation of PV performance can take into account the effects of mountains and hills casting shadows onto the PV system. The resolution of the horizon information is 3 arc-seconds (around 90m), so things that are very near, such as houses or trees are not included. However, you have the possibility to upload your own information about the horizon height. The horizon file to be uploaded to our web site should be a simple text file, such as you can create using a text editor (such as Notepad for Windows), or by exporting a spreadsheet as comma-separated values (.csv). There should be one number per line, with each number representing the horizon height in degrees in a certain compass direction around the point of interest.

The horizon heights in the file should be given in a counterclockwise direction starting at East; that is, from East going to North, West, South, and back to East. The values are assumed to represent equal angular distance around the horizon. For instance, if you have 36 values in the file, PVGIS assumes that the first point is due east, the next is 10 degrees north of east, and so on, until the last point, 10 degrees south of east.

An example file can be found here. In this case, there are only 12 numbers in the file, corresponding to a horizon height for every 30 degrees around the horizon.

Note that the actual calculation made here will use the average solar irradiation for the given location to estimate the power output. If you compare with the output for a given location, please remember that actual weather conditions can change the output by a large amount. If you had unusual weather for a period the actual power output may be up to 100% smaller or larger than the value calculated here.

3. Peak power and efficiency, a guide for the confused

If you know the *nominal peak power* or *rated power* of your system, you don't need to know the efficiency, except to calculate the area of the modules. This is why: The *nominal peak power* is the power rating given by the manufacurer of the module or system. It is the power output of the module(s) measured at 1000W/m^2 solar irradiance (and a module temperature of 25ï¿½C and a solar spectrum corresponding to an air mass of 1.5). This means that if your modules were 100% efficient, you would

need 1 m^2 to get a system with a peak power of 1kW. These conditions are known as *Standard Test Conditions*(STC).

Since the modules are NOT 100% efficienct you need a bigger area. If you have 10% efficient modules you need 10m^2 to have a 1kWp system. The module efficiency at Standard Test Conditions we will call eff_{nom}.

In other words, if P_{pk} is the nominal peak power and A the area of the module(s), we have

$$P_{pk} = A * eff_{nom} \quad (1)$$

The actual power depends on the irradiance G and the real module efficiency eff which is a function of irradiance and module temperatureT_m (and sometimes more things which we will forget about here). So you have the actual power:

$$P = G/1000 * A*eff(G,T_m) = G/1000*A*eff_{nom} * eff_{rel}(G,T_m) \quad (2)$$

where we have written the actual efficiency as the product of the nominal efficiency eff_{nom} and the *relative efficiency* $eff_{rel}(G,T_m)$.

Combining Eq. 1 and 2 you get:

$$P = G/1000 * P_{pk} * eff_{rel}(G,T_m) \quad (3)$$

Therefore, if you know the relative efficiency and the peak power, you don't need to know the nominal efficiency or the area.

BUT: if you want to know either the nominal efficiency OR the area, you will need to know the other of the two parameters. If you know the nominal efficiency and the peak power, you can calculate the area using Eq. 1:

$$A = P_{pk}/eff_{nom} \quad (4)$$

So we don't actually have a nominal efficiency in the program. That would be useful only to tell the user how much area his/her system would use.

4. Calculating the performance of different PV module types

The actual energy output that you can expect from a given PV system depends on a large number of factors. One of these is the type of modules chosen for the system. The power output of a PV module depends not only on the amount of solar radiation that arrives at the surface. Among the reasons are:

The PV efficiency is affected to a greater or lesser extent by the temperature of the module, usually decreasing with increasing temperature.

Nearly all module types show decreasing efficiency with low light intensity. The strength of this effect varies between module types.

Some of the light is reflected from the surface of the modules and never reaches the actual PV material. How much depends on the angle at which the light strikes the

module. The more the light comes from the side (narrow angle with the module plane), the higher the percentage of reflected light. This effect varies (not strongly) between module types.

The conversion efficiency depends on the spectrum of the solar radiation. Where nearly all PV technologies have good performance for visible light, there are large differences in the efficiency for near-infrared radiation. If the spectrum of the light were always the same this effect would be assumed to be part of the nominal efficiency of the modules. But the spectrum changes with the time of day and year, and with the amount of diffuse light (light not coming directly from the sun but from the sky, clouds etc.).

Finally, some module types have long-term variations in the performance. Especially modules made from amorphous silicon are subject to seasonal variations in performance, driven by long-term exposure to light and to high temperatures.

Since there are many effects in play, it is difficult to design experiments that are both realistic and able to separate these effects. Furthermore, the importance of these effects varies with geographical location (sunny or cloudy climate, hot or cool). The debate about the relative merits of different PV technologies is still open, also because some of these technologies develop rapidly. Results from just a few years ago may no longer be relevant, especially for the newer thin-film materials.

The PVGIS energy rating method

The method used in PVGIS to estimate the actual PV output from a given type of PV module is based on a mathematical formula that takes into account the first three of the effects mentioned above. This means that the method can only be used on PV technologies that do not depend strongly on the solar spectrum, and do not show effects of long term exposure to irradiation or high temperatures. Therefore we do not at the moment try to calculate the output of amorphous silicon modules which are more dependent on these two effects.

The formula for estimating the relative efficiency used in Eq. 2 looks like this:

$$eff_{rel}(G',T_m)=1+k_1\ln(G')+k_2\ln(G')^2+k_3T_m +k_4T_m\ln(G')+k_5T_m\ln(G')^2+k_6T_m^2 \quad (5)$$

where $G'=G/1000$.

The coefficients k_1 to k_6 depend on the type of PV technology used. These coefficients have been found by comparisons with measured values for each of the different technologies.

The module temperature T_m is calculated from the ambient temperature by the following formula:

$$T_m=T_{amb}+k_TG \quad (6)$$

This formula shows how the modules are heated up by the solar radiation. It is a very simple formula that doesn't take into account cooling effects such as wind. If your system is in a very windy area, this will reduce the temperature of the modules and this will help increase the efficiency a bit. The coefficient k_T depends on the type of mounting used for the PV system. In general, a building-integrated system will be hotter than a free-standing rack-mounted system because the air cannot circulate freely around the back of the modules and cool the modules. In PVGIS we have used the following values:

k_T=0.035ï¿½C/(W/m^2) for free-standing systems, based on measurements done at our laboratory

k_T=0.05ï¿½C/(W/m^2) for building-integrated systems, based on values taken from literature

How we determined the coefficients for the different PV technologies

The coefficients in Eq. 5 have to be found from experimental data. These data may be measured using indoor solar simulators or by putting the PV modules outdoors for a time.

For the crystalline silicon estimates we have based the calculations on data from a number of different PV modules measured indoors. The data from all the modules have been combined and used to make an estimate for an "average" crystalline PV module. The results show that there is not a significant difference in the behaviour of monocrystalline and polycrystalline modules. The spread in values between modules have a standard deviation of 1.25%, meaning that with 90% probability the deviation of a given module from the estimated value will be less than 2%. The estimate is only valid for "classic" crystalline silicon and not for the new types of heterojunction modules that have come on the market in the last few years.

For CIS modules the estimate is based on outdoor measurements performed in Ispra on three different modules from two different manufacturers. The modules were measured over a four months period during spring and summer. All the modules are rather new, produced in 2006/07, and should therefore be representative of the current state of the technology.

5. Uncertainties in Data and Calculations

All measurements and mathematical models are affected by uncertainties and the chain of measurement data and calculations leading to the PVGIS estimates for PV performance is rather long, each link having its own uncertainty. We will try to look at each of them in turn.

Ground station measurements

The European database in PVGIS is based on ground station measurements. Most measurements are made with some sort of pyranometer measuring directly the

amount of short-wave electromagnetic radiation, typically covering the spectrum from the near-ultraviolet to about 2.5micron in the near-infrared. However, in some cases the global irradiation is estimated from the number of sunshine hours and the (naked-eye) observed cloud cover. Generally, a direct measurement will be more accurate, but even in this case there are reasons why measurements could have errors. Data may be missing and not interpreted as such, the pyranometer may be malfunctioning and reporting arbitrary results, and the pyranometer may be partially covered with dirt, snow or frost. Some of these errors are random in nature (results could just as well be too high as too low), but some of them will primarily lead to an underestimate of the radiation, in particular those connected with dirt or snow.

The underlying data have been measured by many different organizations in dozens of different countries. It is therefore very difficult to estimate the errors that affect each station. The data were checked and cleaned as a part of the European Solar Radiation Atlas. In addition, we have removed a number of suspicious data points, including stations in high mountains that were affected by shadows from nearby mountains.

Interpolation uncertainties

We have estimated the uncertainties involved in the spatial interpolation of ground station data in a number of places. See for instance here, where we give overall estimates of the uncertainty caused by the interpolation technique. In addition it should be noted that the uncertainty depends on the distance between stations. In areas with a high density of stations, the interpolation uncertainty is generally low while in areas with few stations it may be much higher. It also depends on local climatic conditions. If you are in a region with a climate that changes strongly over short distance, such as in mountains, the accuracy will depend on whether or not you have a station nearby with the *same* type of climate. As an example, the variation in solar radiation with altitude is very well resolved in PVGIS for the Alpine Region, since we have stations at several different altitudes. But in other mountain regions, such as Scandinavia or the Caucasus, we have almost no stations at high altitude, and therefore the uncertainty in the estimates at high altitude are much higher than the estimates for the valleys.

Problems with diffuse radiation data

The basic data contains values both for the global horizontal irradiation and for the horizontal diffuse irradiation. Both are needed for estimates of the irradiation on inclined planes. Generally, the uncertainty is higher for the diffuse irradiation, both due to problems with the measurements and because a higher proportion of the diffuse data are not measured directly but estimated from other meteorological parameters. We do not know the uncertainty of the diffuse data used in PVGIS. However, we can estimate the effect of uncertainty on the predictions of PV performance. We have found that for an optimally inclined plane, the uncertainty in

PV energy yield is only about one fifth of the uncertainty in the ratio between diffuse and global irradiation (D/G). Thus, if the D/G ratio has an uncertainty of 10%, this would result in an uncertainty of about 2% in the PV energy yield.

Problems from using long-term averages

The model for PV performance describes the PV output as a function of instantaneous values of solar irradiance and ambient (air) temperature. But this means that if you do not have instantaneous values but only long-term average values, you are likely to make an error. For this effect, we found that using averaged values will lead to an overestimate of the PV output for crystalline silicon of about 1%, probably depending slightly on the geographical location. This is due to the fact that the irradiance and air temperature are not independent. In general, the higher the irradiance (the more sunny the weather), the higher the temperature will be. This will lead to an extra loss in module efficiency at high irradiances which is not taken into account when using averaged data.

6. Legal Notice

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1 metre/sec = 1.94 knots = 2.24 mph

m/s	knots	mph	Beaufort scale
2	3.9	4.5	2
4	7.8	8.9	3
6	11.7	13.4	4
8	15.6	17.9	4
10	19.4	22.4	5
12	23.3	26.8	6
14	27.2	31.3	7
16	31.1	35.8	7
18	35.0	40.3	8
20	38.9	44.7	8
22	42.8	49.2	9
24	46.7	53.7	9
26	50.5	58.2	10
28	54.4	62.6	10
30	58.3	67.1	11

Figure 116 Converting tablefor the Wind Speed

- I Pictures of canopy and charging column:

- II Canopy: