INTERIM REPORT

Team 1

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Table of Contents

Abstract

Nowadays, excessive fuel consumption has become a serious problem. People are searching for new solutions of energy creation. Fortunately, there are several options of how to obtain sources of energy without devastating already destroyed environment. One of these solutions is growing of microalgae, from which one can obtain biodiesel. This report presents the device we created to harvest the algae by drying them with the usage of solar energy. Such alternative to already existing methods is competitive as far as energy usage is concerned. Working on microalage lets us feel that we may contribute to broad field of biodiesel derivation investigation. Solar alage dryer is a distiller getting rid of the unnecessary water from algae solution. Paper describes what kind of technologies, materials and equipment were used in order to build prototype of solar alage dryer. It also presents the device from point of view of ethics and sustainability. Marketing plan and possible future enhencements are also demonstarted.

Glossary

Eco - efficiency measures for Sustainability:

Microalage: a vast group of photosynthetic, heterotrophic organisms which have an extraordinary potential for cultivation as energy crops [1].

Biodiesel: a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters [2].

Harvest: the act or process of gathering a crop [2].

Bioremedation: the use of microorganismal metabolism to remove pollutants [2].

Nutrient: a chemical that an organism needs to live and grow or a substance used in an organism's metabolism which must be taken in from its environment [2].

UV radiation: light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays, in the range 10 nm to 400 nm, and energies from 3eV to 124 eV [2].

Ehtics and deontology:

Ethics: a system of moral principles.

Deontology: branch dealing with duty, moral obligation, and right action.

Law: the principles and regulations established in a community by some authority and applicable to its people, whether in the form of legislation or of custom and policies recognized and enforced by judicial decision.

Norm: a standard, model, or pattern.

Decree: a formal and authoritative order, especially one having the force of law.

Community: a social group of any size whose members reside in a specific locality, share government, and often have a common cultural and historical heritage.

Client: a person or group that uses the professional advice or services of a lawyer, accountant, advertising agency, architect, etc.

Profession: a vocation requiring knowledge of some department of learning or science.

Liable: legally responsible.

State of the art

Ultra sound sensor: Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

Introduction

Problem

The problem we were presented was how to dry microalage solution with the usage of solar energy. Even though there exist plenty of methods of algae drying, only some of them introdcuce sun radiation to the process. Hence, our idea was to create a distiller that would incorporate direct solar radiation and indirect one, so with the use of solar panel. We thought of prototyping solar algae dryer that would be competitive to already existing devices.

Motivation

From the start we were drawn to the projects that had to do with solar power, to the eco-friendly character. What attracted us in the solar dryer that it was a project that might help the development in bio-diesel. Because the high use of fossil fuel is one of our biggest contemporary problems. We were going to develop the solar dryer for a department in our school, the chemical department. For us this was an other advantage. So we choose this project because we wanted to be a part in the search to a more ecologically friendly solution for fossil fuel. Because the fuel that is used now is limited and polluting the earth.

Objectives

The main objective of the work is to create a device drying microalgae, that uses solar power for its operation. It must have a safety system letting it to stop working, if the temperature exceeds 50°C. The reason for that is the fact that algal biomass, for instance oil or pigments, so what we would like to get after dyring, may easily get spoiled in elevated temperatures. Other aspect is that the whole process has to finish in one day. Our idea was to provide a dryer, that uses small amount of power.

Expected Results

We expect that the Solar Dryer will fulfill the clients needs which are drying algae with the use of solar power. We expect it to dry the algaes to less then 10 % humidity in one day. We also expect our algae-dryer to be the one that uses the least energy in the market, and therefore is the most environmental friendly.

Work Plan

Regarding the work plan we separated our task in three modules. The general milestones together with a start and end date for every task is located in the Gantt chart.

Furthermore we allocated each task between the team members, represented in the task allocation. Finally every task is specified and defined in weekly sprints.

Gantt chart

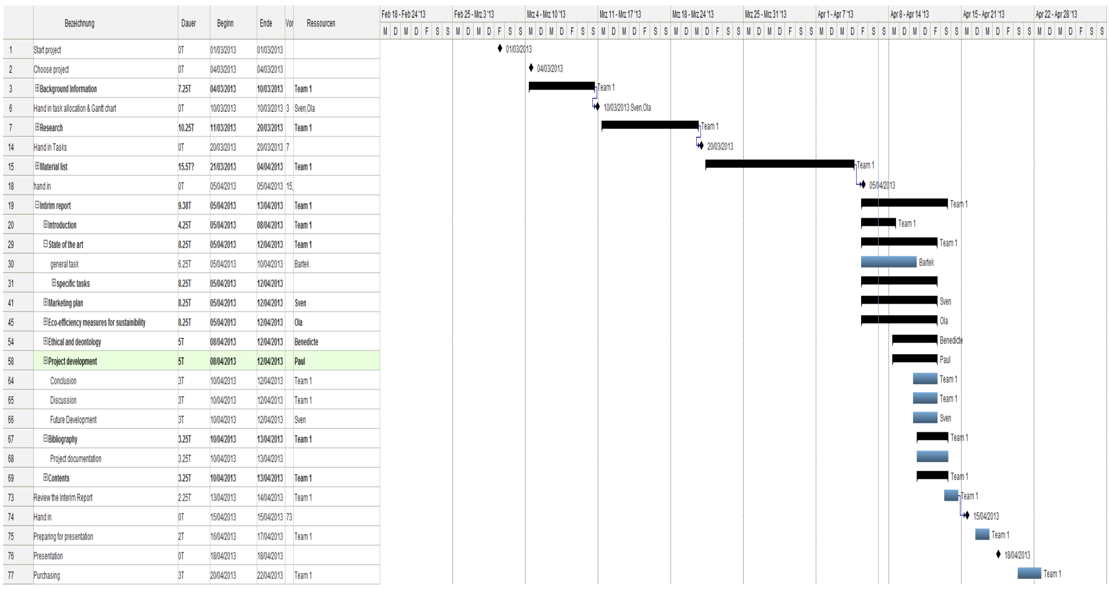

Figure 1. Gantt chart

Task allocation

Task	Responsible
Background information	Benedicte Verbraeken, Aleksandra Brygider
Marketing Plan	Sven Petersen
Drying method	Paul Ahlskog, Aleksandra Brygider, Bartłomiej Marciniak
Solar power application	Bartłomiej Marciniak
Microalgae background	Aleksandra Brygider
Design	Benedicte Verbraeken
Materials	Paul Ahlskog, Bartłomiej Marciniak, Aleksandra Brygider
Sustainability issues	Aleksandra Brygider
Ethics & Deontology	Benedicte Verbraeken
Interim report	Paul Ahlskog, Aleksandra Brygider, Bartłomiej Marciniak, Benedicte Verbraeken,Sven Petersen
Interim presentation	Paul Ahlskog, Aleksandra Brygider, Bartłomiej Marciniak, Benedicte Verbraeken,Sven Petersen
Prototype development	Paul Ahlskog, Aleksandra Brygider, Benedicte Verbraeken
Video	Sven Petersen
Poster	Benedicte Verbraeken
Final report	Paul Ahlskog, Aleksandra Brygider, Bartłomiej Marciniak, Benedicte Verbraeken,Sven Petersen
Final presentation	Paul Ahlskog, Aleksandra Brygider, Bartłomiej Marciniak, Benedicte Verbraeken,Sven Petersen
Technical documentation	Bartłomiej Marciniak

Table 1. Task allocation

Structure of the Report

This report is structured in eight different chapters.

The first chapter is the Introduction and presents the problems we are facing, the motivation, the objectives and our expected results from the project.

The second chapter is the State of the art and describes the different technologies that are available, and presents the ones that we chose for our project.

The third chapter is The marketing plan and presents Market analysis, positioning &

segmentation and Market mix.

The fourth chapter is Eco-efficiency Measures for Sustainability and presents the importance of sustainability in engineering, life-cycle analysis and energy consumption.

The fifth chapter describes the Ethical and Deontological concerns of our project, divided in two subcategories, Legitimacy and Legality.

The sixth chapter of the report is Project development and describes the proposed solution of our project.

The seventh chapter is the conclusion and presents the discussion about our project and what further developments could be made.

The eight and last chapter is the Bibliography chapter and presents all the different references we used for our project.

State of the Art

Related Projects and Products

To find a proper process to dry the algae in a way that the assuptons of our product are fulfiled there must have been a research done on this topic. That is why we provided a search on methods and products that already exist and are used for algae cultivation. It is worth saying, that most of it are photobioreactors, used for mass evaluation of algae species and multi-tonn production. At this point it is worth to present how the photobioreactor works. It is a closed system, that does not exchange gases and contaminants with the environment. It is refered as a bioreactor with a light-supplying system to introduce the photonic energy to the microalgae, in this case, to help it grow faster. Most of the times it is a system of pipes, with the solution of algae and water inside. There are few types of photobioreactors, varying in position of the pipes. There are ones, that are built close to the ground, installed in parallel to the ground, just like the product of "Solix" company from the United States.

Figure 2. Algae farm

This algae farm is built as a system of thin pipes to make sure that maximum amount of light comes to every single part of the solution to fasten the process. The advantage of this product is definitely high speed of growing of the algae and in a mass manner. However the disadvantage is that it is expensive to build, so in our case, as we need a device that dries just 5 liters of the solution and at the same time to be cheap, it would not fit our needs.

As the algae farms, using photobioreactors are the most common way of harvesting the algae and extracting the oil from them, it is worth saying a bit more about different types of these devices. Nowadays one of the most developing types is so called “Chrismas tree” photobioreactor, designed by German company “Gicon” in Dresden. It is named that way, due to the fact that it is thick at the bottom and gets thiner at the top, just as seen in the picture below:

Figure 3. Reactor

This reactor is built in such manner to make sure that the sunbeams get to every part of the structure as long as possible. Other advantage of this system is that it save space in comparison to previously mentioned photobioreactor of a traditional structure. Because of the two-walled technology of the pipes it is possible to change he temperature of the surrounding extremely quickly, which also helps to harvest the algae fast. As the producer sais, the design is extremely lightweight, therefore easy to build and manage and as they state power-efficient, comparing to other existing technologies.

Tank

The main part of our project is the tank where we will dry our algae. Every part of the project has to fit with the tank and therefore we need to have the tank as a base for our project. When deciding which material to use for the tank we must start from what are the needs of the tank.

- It has to be completely waterproof
- At least the top of it has to be transparent
- It has to be easy to assemble
- Light material
- Environmental friendly material
- The price has to fit in our budget

With these needs we started to consider different materials to build the tank. In Figure 1. we have listed the advantages and disadvantages for three different material solutions for our tank:

	Advantages	Disadvantages
Aluminium	5. Very good Thermal Conductivity (205) 6. Light material 7. Reflective 8. Durable material	3. Expensive 4. Hard to build with
Plexiglass	3. Transparent 4. Relatively cheap	2. Low Thermal conductivity (0.2)
Plastic	6. Cheap 7. Light 8. Durable 9. Easy to existing plastic parts 10. Easy to assemble	2. Low thermal conductivity (0.1-0.3)

Table 2. Different materials for the tank

After looking at this we thought that it would be a good idea to build the tank out of aluminium, because of its good Thermal conductivity. But after considering the alternatives a little bit more we stated that the plexiglass will probably be the best solution. We would anyway need the plexiglass for the top of the tank, and therefore it would be the best way to build the whole tank out of plexiglass. In this way we can assamble it more easily and we also get transparent sides for the tank. Plexiglass is also cheaper than aluminium and it's not too heavy. We can also easily make the bottom of the tank absorb the sun more efficiently by painting it black.

UV & Plexiglas

One of the very important aspects as far as algae drying is concerned, is to make sure they will not get damaged during drying. It is known that algae suffers from excessive UV radiation. As our device serves for drying algae with the help of sun beams, they will be constantly exposed to UV radiation. Hence, in order to prevent damage, it is wise to install some kind of filter protecting them from harmful UV radiation. Before coming to solution, let us firstly focus a little bit on UV radiation itself.

According to Gary Zeman , member of Health Physics Society, ultraviolet radiation is this part of the light invisible to our eyes, a portion of electromagnetic spectrum in between 400 – 100 nm. In addition, it also has its main components, which are UVA (320-400 nm), UVB (290-320) and UVC (220-290 nm) radiation. Most common one is the UVA radiation needed by humans for synthesis of vitamin D, UVB radiation, on the other hand, is considered as the most harmful. That is due to the fact that this kind of UV radiation has enough energy to cause "photochemical damage to cellular DNA" [3].

Obviously such problem cannot be ignored especially if our aim is to get advantage from algae structure. Destructive properties of UVB are also proven by the fact that it impairs photosynthesis in many species of the plants, so also including microalgae [4].

We considered two possible solutions. The first one was very simple - glass. Glass blocks over 90% of the light below 300 nm [5], so hurtful UVB radiation. In order to get 100% protection, we thought of using laminated glass. It consists of two pieces of ordinary glass connected by PVB - Poly Vinyl Butyral. Such structure ensures 99% of UV radiation blockage, but also is very hard, which gives us the other advantage in our design properties. [6] The other advantage was that glass is completely transparent and taking into account fact that our distiller needs light to warm up the solution to get it evaporated, this feature is really important. Transparency means that it does let through the visible light and Infra red (IR), which causes heat. The device is aimed to be used outside, thus glass transparency seem extremely proper.

The other solution was plexiglas, so Poly(methyl methacrylate). It has almost the same properties as simple glass does, but has main advantage over glass. Meaning, it is significantly lighter. This feature comes in really handy, taking into account fact, that we are considering the dryer prototype to be replicable. One cannot imagine a huge container made of glass that can be easily reassembled or to be lifted up. According to the producer, plexiglas has following properties: it has low density, so lets through the sun beams easier, its resistance towards abrasion is close to the one of aluminum, it is resistant to any chemicals, it is completely transparent (this feature was already mentioned to be of great importance) and the most important is that it is a protection from UV radiation. [5]

Temperature controller

One of the requirements of our solar dryer was to have a temperature controller installed. This is necessary to protect the algaes, because the algaes will get damaged if the temperature rises over 50° C. The needs of this temperature controller are:

- Measure the temperature inside the tank
- Alarm when temperature rises to 50°C → Adjust the temperature
- Waterproof

For this problem we were thinking about using a temperature sensor that will measure the temperature inside the tank and if/when the temperature rises to 50° C it will give a signal to the micro-controller and the cooling down process will start. The chosen temperature sensor is a waterproof temperature sensor model DS18B20. This temperature sensor is connected to our Arduino micro-controller and alarms when the temperature rises over 50°C.

Here in figure 2. are presented the block diagram for this temperature sensor:

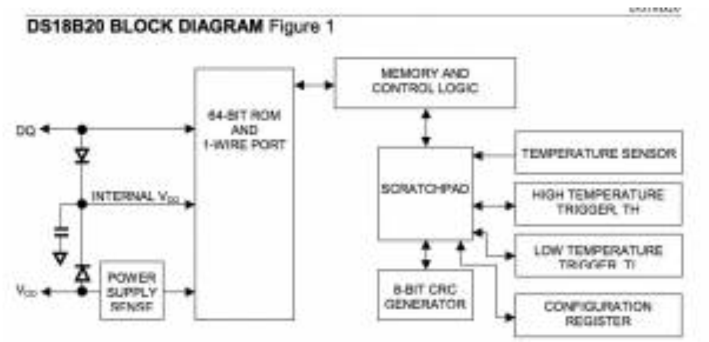

Figure 4. Block diagram for temperature sensor [23]

FEATURES
- Unique 1-Wire interface requires only one port pin for communication
- Multidrop capability simplifies distributed temperature sensing applications
- Requires no external components
- Can be powered from data line. Power supply range is 3.0V to 5.5V
- Zero standby power required
- Measures temperatures from -55°C to +125°C. Fahrenheit equivalent is -67°F to +257°F
- ±0.5°C accuracy from -10°C to +85°C
- Thermometer resolution is programmable from 9 to 12 bits
- Converts 12-bit temperature to digital word in 750 ms (max.)
- User-definable, nonvolatile temperature alarm settings
- Alarm search command identifies and addresses devices whose temperature is outside of programmed limits (temperature alarm condition)
- Applications include thermostatic controls, industrial systems, consumer products, thermometers, or any thermally sensitive system

Figure 5. Features for the temperature sensor DS18B20 [23]

Water level controller

In order to be able to control when the drying process is ready we need to have some kind of controller that tells us when it's ready. The best way of doing this is to put some kind of controller attached to the water level that alarms when we have reached our goal of 10% water left in the solution. The needs of this controller are:

- Has to be precise (water level will drop from ~20 mm to ~2 mm)
- Has to be able to work in temperatures between 0°C - 60°C
- Has to give a signal to the micro-controller when the water level is low enough (drying process ready)

When facing this problem we thought about different solutions to solve it, they are listed below in figure 4. with their advantages and disadvantages.

Type of controller	Advantages	Disadvantages
Liquid level sensor	-Cheap -easy to install	-hard to find precise enough
Optical sensor	-precise	-Expensive -problem to install inside
Ultra sound level sensor	-Precise -Fits for our product because it can measure short distance -Cheap because we have one already and don't need to buy it	

Table 3. Different water sensor solutions

The easiest and cheapest way to control the water level is the liquid level sensor. It works with a float that is moveable and floats with the waterlevel, and you can adjust it to at which waterlevel you want it to alarm. The problem is that it's hard to find one that can measure the levels that we are going to have in our tank. Because of thisproblem we will go with the Ultra sound sensor, we already have one in the school and it will be adaptable to our solution. This sensor will be connected to our Arduino micro-controller and alarm when the water level is low enough and the process is ready. Ultrasonic level sensors are used for non-contact level sensing of highly viscous liquids, as well as bulk solids. They are also widely used in water treatment applications for pump control and open channel flow measurement. The sensors emit high frequency acoustic waves that are reflected back to and detected by the emitting transducer. The chosen sensor is a Devantech SRF04 Ultrasonic Range Finder.

- Voltage – 5 v
- Current – 30 mA Typ. 50mA Max.
- Frequency – 40 kHz
- Max Range - 3 m
- Min Range - 3 cm
- Sensitivity - Detect 3 cm diameter broom handle at > 2 m
- Input Trigger – 10 uS Min. TTL level pulse
- Echo Pulse - Positive TTL level signal, width proportional to range.
- Small Size – (1.7 in x .8 in x .7 in height) 43 mm x 20 mm x 17 mm height

Figure 6. Features of the Ultrasonic range finder [24]

Figure 7. Picture of SRF04 Ultrasonic Range Finder [24]

Fan

The speed of the distilling process depends on the speed of evaporation. Evaporation speed depends on the temperature of the air and the algae, size of the exposed surface to the air, concentration of the substance evaporating, pressure and the flow rate of air. We can control this last factor. We want to make the air circulate by adding a fan. We considered a fan with a heater build in. But we decided that the gain of hot air is not worth the loss, it uses a lot more energy. Then we had an option to make the system closed or open. If the system would be open, there would be a supply of colder fresh air. But since we don't need the supply and the inside air just needs to move faster we decided to make the system closed. An other advantage of a closed system is the fact that it is more weather proof. No rain can enter the tank for example. A last decision we made is to install three fans instead of one so we can speed up the air more and we cover more area.

Microcontroller

To make sure, that the whole system works just the way we want it to, we have to install a microcontroller, which has to be programmed to distribute tasks to the previously mentioned parts, such as temperature controller, level controller, the diodes, fans and a mechanical system responsible for reducing the temperature inside the tank, not to be higher than 50°C. The board we chose is Arduino Uno board with microcontroller ATmega328. We use it, because of its simplicity, but at the same time enough number of analog and digital ports. Because of the fact that we require just one analog and few digital ports such board is enough. Here in Table 1. are shown the official specifications taken from the producer's webpage.

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 kB (ATmega328) of which 0.5 kB used by bootloader
SRAM	2 kB (ATmega328)
EEPROM	1 kB (ATmega328)
Clock Speed	16 MHz

Table 4. Specifications of Arduino

Figure 8. Picture of the Arduino board

Solar Panel

The main idea of the project was to provide the power to the system just from the solar panel. It had to be checked what output power would satisfy our needs and it has been decided that 15 W solar panel would be required. Because of the fact that the fans consume lots of power, it was not possible to aquire smaller panel. Other components of the system that have to be powered by the energy taken from the sun are the temperature controller, level controller, diodes indicating if the wanted level of the liquid has been reached or if the temperature exceeds 50°C. Other part of our design that has to be supported by the power from the solar panel is the step motor, working with blinds on the top of the tank to control the temperature inside the dryer, by reducing the sunbeams acting on the algae solution. Of course the whole system could not work with the energy taken directly from the panel. It happens due to the fact, that the sun does not operate on the same level of instensity all the time and the idea for the system is to work all the time. That is why the battery was needed to be applied to be charged by the panel. We have chosen a 12V battery, because the whole circuit is supposed to operate in this voltage. Therefore, an additional circuit between the panel and the batterywill be needed, because the panel of such power, that we need operates in 17.5 V. The panel that we chosen is shown in the figure below:

Figure 9. solar panel

Conclusions

Summing up, all the products that we have chosen after a brief research were picked because of their contribution to our product, being low energy consuming, cheap and that it would fulfil the needs. We chose such solar panel due to the fact that it just has to be powerful enough to supply power to other components and cannot be too heavy. The fans have to give enough velocity of air of 1 m/s to rise the speed of the process. After a huge study of temperature and liquid level controllers we decided to use ultrasonic level controller. The reason was that most of other products did not have such small range of operation, as we needed. The temperature controller however was chosen because of the fact that it sends analog signal, what facilitates circuit design. The last component to select was the microcontroller, which had to be simple, because of the fact that our circuit is not a complicated one. The only thing that had to be checked was the number of digital and analog ports in the board. That is why Arduino Uno was chosen.

Marketing Plan

Executive summary

In times of worldwide air pollution and decreasing energy resources it is absolutely necessary to support systems that do not harm product environment and use less energy. Our product will fit into the actual eco-political and economical trends of "green energy". To concentrate on the right competitive advantages of our product, it is very important to study potential competitors and of course the customer needs. Therefore we will concentrate on the European market for analyzing the advantages and disadvantages of nowadays solutions.

Product description

Product: Solar dryer

Definition: What?

Our project is creating a microalgae dryer, powered only by solar energy. We dry the algae by evaporating the water.

Wherefore?

At the moment one of the biggest problems is the high consumption of fossil fuel. In contrast can the oil contained in micro algae be used as an ecological and a sustainable solution because it is usable as alternative fuel.

Why?

We wanted to be part of the development of a more ecologically friendly solution for fuel. Today's fuel is limited and polluting our earth.

How?

We are working on a solution that is very energy-efficient and uses renewable energy. As a by-product the algae absorb CO_2 to produce biomass.

Market Analysis

In order to identify strengths, weaknesses, opportunities and threats correctly a company has to understand the market environment in which the company operates. The market environment includes all factors with impact from outside. They are influencing the ability to develop successful relationships with the target customers. With regard to the specific company these factors can divided into micro environmental and macro environmental.

Microenvironment

The microenvironment consists of five components. At first the organization's internal perspective and its affects on the different departments. Secondly microenvironment includes all companies cooperating with suppliers, the intermediaries and us. The third component contains of the potential markets; the producer, consumer, reseller, government and international markets. The prospective customers are mentioned in the fourth part. At least the fifth component consists of the public including all potential organizations, which have an actual interest on the organization's accomplishment to achieve its objectives.
In the current situation a company doesn't exist. Our team consists of four students from different faculties. Consequently in our case internal perspective is about, how to work and act in a group. For instance how to solve problems in communicating between people and which are the rules of collaboration. Through this internal environment we should be able to develop a product as good as we expected it to be.

In this case Intermediaries are for our solution not interesting. The product we are going to develop is really specific and needs a lot of explanation. In this case it is really important to focus on “one to one” marketing.

After analyzing prospective customers we found out that there are already companies in the energy sector using the microalgae production to produce energy. These companies are familiar with the idea and want to support the system of gaining biodiesel out of microalgae. Almost each company used their own technology to dry the algae. To meet those needs, we have to create a product based on a main solution with flexible adaptations to apply the relevant needs. Thereby the stakeholders have the opportunity to choose the most suitable solution. Attached you find a list of international prospective customers.

Company	**Country**	**Task field**
Solix Biofuels	USA	Energy production from algea
Biofields	Mexico	Biodiesel from algae
BioCentric Energy	USA	Biodiesel from algae
Solazyme	USA	Biodiesel and food products from algae
Seambiotic	Israel	Production of microalgae with C02
TransAlgae	Israel	Energy and food products from algae
Cavitation Technologies	USA	Oil production from algae
Symple Green Biofuels	USA	Biofuels from algae

Table 5. potentional customers

Other prospective customers are universities and institutions, which already involved with the production of algae. We believe that we can integrate our solution in existing systems enable them to get the necessary power by solar energy instead of fossil energy sources. Possible customer from Germany you find attached.

Institute	**Task field**
Ruhr-Universität Bochum	Formation of hydrogen using green algae for fuel cells
Fraunhofer Institut für Grenzflächen und	Algae production in the bioreactor for

Bioverfahrenstechnik (IGB)	material and energy
TU Berlin	Algae in the water restoration
Projekt HydroMicPro	Hydrogen from algae (fuel cells)
Brandenburgisch Technische Universität Cottbus	Department of Conservation
Jacobs Universität	
Karlsruher Institut für Technologie (KIT)	

Table 6. possible customers

It is our objective to distribute our product via Business-to-Business market (B to B). Furthermore, our unique system requires a unique approach. We are successful once our potential target audience is convinced that our system does not only fulfill their requirements such as capacity but also support our customer's own sustainability approach.

Basically each prospective company can be customer or competitor. Meaning, every company, which already have a solution to dry the algae. Certainly the aim of the relevant companies is to produce the algae. There are only a few companies that are primarily specialized in producing and selling components to dry the algae. As mentioned previously, most of the companies have their own solutions. For instance some competitors, who sell components for the algae production are placed in Germany.

Company	**Task field**
Subitec	Production of algae biomass
Hezinger AlgaeTec	Algae production
Blue Biotech	Production, trade, sales of algae
Phyton Energy	Energy from algae
Algomed	Products from algae
Breen Biotec	Biodiesel from algae

Table 7. Algae companies

The general problem of nowadays solutions is the waste of energy. Furthermore they have to decrease the high consumption of used materials and change to alternative energy instead of fossil fuel to run their system. Nevertheless most of the existing solutions are faster and more efficient then our system id going to be. It depends on the perspective to be efficient. Our product will use less energy then nowadays. Therefore is the whole system running with solar energy. Anyway most of the existing systems are ideal for prototyping and adjust our client needs. Consequently we have to gain more information to improve our product. We will consider the former strategy of our competitors. In order to enter this market within a short period of time, it is necessary that the market is aware of our product.

Furthermore, we simplify the networking with suppliers. We believe that cooperating with the energy/utility sector is the first step to enter the market. With their support we can reach a large target market and our target costumers. In addition we can use an existing system and must overcome the need for complicated market immersion barriers. Are direct considered tenders in this area and allows us to quickly draw attention to our product without investing great marketing promotion.

Macro environment

In general the macro environment is composed of those factors that the company has very little impact on. The important factors compromising the macro environment of marketing are demographic, economic, socio-cultural, natural, technological and political-legal. We describe the influence of each factor in more detail.
Regarding our project the macro environment is concerned with topics of demographic, technological and political parts. In the following I will deal with each part and briefly characterize them.

Demographic

Demography is the study of human population, which includes different types: density, location, age, occupation and other terms. The major interests of marketers are people, because demographic involves people and people create markets. The only constant thing in life is changing, the same applies for demographic trends.

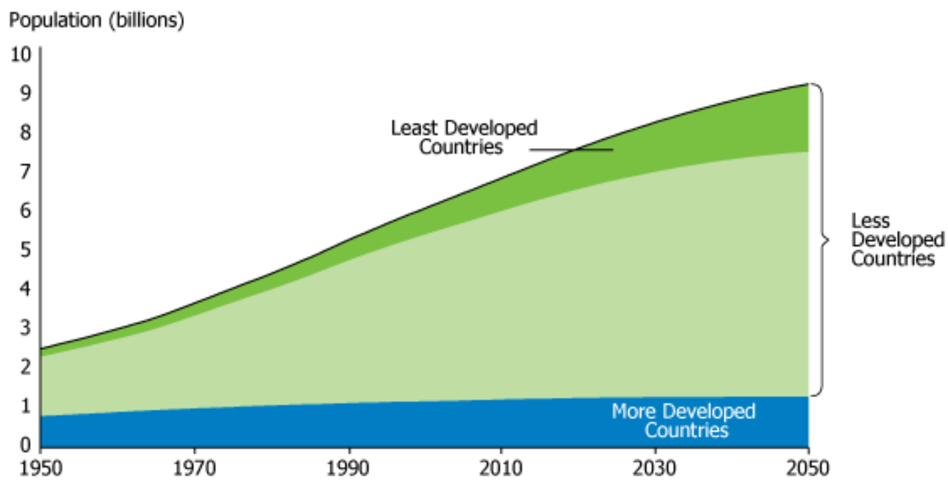

Figure 10. Demographic graph

United Nations Population Division, *World Population Prospects: The 2010 Revision,* medium variant (2011) [26]

The al demographics development shows that the population becomes/gets bigger.
As we can see in the graph, the worldwide population will increase to about 8 million people in 2030. Worldwide, there are around 900 million cars in 2007, of which 231 million in the EU. One reason for this is that mobility and flexibility are becoming important topics to be successful and competitive in times of fort ran globalization.

Overview

USA:	775 cars per 1000 Inhabitants
Luxembourg:	655
Italy:	605
Germany:	573
Austria:	511
EU:	467

Table 8. (APA/Red.) [27]

Nevertheless the energy reserves decrease rapidly and as a consequence the need of alternative fuel increases. Consequently our product has to use less energy and preferably the whole system should run with solar energy.
A big resulting problem caused by the increasing population is high air pollution.

Political

Political factors influence organizations in many ways and are able to create strengths and opportunities for organizations.
Finally since the failure of the UN Climate Change Conference in Copenhagen 2009 everyone should be aware of its results. For instance, the German government supports research programs in the "green energy" area. The university of Senftenberg and the "Green Mission" GmbH got 4 million Euros for the algae research in 2010. Concerning the research three main categories are taken in considerations. Which strain of microalgae is best? What is the energy balance of the algae cultivation? At what amount of CO2 supply algae grow most effective? Meaning, actually they are

not interested to dry the algae as fast as possible. The aim of this project is to get satisfactory results. Consequently these should be our target projects, because we find a current win-win situation. It means in effect / This implies that we are able to integrate our solution in the/their existing system enabling them to get the necessary power by solar energy instead of fossil energy sources, and we will get the needed information to modify our system.

Other opportunities to raise the financial resources are funds of the European union. For instance the Eco-innovation initiative is a part of the EU's Competitiveness and Innovation Framework Program (CIP). This program is also linked to the Eco-innovation Action Plan (EcoAP), Europe's green technology roadmap and the policy background for Eco-innovation. These initiatives enable new products, processes or services, which will create a beneficial impact on the environment, to get into the market. Actually this fund will not finance the whole requirements of our product. Nevertheless it is useful to improve our product. Finally we believe that we could be able to produce at lower cost as well as decrease the cost of the market launch.

Technology

Technology means continues change. Consequently, technological force is rising by the used level of development and influence organizational degree. Currently we are using the newest technology and the fact that the whole system runs with solar energy meet future trends.

SWOT-analyses

To summarize the objectives concerning our product we did a SWOT analysis. The attached table shows the clarified ideas (advantages & disadvantages of the environmental analysis).

Strenghts	**Weaknesses**
use "green" energy (solar) possible adaptation to meet customer needs participate in sales network algae’s are able to absorb CO_2 to reduce air pollution our system uses less energy then nowaday's the whole system runs with/by solar energy algae’s are easy reproducible less consumption in general possibility to install water recovery system in the future mobility of the equipment -> may stand anywhere outside algae are about 70% more efficient than other energy crops all the parts may be either recycled or reused	system uses a lot of time for evaporation materials are ideal/suitable for prototyping limited financial resources lack of time to improve the system no already existing researches/tests - need to build prototype to conduct them seasonal operation mode (summer, sunny days)
Opportunities	**Threats**
existing funds supporting initiatives playing major role in harvesting algae research	product acceptance prototype may not meet our assumptions longer evaporation period, blinds and mirrors may not work lack of possibility to build replicated product with the same materials lack of possibility to buy all the needed equipment for mass production at local suppliers

Table 9. Swot analys

Market segmentation

Market segmentation is the process of identifying prospective segments within the general market, which have similar specific needs. The distribution of the market is really important, because including the knowledge of our target market we are able to meet customer needs and create competitive advantages.

To understand customer needs and meet them, we should ask about the main problems in our target market. The main question, which many companies trying to answer, is how can we produce enough to meet the demand for alternative fuel, for instance biodiesel? Those companies are focused on mass production and distribution, because they are in possession of large financial background as well as specialized faculties. Consequently we have to separate our target market in two groups. At first we are going to sell our product to prospective universities to gain more information. Especially we are looking for individual laboratories, which practice to find the most efficient microalgae. Probably they have a lack of funding and the demand of such a solution. After modifying our system and improving it towards future needs, we are able to enter the energy market.

Available structures for implementation exist/ are placed in Europe. As already mentioned in the previous part regarding/concerning market analysis different opportunities, which could support our product, are given. Furthermore political trade barriers are minimized and the fact that all team members have gained their knowledge in different regions of Europe could be helpful to enter the market.

Product differentiation

We believe that our product cannot be a "stand alone" solution. Once our system is installed our customers will not only be supported by our Customer Care Team but also be informed about the future development by our After Sales Management. This service plays in important role in terms of our product's USP (unique selling point).

The research shows that the circumstances in the existing market are different, as well as duration and functionality. It appears that the existing solution are inflexible and without a large function variety. Finally the development of the solar dryer should be a main solution with flexible adaptations for specific customer needs.

Market positioning / strategy

The positioning task contains three steps: At first identifying possible competitive advantages, then choosing the right advantage, build up a basic position and select a collective strategy. At least it is very important to communicate the chosen position effectively to the market. We are successful once our potential target audience is convinced that our system does not only fulfill their requirements such as capacity but also supports our customer's own sustainability approach. Improving and modifying our prototype is really important to develop a conclusive solution that can be produced in mass production. Therefore we are going to use the follower strategy. The biggest competitive advantage differentiating our product is the easy establishment in an existing solution. Through consisting opportunities, which are already mentioned in the market analysis, we should be able to produce our product at lower costs. All in all our product's consumption is less than the currents.

Summary/Conclusion

The bio diesel extraction out of algae is a new technology, consequently the research and development is at its beginning. The same goes for our product. A range of important decisions has to be made and accordingly have not been made. Hopefully the next labor experiment will clarify the framework of our product, so that we are able to particularize the research of possible competitive advantages, the market strategy and finally the marketing mix.

Eco-efficiency Measures for Sustainability

Introduction

Nowadays, the matter of saving our planet is of great importance. People get more and more conscious of the possible dangers and threats towards environment. Due to that, all the producers and manufacturers of all the branches of industry think of the ways to create new products in an ecologically friendly manner. Our project focuses on developing a new project, hence we want to create it and make it as environmentally harmless as possible. Due to that, we made a thorough research on already existing companies present at our field of interest. What we found out is that all of current algae drying companies creating different kinds of equipment like centrifuges, use and waste a lot of power in order to get the algae dry. Aim of being competitive on the market forces us to attain one of possible directions: either we mostly focus on drying algae faster or we make it as energy efficient as possible. We decided to follow the second idea. Thus, we create the algae dryer completely dependent on renewable source of energy – solar power. However, not only is our device energy – efficient, but also the greater idea behind it is very sustainable. Algae dryer serves for drying algae, which then are used to create biodiesel, extremely advantageous as far as current excessive fuel consumption is concerned.

Biodiesel

It is already widely known that we run out of the planet's fuel resources. Due to that people are searching for alternatives for oil and transportation fuels in general. One of such solutions is biodiesel obtained from microalgae oil. In order to extract such oil, microalgae must be first selected, grown up and harvested, which may be implemented in numerous ways. And here comes the importance of our project. One of the methods is drying algae in order to get rid of the unnecessary water. Then, the oil must be extracted, which again can be done in different manners. Later on, such bio-fuel would be transformed into biodiesel. The scheme below (fig. 11) represents the simplified process of obtaining biodiesel from micro algae [1].

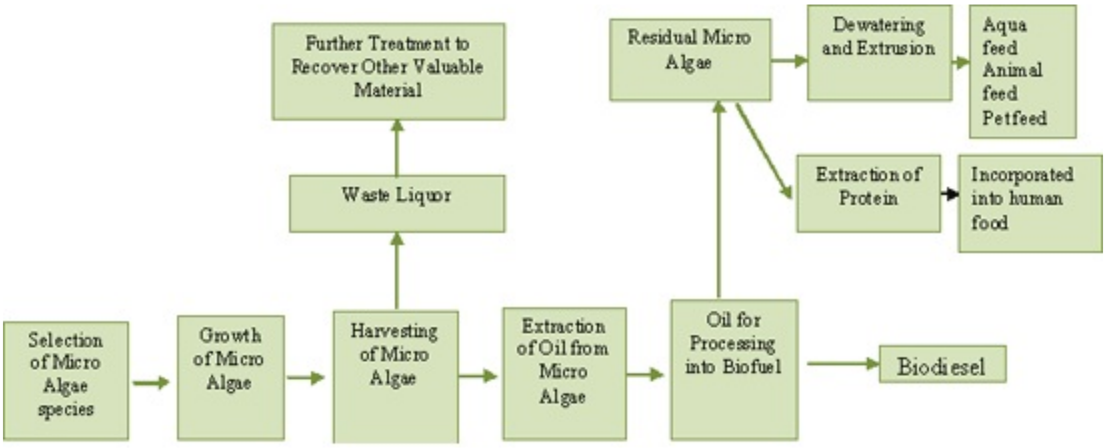

Figure 11. Process of biodiesel receiving [1]

Observing the presented diagram, we may also notice that any side products or leftovers of the process can be reused or recovered. This proves the eco – friendliness of algae cultivation. There are also numerous other microalgae sustainable properties. For instance, they are able to grow almost everywhere. What is more, different specious can easily adapt to the diversity of environmental conditions. Thanks to that they are very competitive to other energy crops from which one can attain bio fuels (rapeseed, corn, soybeans). Their competitiveness justifies also the fact that one can return 10 to 100 more fuels and use from 49 up to 132 times less land area growing algae comparing to already mentioned crops. The table below (table 10) presents the lipid content and productivity of microalgae in comparison to other energy corps. It is clearly visible that microalgae have a great ascendance as far as oil content and biodiesel productivity is concerned, having the lowest area consumption at the same time.

Table 2
Comparison of microalgae with other biodiesel feedstocks.

Plant source	Seed oil content (% oil by wt in biomass)	Oil yield (L oil/ha year)	Land use (m^2 year/kg biodiesel)	Biodiesel productivity (kg biodiesel/ha year)
Corn/Maize (*Zea mays* L.)	44	172	66	152
Hemp (*Cannabis sativa* L.)	33	363	31	321
Soybean (*Glycine max* L.)	18	636	18	562
Jatropha (*Jatropha curcas* L.)	28	741	15	656
Camelina (*Camelina sativa* L.)	42	915	12	809
Canola/Rapeseed (*Brassica napus* L.)	41	974	12	862
Sunflower (*Helianthus annuus* L.)	40	1070	11	946
Castor (*Ricinus communis*)	48	1307	9	1156
Palm oil (*Elaeis guineensis*)	36	5366	2	4747
Microalgae (low oil content)	30	58,700	0.2	51,927
Microalgae (medium oil content)	50	97,800	0.1	86,515
Microalgae (high oil content)	70	136,900	0.1	121,104

Table 10. Comparison of microalgae to other biodiesel crops[7]

Moreover, algae are so called “bioremediation agents”. Meaning, they are able to absorb great volume of CO_2, which makes them very beneficial as far as fight with excessive emission of CO_2 is concerned. In addition, they are also able to get rid of the dangerous nutrients and toxins from wastewater and sewage by growing in the polluted water and using the contaminants as nutrients. The simple scheme fig. demonstrates the cycle of microalgae cultivation. We may observe the continuous process being purely sustainable [1][7].

Figure 12. Biodiesel development cycle [1]

Sustainability

The importance of sustainability in our project

According to Oxford Dictionaries sustainability is “conserving an ecological balance by avoiding depletion of natural resources”. [8] The other sources, for instance, World Commission on Environment and Development claims that sustainability is to meet the needs of the present without compromising the ability of future generations to meet their own needs[9]. Generally speaking, the common understanding of sustainable engineering and development, which cannot be rigid, is facing humans needs, yet not deteriorating the Earth at the same time. Essentially, our project serves this mission. Not only does it use renewable source of energy to run the system and recyclable materials, but also harvests microalgae to produce bio fuel.

Main aspects of sustainable production

Sustainability consists of three main pillars: environmental, social and economical one. In these broad fields one may point out several requirements that must be met so as to create a real sustainable development. With the purpose of describing those areas in terms of our project, we need to distinguish two possible ways of consideration. First, sustainability as far as the algae dryer prototype, which is main product of our project, is concerned. And the other, as far as replicated on the large scale product is concerned. Taking into account the fact that the real sustainable conditions of such product is currently unavailable, our considerations would only be probabilities and estimations.

Let us begin with the environmental criteria of the sustainable development of our product. In order to introduce it into the production of the design, it is advisable to follow and take advantage of several approaches and tools. One of these is the concept that sustainable development has to be able to renew the resources at the same or greater rate than the pace at which they are consumed [10]. This concern brings our attention to the renewable sources of energy, which usage would be described later on. Furthermore, life cycle analysis make it possible to obtain a good overview of the product impact on environment. Such assessment can also be found in the proceeding subchapters of this report. Another important issue is the fact that sustainable engineering ought to be competitive to the non-sustainable one. Meaning, the outcome of the sustainable process and needs of the customer of the product must be reached at the same satisfaction level as in the conventional approach to achieve success in the long run. The last, but equally important factor is eco – efficiency orientation. Aiming at production of goods in sustainable manner, one needs to stick to eco – efficiency assumptions, which are described in the next part of this section.

Coming to economical issues, people not only need to be aware of the invested amount of money, but also the cost of running the device. Taking a look at our prototype, we try to buy as less as possible. Most of the accessories needed are taken from the university. Taking into account running cost, the amount is low again. That is due to the fact that device is run by the solar energy, hence the solar algae dryer is completely autonomous as far as using other, to be paid, sources of energy are concerned. Taking mass production into consideration, it is equally important to buy necessary materials at local suppliers, hence limiting the time and cost of transportation. Thinking of our design even broader, we may be a contribution to investigation over alternative sources of fuel. Such field of market is at its peak nowadays and may be very beneficial. If the product gets accepted by Universities, we may even consider sales network.

The last part is the social concerns, which involve not only growing issue of being ecologically friendly, but also getting involved in research over alternative sources of energy. The social factor also stands for securing the future. By being a part of such venture, we make ourselves and others willful of ecology protection and aware of potential threats to the future of our planet. What we are also doing is rising the current generations with the environment consciousness in their minds.

All of the presented sectors are interrelated and cannot be executed separately. It is important to take care of all the aspects in order to achieve good sustainability practice.

Eco – efficiency

The eco – efficiency is basically increasing the production of goods with reduction of the resources, pollution and waste input. According to World Business Council for Sustainable Development being eco-efficient is wise as far as business issues are concerned. One may conclude that attaining eco – efficient attitude is allegedly a tool companies could follow in order to run business strategy towards sustainability. As claimed in: "Eco efficiency. Creating more value with less impact" by World Business Council for Sustainable Development [11], eco – efficiency can be considered in three broad perspectives. We would try to present a brief overview of our design with regard to those general objectives.

Reducing the consumption of resources

This first aspect include decreasing utilization of materials, water, land and energy. As far as these criteria are concerned our aim is to recover the water from algae drying rather than using more of it. Taking into account usage of materials, land and energy we would like to present two perspectives, first considering building the prototype, the other building our product on a larger scale.[11]

Land

Let us first start with usage of land. The area occupied by the dryer prototype equals to around 0,5 m2. Such area is devoted to dry 5l solution of microalgae. If we assume that replicated product would be able to dry 50l of solution, we may estimate that the total area needed for solar algae dryer would be equal to 5 m2. Those numbers on the other hand does not mean one needs to devote the land to install the device. Our aim is to make the design portable, so that no land needs to belong to the algae dryer both as for prototype and large scale product.

Energy

Coming to the energy issue, our project was to create solar algae dryer. Due to that all the appliances that need energy to operate (fans, ultrasound water level controller, temperature sensor, diodes, micro controller and step motor) are run by the solar power caught by solar panel placed on top of the tank. The placement of the solar panel is shown in the Figure 13.

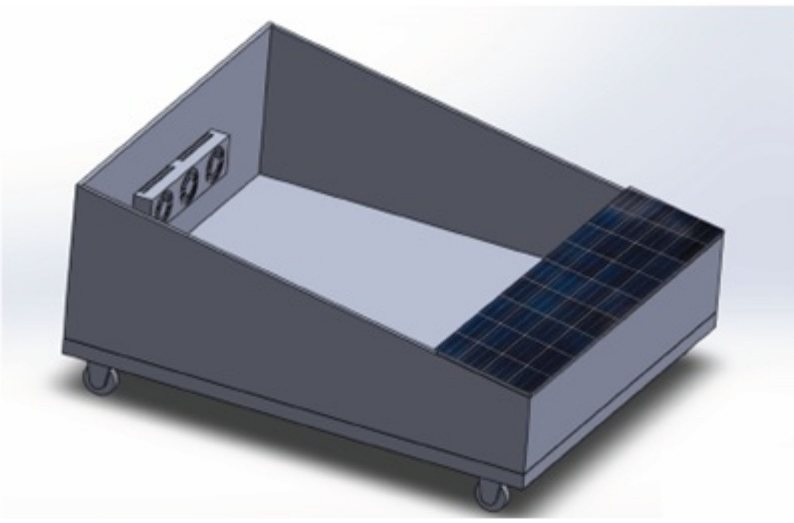

Figure 13. Placement of solar panel

15 W solar panel used in the prototype would power the 12 V battery, which eventually runs the whole system. Considering the replicated product, we believe all the already mentioned appliances would require more power, hence the bigger solar

panel. Then the question arises, is it more sustainable to run the device on the solar power or simply connecting it to the casual electricity grid. In order to answer this question many aspects must be considered. Firstly, we would have to consider production of the solar panel itself. According to the survey run by Sherrell R. Greene, Vice President for Consulting Services at EnergX posted at his blog [12], we may notice that CO2 emission from solar electricity generation is not significantly lower than natural gas, coal or oil resources. The results of the survey are presented in the graph below (fig. 14).

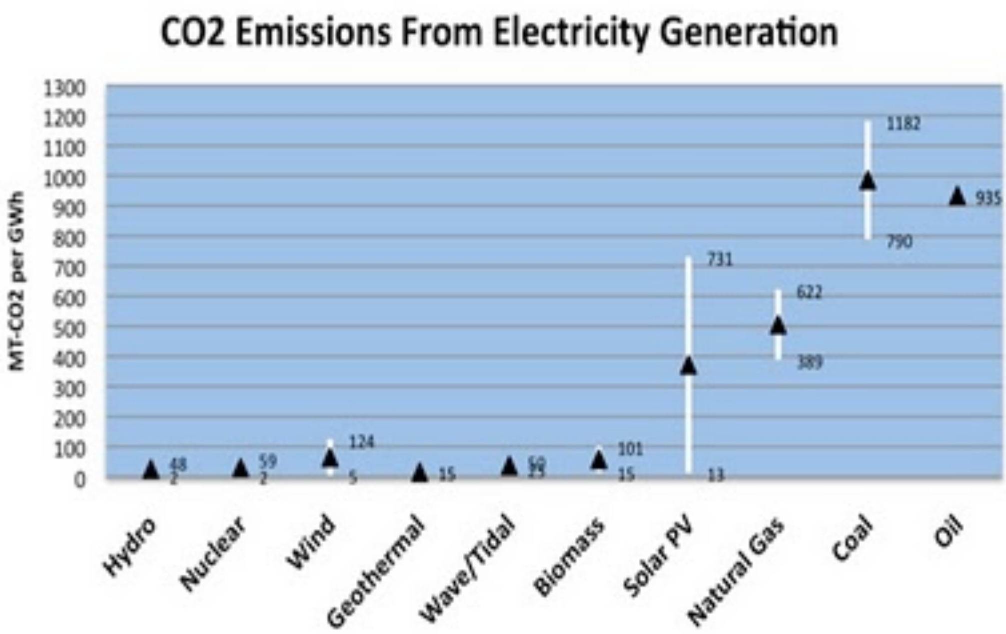

Figure 14. Graph presenting emission of CO2 from electricity [12]

These results would force us to check what kind of electricity generation the potential customer uses. Taking into account the fact that the potential customer would be universities in Europe running test on algae oil production, we may assume that it is possible that they would use renewable sources of energy to create electricity. If not, it is also possible that energy consumed by the device would not significantly affect the power consumption of given university lab. The other concern is time consumed during distilling process. Usage of solar power lets us dry the algae solution only during summer and sunny days. On the other hand, device connected to the grid would be running constantly, whole year long and 24 hours a day. Assuming such performance, we would have to check the energy consumption of the replicated product. The customer would have to decide if it severely affects the electricity costs. What is more, the mentioned time of exploitation of the solar algae dryer would also be dependent on the client. It would be advisable to check whether the operation mode of the equipment could be seasonal. The other important factor is the principle of operation. Our solar distiller is aimed to evaporate water from algae solution. In order to do that we use direct solar radiation. Solar energy is used only to support electrical appliances. Hence, the equipment must be placed outside. So as to connect the device to the grid, one may have to use extension rods. That would require investigation over such parts production and taking care of safety issues. The last concern would be battery usage. The type of battery used in our project is discussed in the following part of this subchapter. Yet, when considering replicated product, the battery may become quite an important issue. Obviously, if connecting the equipment to the casual current unit, the battery will not be needed. However, if solar panel would still be used, one may have to be aware of the adequate battery installation. Allegedly, nowadays, the most ecologically friendly power storage solution is Li – ion battery. In order to decide whether to install such battery or not, one may have to think of the recharging process, of recyclability and safety issues concerning exploitation of Li-ion battery. Such batteries are already broadly used in e-cars, so ones run by electricity. Concluding this discussion, there is no straightforward answer to the given problem. The first step that would have to be taken is conducting the thorough research on customer (European universities running test on algae oil extraction) needs. Moreover, it would be necessary to run several test on the large scale product using solar panel and ordinary electricity grid to get the answer in numbers. It would be also helpful to compare in numbers the CO_2 emission from electricity generation of solar power, the type of electricity power that the customer uses and while producing extension rods equipment.

While talking about energy, one cannot omit the battery used in our device. As far as prototype is concerned, the 12 V sealed lead acid battery is installed (shown in fig. 15).

Figure 15. The battery used in the project

The reason of choosing this one was extremely simple. The battery was offered by the school. Taking into account the sustainability issues, the lead acid batteries can be fully recycled. Meaning, various parts of them are recyclable. For instance, the sulfuric acid is purified and recycled. In addition, the lead plates can be melted, refined, and then recycled. The plastic case is shredded and recycled. [13] According to Battery University [14] over 50% of the lead acid battery supply comes from recycled products. Moreover, lead acid batteries serves for off-grid systems, hence they are important components of the systems based on renewable sources of energy. On the other hand, the materials used in batteries structure are lead and sulphuric acid, which are hazardous substances and require extremely safe handling [15]. There is no harm for the environment when using this kind of batteries as long as we wisely dispose of them.

When considering large scale product probably the best option would be to choose already mentioned Li – ion power storage. They are less environmentally harmful, as they do not contain such hazardous elements as lead acid do. Moreover, they have high energy density, so the measure of how much energy the battery can hold in comparison to given lead acid, which can be seen on the chart below (fig. 16).

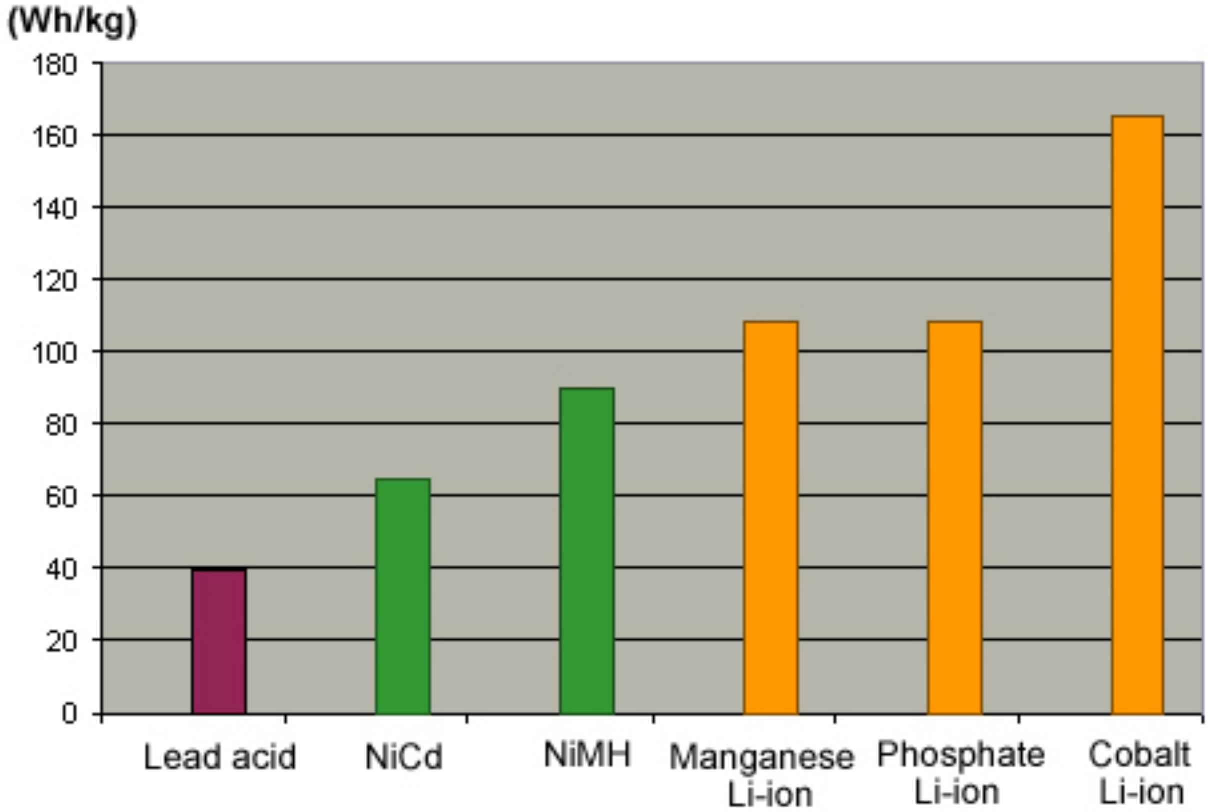

Figure 16. Energy density performance of batteries [14]

In additon, the technology of Li – ion recycling is now developing. The picture below (fig. 17) shows simplified recycling process of such batteries using their own Umicore technology.

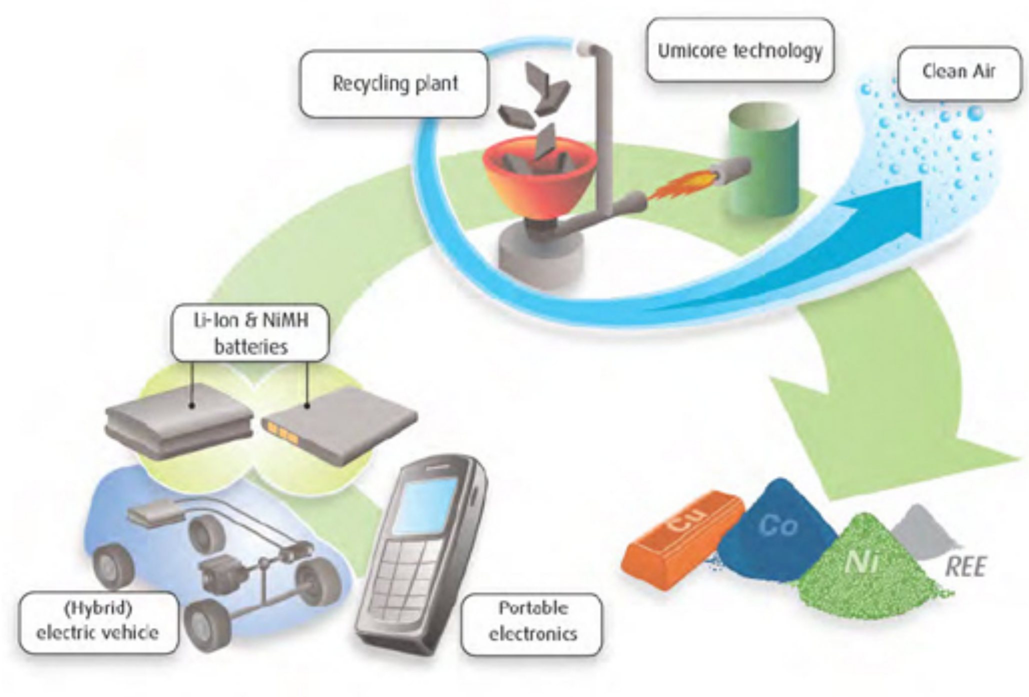

Figure 17. Recycling of Li - ion batteries [16]

Allegedly, the process does not include production of any kind of poisonous waste. One of the obvious disadvantages of Li – ion batteries on the other hand, is the high production costs, which contributes to high price.

The second aspect of "Reducing the consumption of resources" is taking care of recyclability, durability of the product and assurance of closed material loops. Our product durability would be dependent on the proper usage. The materials used in production are claimed to be durable. The recyclability criteria may refer to solar panel, plexiglass, from which the tank is made and battery. Recycling of battery was already described in the previous paragraph. As far as solar panel recycling is concerned, 90% of solar panel is made of glass, which is completely recyclable. Coming to the plexiglass, the material obtained from recycling process can be reused in 100 %. What is more, a lot of materials that we use for building our prototype are taken from the university, hence we make sure we do not buy unnecessary parts. Further on, we hope one may take advantage of the part of our design. [11]

Reducing the impact on nature

This feature of eco – efficiency involves reduction of any kind of polluting emissions or water discharges. It also includes waste disposal and getting rid of toxic substances as well as maximizing involvement of renewable resources usage. The main concept of our project involve usage of solar energy, so the renewable source of energy. The only "waste" or rather side effect of algae harvesting in our distiller is evaporated and then condensed water. Even though water recovery is not integrated into our device, there are already existing methods allowing this process that could be easily applied in the future. [11]

Increasing product or service value

According to World Business Council for Sustainable Development this concept means adapting to the real customer needs and incorporating additional features to the product. Thanks to that those needs may be fulfilled within one product, spending fewer materials and resources. We would like to work on incorporating water recovery system into our product produced on the large scale. [11]

Life – cycle analysis

Figure 18. The process of life – cycle [17]

Life – cycle analysis or assessment, which scheme is presented in the Figure 18 above, is extremely helpful tool while trying to measure the real impact of our product on environment. Such survey consists of several steps. The first one is the analysis of the raw material extraction. Then, one may focus his attention on processing of the materials. The next stage of life – cycle consideration is manufacturing of needed parts. Afterwards, we come to assembling process. The two steps left is usage of the product and its end of life. Taking into account the device we are creating, our position is at the assembly process. We are buying already existing parts and elements to produce solar algae dryer. Materials needed to produce our distiller are as following: Poly(methyl methacrylate) also known as plexiglass, mirror serving as reflector, devices: ultrasound water level controller, water proof temperature level sensor, fans, solar panel, 12 V lead acid battery, micro controller and step motor controlling blinds. The remainings are parts needed to assemble the whole structure like: glue, pipes, valves etc. As far as life – cycle analysis is concerned we would mainly focus on the stages on from assembly process. Yet, we try to show the previous steps for plexiglass. Let us start with it. In order to produce PMMA, so plexiglass, which can be seen in the picture below (fig. 19).

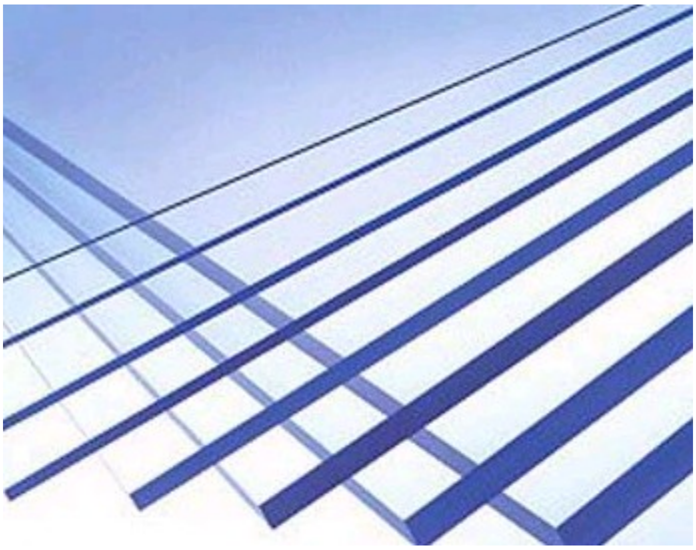

Figure 19. Plexiglass [18]

Raw material for plexiglass creation is polymer of methyl methacrylate that can be developed in laboratory and does not need the presence of any endangered natural resources. Moreover, part of its production right now is created from recycled plexiglass. The processing of the material requires its heating up, but no harmful air emissions were noted during this process. Afterwards, the material can be either molded or extruded, which again do not cause pollution. Coming to assembly process, PMMA must be first cut. This proceeding is usually done by usage of laser. Unfortunately, some amount of CO2 is relieved during this process. The glue used to join the parts together is Cyanoacrylate, the substance that may irritate sensitive membranes of human body. Hence, the usage of it must be controlled and performed in well ventilated areas. Usage of the product makes no environmental harm. In the end of its life, plexiglass may be and is commonly recycled [19] [20].

When examining the whole device, it is wise to consider stages starting from assembly process. This is the step, where our project get involved into the life – cycle process of the used materials. Assembling of solar algae dryer requires physical input and using already mentioned "superglue". Our aim would be to limit the transportation involvement as much as possible. In order to do that we would like to buy plexiglass and mirrors in a large amounts at the local suppliers store and thanks to that reduce transportation frequency and cost. What is more, our plan is to be able to buy all the needed electrical appliances at one producer, which serves the same goal. Exploitation of the product may have different ecological impact depending on the choice of either using solar panel to run the device or connecting it to the grid as already described in the previous section of this chapter. The only waste present at the utilization of the distiller would be the water from microalgae solution. End of the product life may be caused by two possible situations. The first possibility is that the equipment is no longer needed. In such situation, almost 100% of the parts may be either recycled (plexiglass, battery, solar panel, fans) or reused (mirrors, step motor and blinds, valves, pipes, controllers, micro controller or diodes). The other option is reaching battery's end of lifespan. If so, the most sustainable way would be to recycle the battery and get the new one to reuse the equipment again.

Conclusions

To sum up, sustainability issues gathers numerous questions to be answered and a great deal of effort. Yet, it is gaining more and more popularity. In solar algae dryer, the whole great idea behind it makes it already sustainable. Playing role in algae harvesting contributes to research and obtaining bio - alternatives to transport fuels. It is important to cultivate algae as they have number of properties advantageous in saving our planet. In order to call our project sustainable we would have to fulfill the three joint pillars of sustainability. That means we would have to make sure we are able to meet environmental requirements, social and economical ones. The possible mass production of our device would have to attain eco – efficient attitude towards production and keep in mind life – cycle analysis of the replicated product. We conclude that it is extremely important to use recyclable or reusable materials and renewable sources of energy. It is also worth attention to limit the waste production and its disposal. We believe, matter of being ecologically friendly is a major issue nowadays.

Ethical and Deontological Concerns

Introduction (Leghal thinking)

We are with many in this world, with all a different background. This means we have different religion, different moral and ethical standards, different rules of courtesy and etiquette and different legal norms. Our product, the solar algae dryer, will be conform according to the laws listed above.

Sources of the Law: The sources of law are modes of formation and revelation of legal rules in a particular jurisdiction. There are two kinds of sources. The first sources are the direct ones. They create legal norms. The indirect sources are the second kind of source. They do not create but they contribute to the formation of legal norms.

- Law

Law can refer to multiple things. Law in the wide sense refers to all acts that establish legal rules. The law in the strict sense refers to diplomas issued by the Portuguese Parliament.

There are different kinds of laws and there is a hierarchy between them. At the top you have the Constitutional Law. It is followed by Law and Decree-Law, Decrees and the last one is Ordinances and Normative Dispatches. (Figure 1)

- Custom

It consists of a constant social practice with a sense of obligation.

- Doctrine

These are studies, review and opinions from juriconsults on the interpretation, integration and application of law.

- Jurisprudence

This implies court decisions.

Figure 20. Law hierarchy

Ethics and deontology in engineering

Engineering codes of ethics

As future engineers we have several duties. Our first duty is to the **community**. By making a solar dryer for micro algae, we are helping the research in developing bio diesel. This is how we fulfill our duty to defend the environment. The safety of the users is ensured because we don't use mechanical processes. There is no cutting, punching, sawing of anything dangerous involved. So the risk that the staff performers or users are getting injured is very low. We studied a lot of different separating techniques and compared their advantages with each other's disadvantages. For every objective we looked for the best possible solution, considering the economy and quality. By searching for the best technical solution we fulfilled the duty of competence and suitability.

The second duty we have to fulfill is the one to the **employer or client**. We contribute to the economic objective by making our dryer very energy efficient. Even though it is not the fastest solution, it is the most green and efficient solution. Because this is such a green solution we promote the improvement of product quality. The performance of the dryer depends on the sun, so we can only ensure its operation when the sun shines. But when there is enough sunlight, the dryer will always work. An other aspect in our duty to the client is charging only the services we actually rendered, considering its fair value. Before we started to create the dryer the client gave us clear requirements concerning for example its capacity, speed,… There was also a maximum budget given. The maximum budget will not be spent; the client only pays the components we buy.

The third duty we have to fulfill is the duty to the **profession**. We fulfill this duty by planning our project properly and by handing it in on time. While we are doing this we are also acquiring knowledge about new techniques and how to absorb them into new ideas. We also fulfill this duty by maintaining a good communication between the client and our team. We oppose unfair competition by not copying existing work, by not using patented technology and not use software where we have not paid for. We have to protect the idea that we develop for our client from other companies. An element of the duty to the profession is the duty of sobriety advertising. But since we don't advertise for our product, this duty is not applicable. Since this is a school project it is up to us to prove that the project lies within our competencies and that we are able to deliver within the time constraints.

The fourth duty is the duty to our **colleagues**. We discussed group attitude rules and what will happen when there is a disagreement between group members. We talked about the sense of leadership, specific roles in our group, the difference between outgoing and ingoing persons, making decisions anonymous or unanimous, how to deal with your feelings in our group and many more things. In the end we choose 3 group attitude rules. They are: "One achieves the most of all group members' function can be discussed and criticized openly." "Everybody should be given an opportunity to speak up and express his/hers views until he/she feels he/she is understood even if it takes a long time." "It's better to accept compromises than to discuss disagreements." So we know we can speak up and criticize each other without taking in personal. Of course the criticizing should happen within certain boundaries. We also respect each other's intellectual property. We understand we all have a duty to cooperate and give assistance when one of the team members requests it.

Professional ethics model

Minimalist Model: The engineer is only concerned with meeting standards and requirements of the profession and any other laws or codes that apply. The model looks for a fault when problems or accidents arise.

Due-Care Model: The engineer had to take reasonable precautions or care in the practice of his profession. The goal of the model is to prevent harm.

Good Works Model: The engineer goes beyond the basics of what is required by standards and codes. They try to improve product safety, social health and social well being.

So the feeling of responsibility of the engineer is the greatest in the last model and the smallest in the first model.

We are following the Due-Care model because safety is not our main goal but it is a goal. We think it doesn't has go be our main goal because our project doesn't include dangerous techniques like cutting or punching. But we do understand the importance of safety.

Ethical and deontological problems

We are dealing with an ethical and deontological problem when all the possible solutions might have negative ethical consequences. Luckily we have not been confronted with those kinds of problems during the development of our dryer.

IEEE code of ethics

1. "*To accept responsibility in making decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment.*"

Everyone has the obligation to not endanger others, but we have a special responsibility because are creating the products and systems that can harm others. We as engineer students are well aware of this responsibility. While creating our algae dryer we have always considered safety. We are also aware of the obligation to speak up when we see something that might be harmful, even if it is not our project or responsibility.

2. "*To avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist.*"

We are able to discuss important matters in our team without creating a conflict, because conflicts or personal disagreements should always be avoided. We made agreements on how to behave in our group and what we should do in case of a conflict.

3. "*To be honest and realistic in stating claims or estimates based on available data.*"

We have the basic obligation of always being honest with our client and with our team members. We cannot only publish favorable results or don't to tests because we know the outcome might not be in our advantage. This honesty is not only good for our project, but not being honest might have serious consequences.

4. "*To reject bribery in all its forms.*"

We are rejecting bribery in all its forms.

5. "*To improve the understanding of technology, its appropriate application and potential consequences.*"

During this project we had to do a lot of research on algae, separating techniques, solar power, distilling and many more topics. This had broadened our knowledge a lot and maybe will make us better engineers in the future. But as engineers we will have the duty to inform the public about new technologies and its consequences.

6. "*To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations.*"

We should only accept jobs that we can execute confidently. But you should not refuse a project where you will do research in new technologies and you should not only do what you are comfortable doing. For us, students, it is different because we don't have a lot of experience and being a student is about getting more confident and improving our competence.

7. "*To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others.*"

This code is about the relationship between engineers. It is about understanding that honest critique must be given, and that is not intended as a personal remark. But also that proper credit must be given to others too. We talked about this as a team and understand that this is a necessary part of teamwork.

8. "*To treat fairly all persons regardless of such factors as race, religion, gender, disability, age or national origin.*"

Not only engineers but everyone has the duty to treat all persons equal.

9. "*To avoid injuring others, their property, reputation, or employment by false or malicious action.*"

This also means we cannot spread confidential information such as trade secrets and intellectual property. But we didn't receive such information.

10. "*To assist colleagues and co-workers in their professional development and to support them in following this code of ethics.*"

We have the obligation to other professions to help them continue, grow and develop. Since we all have a different academic background we will definitely broaden each other's knowledge.

Liability

Legal liability

Our solar dryer is meeting with following directives:

- Directive 2006/42/EC on machinery

- Electrical Safety: Low Level Voltage Directive
- Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive
- Mandatory adoption and use of the International System of Units

Crime law liability

Since our product is not likely to harm someone this chapter is not applicable.

Professional liability

See 2.1 engineering codes of ethics: the duty to the **profession**.

Intellectual property law

The technology we use is not patented, we designed the system and the tank our self.

[25]

Project Development

In the Project development part we describe the general parts of our project, and tries to give a hint of how it works. Here is presented the materials that we use to build our project, the architecture, the different modules of our project, the functionalities and what tests we need to do to find out if we succeeded.

Materials

When we started to develop our project one of the first things that we needed to do, after finding out which method we are using, was to assembly the material list. We had to do a lot of research to find out which parts we had to implement in our project. Below in table 11 is presented the complete material list for our project. The budget that we had for our project was 500 € but we managed to keep the cost much lower.

Quantity	Material	Description	Company	Price
1	Plexi glass (118x126cm) 6mm thickness	Side top and bottom of tank	Plexicril	55.20 €/m2
1	Ultra sound level controller	For stopping process	From school	-
1	Waterproof temperature sensor DS18B20	To verify that the temperature remains < 50°C	Inmotion.pt	8.95 €
1	Plastic tank	For the dry algaes	From Nidia	-
1	Plastic tank	For the evaporated water	From Nidia	-
1	Connecting pipe ϕ13 mm	Between tank and algae/water tank	From Nidia	-
1	Mirror (20×50) cm2	Reflector to increase the efficiency	Vidraria Fonseca	5.95 €
1	Mirror (11.7×50) cm2	Reflector to increase the efficiency	Vidraria Fonseca	5.95 €
3	Fan 12 V DC	To circulate the air and increase the efficiency	farnell.pt	25 €
1	Solar panel 15 W (29.6 x 50.7 cm)	To recharge the battery	farnell.pt	105.80 €
3	Rubber seals	Matching dimensions of valves	Leroy Merlin	-
1	Black paint	For the bottom of the tank	From school	-
1	Red LED-diode	To display the status	From school	-
1	Green LED-diode	To display the status	From school	-
1	Battery 12 V	For solar panel	From school	-
1	Stand	to assemble the tank on	From school	-
1	Glue	To assemble the container	Plexicril	5.50 €/200ml
1	Micro controller Arduino Uno	For the control process	Inmotion.pt	20.00 €
1	Step motor	To control the blinds	From school	-
1	Blinds (60 x 130 cm2	Heat control	Leroy Merlin	4.99 €
3	Valve 13 mm	To pour in and out algae solution	Leroy Merlin	7.25 €
4	Wheels	For the stand	Local	30 €

Table 11. Material list

Architecture

This chapter presents a rough overwiev of the different parts of the project. These are the main parts of the project and it shows how they are connected with each other.

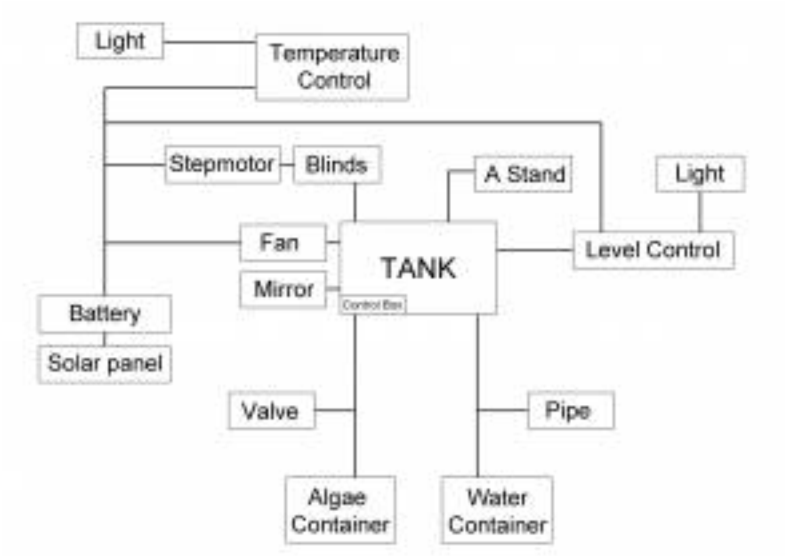

Figure 21. Boxworld

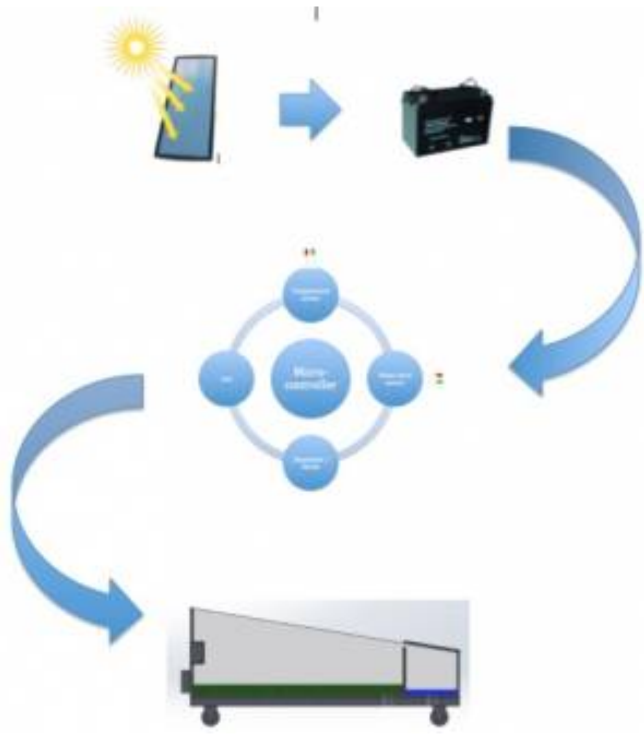

Figure 22. Sketch of the system

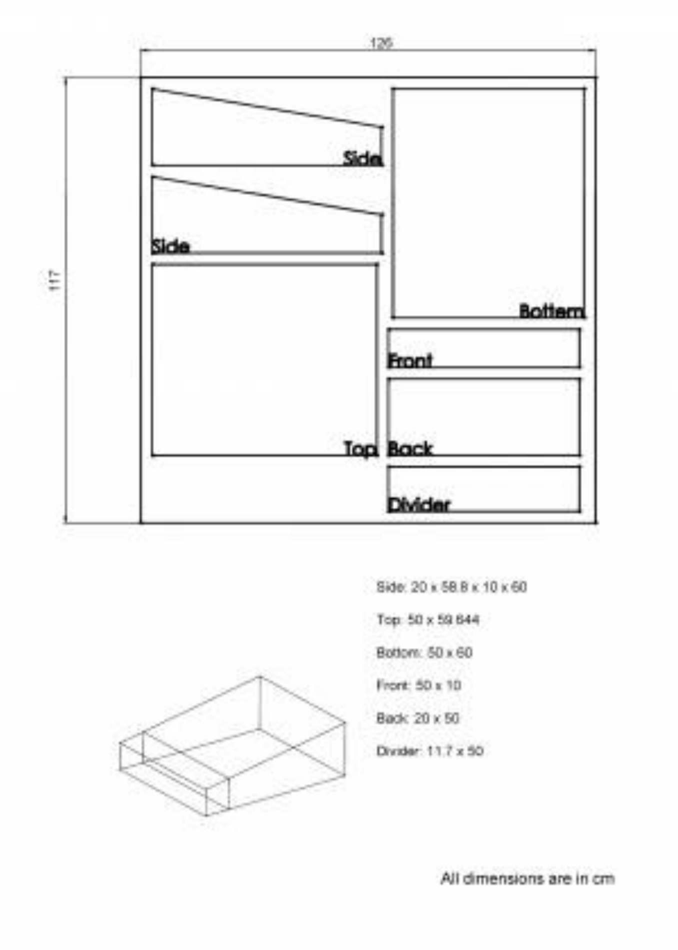

Figure 23. Dimensions and shapes of the tank plates

In the figure 23. you can see that the tank is the ”main” part of our project, it is where we have our solution and it is where the process is taking place. We developed our project starting with the tank. After the tank we thought about what parts we have to use for controlling the process, these are the level controller and the temperature controller. Then we have the Control box (micro-controller) which receive information from the controllers in order to control the cooling down and stopping process, which are operated by the stepmotor and the blinds. We also have the solar panel to recharge the battery and the battery distribute electricity for all the components. Another important part of our product is the fans inside that help to speed up the evaporation process. We have two different containers, one for the algae solution and one for the evaporized water. This means that we collect all the water and don’t let any of it go to waste.

Modules

The solar algae dryer is based on the plexi glass tank and it consists different kinds of mechanical and electronical parts and modules. In this chapter we describe these different modules and how they work, independently and as a part of the system.

Our system consists of three different modules. The drying process block, the controlling block and the power supply block.

The drying process takes part in the plexi glass tank. This is where we put our solution, and the evaporation process takes place. We designed and assembled the tank by our own and it is made out of plexi because of the need to be transparent, waterproof, easy to assemble, environmental friendly and cheap. During the process the evaporized water will rise to the roof of the tank and slide down to the water tank, in this way we will recover all of the water that we use in our process. The concentrated algae solution will remain in the major tank and be transported to an algae container when the process is ready.

The second block is the controlling block, this module helps us control the process. Here we have the micro-controller as our major part of the controlling system. For the micro controller we are using a Arduino Uno ATmega328. All parts in the controlling block are connected to the micro-controller and the micro-controller is communicating and controlling all the other parts.

First we have a waterproof temperature sensor model DS18B20 for measuring the temperature of the water-algae solution. This is needed due to the fact that the water temperature can't rise over 50°C because it would harm the algae. The temperature controller is connected to our micro-controller and gives a signal if the temperature rises over 50°C.

For our stopping process we are using an Ultrasonic Range Finder model Devantech SRF04. The sensor emit high frequency acoustic waves that are reflected back to and detected by the emitting transducer. This is needed for the system to know when the process is ready and the algae are dry enough. When the water level is low enough the Ultra sound sensor will give a signal to the micro-controller and tell it to shut down the system.

The shutting down system is controlled by a step-motor connected to blinds. When the temperature rises too high or the process is ready the micro-controller will tell the step-motor to close the blinds in order to lower the temperature inside the tank.

Another important part of the controlling process is the fan. It is used for speeding up the drying process. The fan will be connected to the micro-controller and it will run constantly until the end of the process when it will be shut down by the micro-controller.

Tests

For our project we have to implement some tests to ensure that the product can fulfill our clients needs. For our drying process we put a 5l solution of algae and water in to the tank, and in the end we want a 0,5l concentrated solution. During this process we have to make sure that the temperature of the water doesn't raise to over 50°C. To ensure that it works correctly and the temperature doesn't go over 50°C we have to test it and put water into the tank with a temperature over 50° degrees. In this case the termometer should give a signal to the micro-controller that it should adjust the blinds and cool down the process.

The other test that we have to perform on our project is in the end of the drying process. When the algaes are dry enough they should contain less than 10 % of water. This means that in the end of the process we would have a 0.5 l solution left of the 5.0 l. When the process is ready, the solution is 0,5l, the ultra sound level controller should give a signal to the micro-controller to stop the process – close the blinds. These are the two main tests that our product have to fulfill.

Best product performance

In order to check the possible operation efficiency of our device, we gathered the data concerning predicted weather and atmospheric conditions for the ongoing and next year. The following pictures (fig. 24, 25) present average heat index in degrees Celsius and solar radiation in watts. The next is the Climate graph for Portugal including average temperature, relative humidity and wet days.

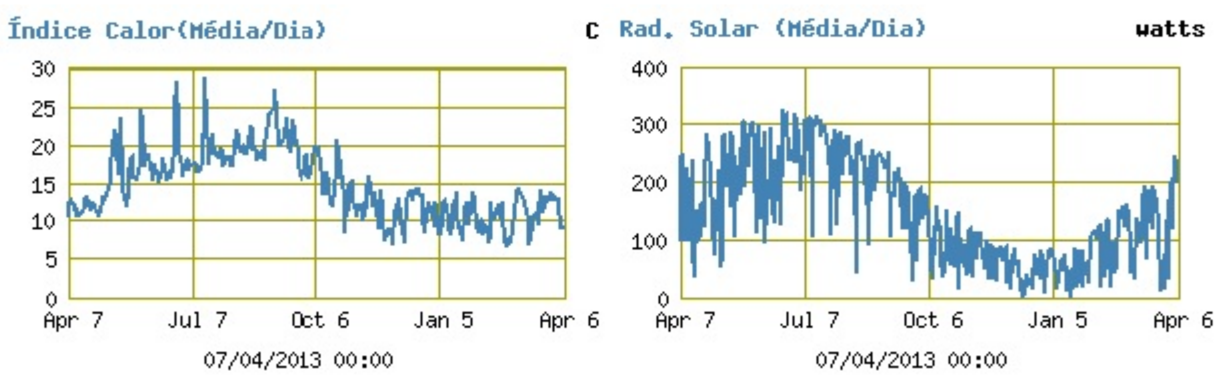

Figure 24. Solar radiation and Heat index diagrams [21]

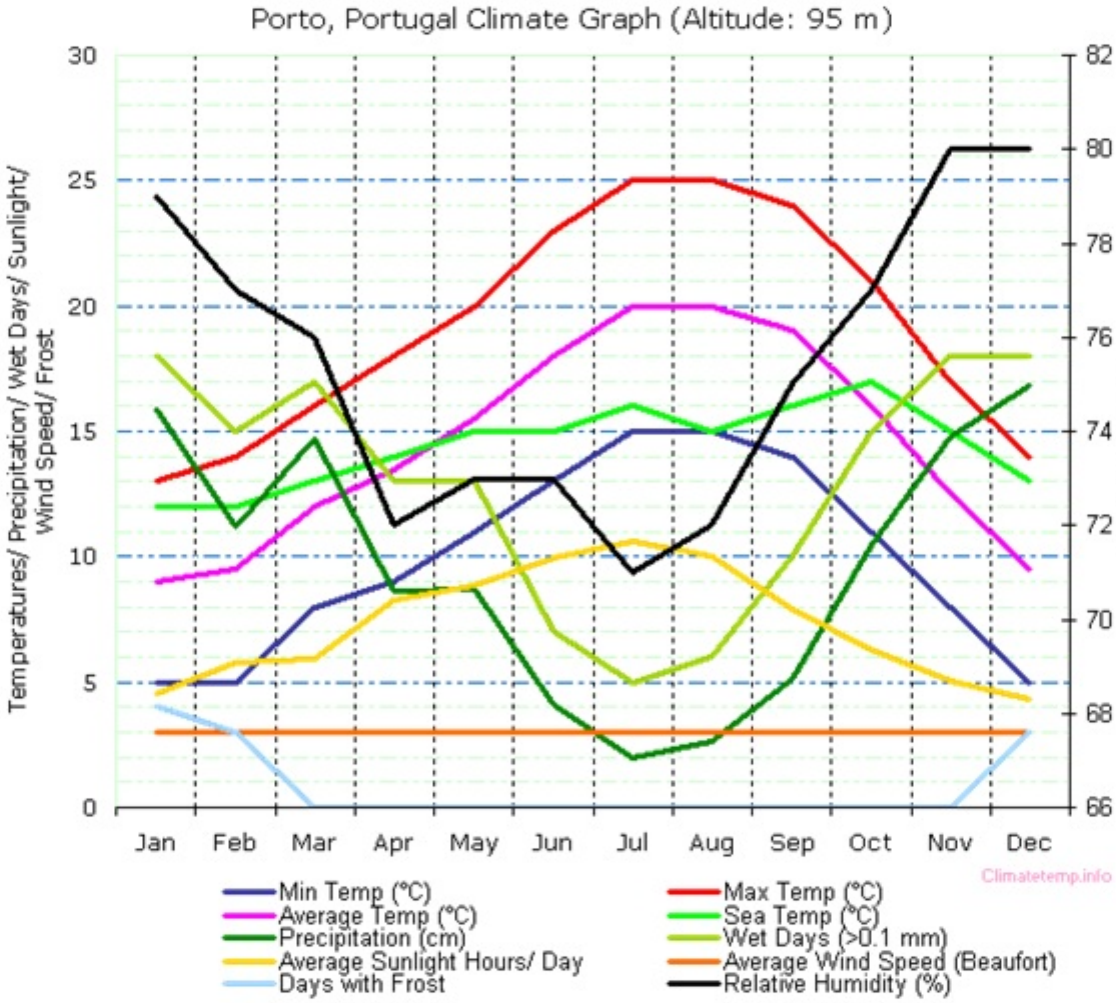

Figure 25. Climate graph for Porto [22]

The presented diagrams and graph make it possible to expect the best distiller performance from April till October. High solar radiation, followed by extensive heat index and significantly higher average temperatures are noted in the mentioned months. Those factors speed up evaporation process. What is more, relative humidity is also at its lowest ratings, which does not contribute to slowing down the whole process.

Future Developments

First of all we are going to do the electronic tests. Afterwards we should finally be able to update our material research.

To start building our prototype early, we are going to buy most of the materials from one supplier. After getting every material, we will start to build the prototype. Through tests in each step of development, we should be able to finish our prototype on time. At the moment our product is not suitable for an extension. Many of the components, which are already used, full fill the given tasks and adjust to client needs. Consequently some parts are used, because they are ideal for prototyping. For the future we should focus the research on improving our system for different applications. For instance getting more information of requirements of future clients to modify our product. Finally the product will consist of a main solution with specific adaptions for different customer expectations.

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Appendix

Temperature sensor data sheet
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Ultra sound level sensor data sheet
ftp://entc.tamu.edu/ENTC369/Reference%20Material/Hardware%20Devices/Sonar%20Range%20Finder%20R93-SRF04p.pdf

2D technical drawing of the tank tank.pdf

List of figures

List of Tables