FINAL REPORT

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European Project Semester at ISEP

Level Monitoring System for a Waste Oil Storage Tank

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REPORT

ABSTRACT

Nowadays recycling companies who deal with waste oil have huge responsibility towards humanity. Competition for the best position is tough and it is necessary to optimize their services and production. By avoiding checking containers so often and reduce the need for resources the companies can create good conditions to be leaders in the market.

This report presents primary ideas to develop a system that will enable measuring the level of waste oil deposited in the containers by using electronic devices that check them constantly. To accomplish this, we will start by comparing different types of sensors, control systems, web interfaces and batteries.

The final goal was to build and program a level monitoring system for waste oil reservoirs.

GLOSSARY

Ultrasonic Distance Measuring Module HC-SR04

The Ultrasonic Module HC-Sr04 is used for measuring distance. The sensor sends a signal, which is reflected by the material. We use the time needed for the signal to come back to measure the distance.

Arduino Pro Mini

The Arduino Pro Mini is the main controller, it controls everything in our project, and basically it is the brain of our system. It is a board based on the ATmega168. It has 14 digital input/output pins (of which 6 can be used as PWM (Pulse Width Modulation) outputs), 6 analog inputs, an on-board resonator, a reset button, and holes for mounting pin headers.

Panasonic-LC-R0612P - battery, 6V, VRLA, 12AH

This is a lead-acid battery we choose to work with. It will be used to power up the measuring system.

WiFly Shield

The WiFly Shield is used for WiFi communication, to send data about the current status of the container to a web page. It connects to a WiFi hotspot in order to connect to the web page.

I. INTRODUCTION

The team consists of four people. All of them come from different countries. Olga Olejniczak comes from Poland and studies Biomedical Engineering at the Technical University in Łódź; Naeem Ahmad comes from Germany and studies Sales and Marketing Engineering at the University of Applied Science in Kiel; Mihkel Tasa comes from Estonia and studies Engineering Materials and Marketing at the Tallinn University of Applied Science, and Marcos Moura comes from Portugal and studies Electrical and Computer Engineering at the Instituto Superior de Engenharia do Porto. Each of the Erasmus students are quite different and have their own habits. But the team has the same final goal, which is to build and program a level monitoring system for wasted oil in containers. The students already had some basic information about sensors before they arrived at the European Project Semester.

Our project title is “Level Monitoring System for a Waste Oil Storage Tank”. The task is to develop a level monitoring system for a real world waste oil container. Our group has been very motivated to achieve this aim since the first meeting.

The report consists of nine main parts that are Abstract, Glossary, Introduction, State of the Art, Project Developments, Marketing Plan, Eco-efficiency Measures for Sustainability, Conclusions and Bibliography. In this section of project we would like to present an overall view of our work.

In this report we propose and describe the idea of solving the posed problem. For each of us it was a kind of practical possibility to find out a lot of new things and to learn how to cooperate within the team.

It has already been really difficult to reach an agreement about a final and appropriate solution. Of course we had to look for the cheapest devices as possible.

We have been looking for special and necessary equipments which, would make our ideas become real for the whole week. It was not so easy because of the high prices of the devices. At the beginning we had to check the inside look of the container. It was

necessary because in one of our tasks we had to decide where and how the components could be fixed and placed.

To distribute the conception we needed firstly a special kind of sensor. This is a device that responds to a physical stimulus (for example light, sound, pressure, magnetism, or a particular motion) and transmits a resulting impulse (as for measurement or operating a control). Secondly, we needed the monitoring system that would send automatically an alert message when the container would be full. The special box, which would keep all things together, was very important too. We had to consider the possibility of correctly programming this equipment.

1. WORK PLAN

Below we can see the **Gantt Chart** and **Task List** (Tab.1) which helped us in making the time-work organization.

1.1. GANTT CHART

1.2. TASK LIST

Tab.1. Task list

Task	Responsible
Sensors and control	Marcos
Container	Olga and Mihkel
Web interface	Naeem and Marcos
Marketing	Naeem and Mihkel
Sustainability	Mihkel, Marcos, Olga and Naeem
Design the schematics	Marcos
Programming the microcontrollers	Marcos
Design the website and interface	Marcos
Enclosure	Naeem and Mihkel
Leaflet and poster	Olga and Mihkel
Improve the sustainability report	Mihkel and Olga
Improve the marketing plan	Naeem and Mihkel
Video	Mihkel and Naeem
Article	Olga and Marcos
Manual assembly	Mihkel, Marcos, Olga and Naeem

Testing	Mihkel, Marcos, Olga and Naeem
Final presentation and final report	Mihkel, Marcos, Olga and Naeem

II. STATE OF THE ART

Level measurement sensors are used to measure fluid or solid level within a range. Generally, these sensors produce an analog output that directly correlates to the level in the vessel. To create a level management system, the output signal is linked to a micro-controller.

Micro-controllers can be used to process and handle more than one sensor at the same time and even provide a possibility to send information in many different ways. One way for doing this can be done over the Internet where an administrator/manager can remotely access to data about every sensor where the system is installed display an alarm in case the minimum/maximum level is reached [1].

1. Level/Height measuring sensors

Level sensors detect the level of substances, including liquids, granular materials, powders and solid objects. In some applications it's essential to measure the level in the containers (or other physical boundaries). The substance to be measured can be inside a container or can be in its natural form (e.g., a river or a lake). The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point.

There are many physical and application variables that affect the selection of the optimal level monitoring method for industrial and commercial processes. The selection criteria include the physical: phase (liquid, solid or slurry), temperature, pressure or vacuum, dielectric constant of medium, density (specific gravity) of medium, agitation (action), acoustical or electrical noise, vibration, mechanical shock, tank or bin size and shape. Also important are the application constraints: price, accuracy, appearance, response rate, ease of calibration or programming, physical

size, mounting of the instrument, monitoring and robustness to environmental constraints, etc.

1.1. Ultrasonic sensor

Ultrasonic sensors (Fig.1), also known as transceivers when they both send and receive work on a principle similar to radar or sonar [2]. 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.

Fig.1 Ultrasonic sensor

This technology can be used for measuring: wind speed and direction (anemometer), fullness of a tank and speed through air or water. To measure the amount of liquid in a tank, the sensor measures the distance to the surface of the fluid (Fig.2). Further applications include: humidifiers, sonar, medical ultrasonography, burglar alarms and non-destructive testing.

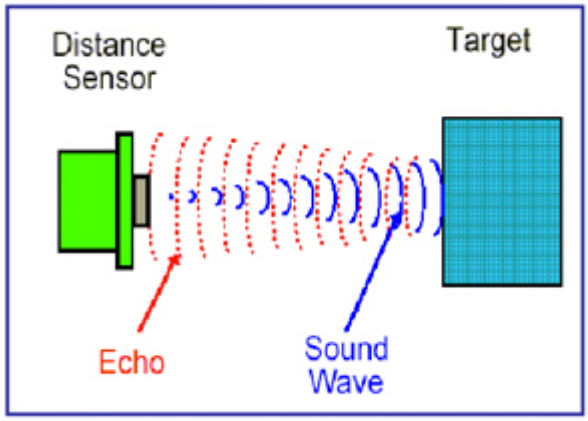

Fig.2 Ultrasonic system - Measurement

Systems typically use a transducer, which generates sound waves in the ultrasonic range, above 18,000 hertz, by turning electrical energy into sound, then upon receiving the echo turns the sound waves into electrical energy which can be measured and displayed.

The technology is limited by the shapes of surfaces and the density or consistency of the material. For example foam on the surface of a fluid in a tank could distort a reading. In table 2 there are a few examples of the ultrasonic sensors.

Tab.2. Examples of Ultrasonic Sensors

Ultrasonic Sensor	Range (m)	Input (V)	Output	Dimensions (mm)	Consumption (mA)	Price (€)
Maxbotix LV-EZ4	0.16 - 6.45 (2.5cm res.)	2.5 - 5.5	0V – 2.5V	20 x 21 x 11	2 - 3	19,8
Parallax PING)))	0.02 - 3	4.5 - 6	Positive TTL pulse	22 x 46 x 16	20	23
Module HC-SR04	0.02 - 4.5 (0.3cm res.)	5	Positive TTL pulse	15 x 43 x 20	2	6 - 8
Module SRF05	0.03 - 4	5	Positive TTL pulse	20 x 43 x 17	4 mA	18
Module SRF02	0.16 - 6	5	Standard I2C Bus or Serial Bus	24 x 20 x 17	4 mA	15

1.2. Infra-red

With the introduction of the GP2DXX (Fig.3) line of Sharp detectors, a new approach was developed that not only gives object detection at a longer range than the previous method, but also offers range information, in the case of the GP2D12, GP2D120, and GP2DY0A ('0A') detectors. These new ranges offer much better immunity to ambient lighting conditions because of the new method of ranging [3].

Fig.3 Infra-red sensor GP2Dxx

These new rangers all use triangulation and a small linear CCD array to compute the distance (Fig.4) and/or presence of objects in the field of view. The basic idea is this: a pulse of IR light is emitted by the emitter. This light travels out in the field of view and either hits an object or just keeps on going. In the case of no object, the light is never reflected and the reading shows no object. If the light reflects off an object, it

returns to the detector and creates a triangle between the point of reflection, the emitter, and the detector.

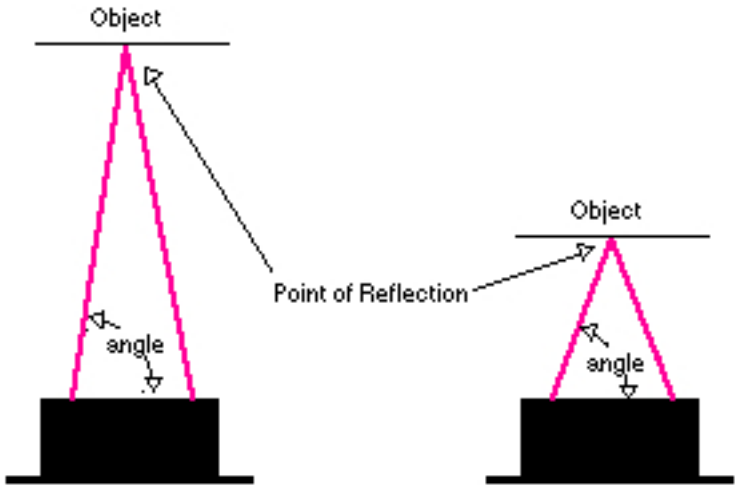

Fig.4 Different Angles with Different Distances [3]

The angles in this triangle vary based on the distance to the object. The receiver portion of these new detectors is actually a precision lens that transmits the reflected light onto various portions of the enclosed linear CCD array based on the angle of the triangle described above. The CCD array can then determine what angle the reflected light came back from and therefore, it can calculate the distance to the object.

This new method of ranging is almost immune to interference from ambient light and offers amazing indifference to the color of object being detected. Detecting a black wall in full sunlight is now possible.

2. Battery

A battery is an electrochemical cell or enclosed and protected material. The battery can be charged electrically to provide a static potential for power or released electrical charge when needed [4].

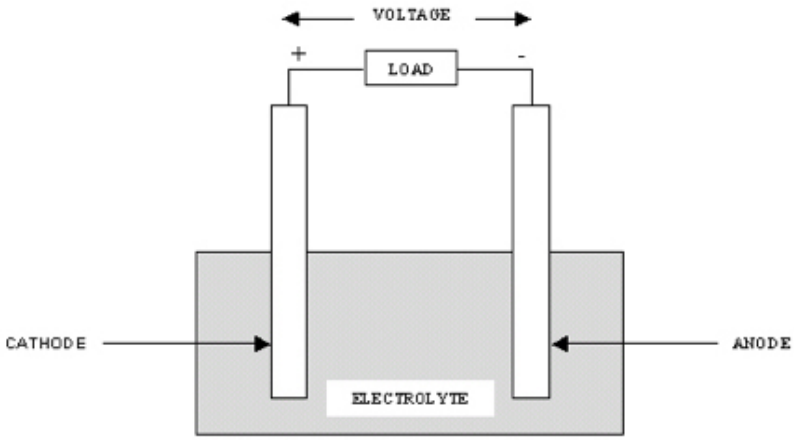

Fig.5 Basic elements of battery

The basic elements of the battery (Fig.5) are an anode, a cathode and an electrolyte. The cathode is a metal that is combined with oxygen. The anode is a metal that would oxidize if it were allowed to and is more likely to oxidize than the metal that forms part of the cathode.

There are different types of batteries. The most common types and the ones we will be studying are the following:

- **Lead acid**

Lead–acid batteries were invented in 1859 by French physicist Gaston Planté. They are the oldest type of rechargeable battery [5]. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, their ability to supply high surge currents means that the cells maintain a relatively large power-to-weight ratio.

- **Nickel–cadmium**

The NiCd battery was invented by Waldemar Junger and patented in 1899.

This type of battery is rechargeable and usually used for portable computers, drills, camcorders and other small battery-operated devices requiring an even power discharge [6]. NiCds use electrodes made of nickel oxyhydroxide, metallic cadmium

and an alkaline electrolyte of potassium hydroxide. This batteries are also the most widely sold.

- **Nickel–metal hydride**

This is a type of rechargeable battery which is very similar to the nickel–cadmium cell (NiCd). NiMH uses positive electrodes of nickel oxyhydroxide (NiOOH), like the NiCd, but the negative electrode uses a hydrogen-absorbing alloy instead of cadmium [7]. A NiMH battery can have two to three times the capacity of an equivalent size NiCd, and their energy density approaches that of a lithium-ion cell.
NiMH batteries have replaced NiCd for many roles, notably small rechargeable batteries. NiMH batteries are very common for AA (penlight-size) batteries, which have nominal charge capacities (C) ranging from 1100 mA·h to 3100 mA·h at 1.2 V, measured at the rate that discharges the cell in five hours.

- **Lithium-Ion**

A type of a battery composed of Lithium, the lightest metal and the metal that has the highest electrochemical potential. Lithium, however, is an unstable metal, so Lithium-Ion batteries are made from Lithium ions from chemicals. Because of its lightness and high energy density, Lithium-Ion batteries are ideal for portable devices, such as notebook computers [8]. In addition, Lithium-Ion batteries have no memory effect. The only disadvantage of Lithium-Ion batteries is that they are currently more expensive than NiCd and NiMH battery packs.

These are the basic information about the most used recharged batteries.
Table 3. summarizes some of the battery characteristics and advantages of the previous types, which have already been described.

Tab.3. Characteristics of the different battery type [9].

Battery Type	Characteristics	Typical Uses	Advantages
Lead Acid battery	Can hold a charge for up to 3 years	Backup emergency power source	Inexpensive
Nickel-Cadmium (Ni-Cd) battery	Fast, even energy discharge	Appliances, audio and video equipment, toys; most popular battery	Relatively inexpensive; widely available
Nickel-Metal Hydride (Ni-MH) battery	Typical power capacity i1.2V-1200 to 1500 mAh; extended life 2300 mAh; 2.5 to 4 hours battery life	Portable computers; cellular phones; same as for Ni-Cd batteries	No memory effect; unused capacity remains usable
Lithium ion (Li-Ion) battery	Stable and safe; highest energy capacity	Portable computers; cellular phones; same as for Ni-Cd batteries	Twice the charge capacity of Ni-Cd; slow self-discharge

After studying each battery and comparing them we decided that the best, which fits ours needs would be the lead-acid battery.

3. Micro-controller

A micro-controller (Fig.6) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Micro-controllers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications [10].

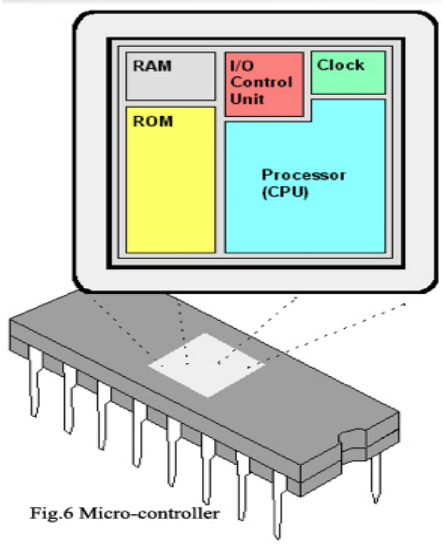

Fig.6 Micro-controller

Micro-controllers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, micro-controllers make it economical to digitally control even more devices and processes. The micro-controller (Fig.7) is the main component of our system. It will control everything and process everything, it will be responsible for controlling all the other components in our system. For that matter we choose the Arduino Pro Mini,

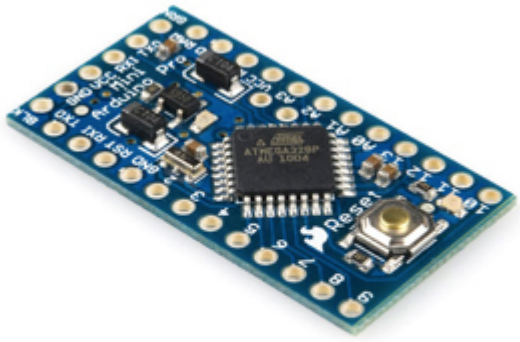

Fig.7 Micro-controller

which is a development board with the micro-controller and also some protection systems, as well as power regulation circuits and so on.

4. Communication

Wireless telecommunication (Fig.8) is the transfer of information between two or more points that are not physically connected. Distances can be short, such as a few meters for television remote control, or as far as thousands of kilometers for deep-space radio communications. It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Wireless telecommunications is the transfer of information between two or more points that are not physically connected.

Fig.8 Wireless communication

In this project we will be using a Wi-Fi communication system to transfer data between the measurement system and the web interface.

Wi-Fi (Fig.9) is a popular technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network which means that no cables are needed to connect devices which need to communicate and even be established a connection through walls and obstacles, this technology includes high-speed Internet connections. The Wi-Fi Alliance defines Wi-Fi as any "wireless local area network (WLAN), products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards". However, since most modern WLANs are based on these standards, the term "Wi-Fi" is used in general English as a synonym for "WLAN" [11].

Fig.9 WiFi

A device that can use Wi-Fi (such as a personal computer, video game console, smart phone, tablet, micro-controller or even a digital audio player) can connect to a

network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (65 feet) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio waves or as large as many square miles — this is achieved by using multiple overlapping access points. We will be using the WiFly Shield as shown in the Fig. 10.

Fig.10 WiFly Shield

Marketing Plan

Team 4

Naeem Ahmad, Mihkel Tasa, Marcos Moura,

Olga Olejniczak

Porto 2012

III. MARKETING PLAN

1.Background information

In the time of sources security, it becomes more and more important to be effective as a company. Entrepreneurs had to work hard to survive in this tricky situation. That's why we are going to launch a new level measuring product called the *level1000*. Our invention is mainly directed to recycling companies. By using our waste oil level measuring system, companies can create advantages over competitors.

The first year primary marketing objective is to sell 200 pieces of our product (*level1000*) with unit price 300€. 200 are chosen, because in first year we don´t have exact knowledge how our production will look like. Therefore 200 pieces seems achievable task for us. Through that our financial objectives are to achieve sales revenues to 60.000 € and to reach the break even early in the second year.

Table 1. Egi Energy inquiry.

<table>
<tr><td>Questions</td><td>Response</td></tr>
<tr><td>How many oil containers has the company?</td><td><table><tr><td>370 L</td><td>160 L</td><td>140 L</td><td>360L</td><td>240L</td></tr><tr><td>47</td><td>69</td><td>50</td><td>176</td><td>13</td></tr></table></td></tr>
<tr><td>How many containers are collected weekly?</td><td><table><tr><td>370 L</td><td>160 L</td><td>140 L</td><td>360L</td><td>240L</td></tr><tr><td>4</td><td>4</td><td>1</td><td>14/16</td><td>2</td></tr></table></td></tr>
<tr><td>How many containers are collected monthly?</td><td><table><tr><td>370 L</td><td>160 L</td><td>140 L</td><td>360L
240L</td></tr><tr><td>15</td><td>15</td><td>5</td><td>56</td><td>10</td></tr></table></td></tr>
<tr><td>How many workers are working in the collection?</td><td>4 workers</td></tr>
<tr><td>What is the distance traveled in a course of collection?</td><td>125km</td></tr>
<tr><td>Other information considered relevant</td><td>These data was considered during the collection process in the month of April 2012. These paths are set in place after the passage of a inspection team, in order to check if the filling level above 50% in order to justify the passage of a heavy vehicle to collect the oil container.</td></tr>
</table>

Based on this table, we know that company-*Egi Energy* has 486 different containers all over the Porto. 214 of them are meant for waste oils. Since, we found four different recycling companies in Porto we can assumed that in Porto (with suburbs) they have approximately 800 containers - in case if every company has 200 containers. Comparing these numbers with population (1.3 million) it means that for

1625 people they have one container. As we know the population in Portugal (2012 estimate population is 10 578 776 million) we can say that they have more or less 6510 containers in Portugal.
Of course these all numbers are hypothetical, but we can still get a picture about our potential market.

Problem statement

for recycling companies
who recycles waste oils
the level weight monitoring system
is a solution
that tells you capacity of container
unlike no other products
our solution has web interface.

1.1. Current market situation

Our product is innovative and we are entering in a new market. At the moment we have to deal with hypothetical companies. They can enter to the market, if they want , that is why we need to estimate future competitive threats. The reasons, why companies may want to enter in new market can be many:

- There are high profit margins in the industry.
- There is unmet demand (insufficient supply) in the industry.
- There are no major barriers to entry.
- There is future growth potential.
- Competitive rivalry is not intense.

- Gaining a competitive advantage over existing firms is feasible.

The most common sources of new competitors are:

- Companies competing in a related product/market
- Companies using related technologies
- Companies already targeting your prime market segment but with unrelated products
- Companies from other geographical areas and with similar products
- New start-up companies organized by former employees and/or managers of existing companies.

In Portugal there are no similar products. But in Germany there are some related products. Considering that, we need to be prepared to compete with others. For customer point of view, we can offer to them accurate and better overview of their containers, because unlike others, we have web interface and our product price is better. Due to that, they can reduce transportation and labour force costs.

1.2. Market Description

The measuring systems market consists of business users and consumers (private consumers) who need measuring systems for their machines/equipments/products. Business segments will be targeted during the first year. The table 2 shows how level1000 addresses the needs of targeted business and consumer segments (second year).

Level1000 product purchasers can choose the right settings for their needs. Different settings are needed, if customer wants to implement *level1000* in various types of containers. Customers may have several needs: Firstly, they want to know when the container is full or not. Secondly, they don´t want to check the container every time.

Thirdly, customers want to have a clear logistic concept, when container cleaning is necessary. Thereby, they can save money.

Table 2. Needs and Corresponding Features/Benefits of Level1000

Targeted segment	**Customer need**	**Corresponding Feature/Benefit**
Recycling companies (business)	• Information about containers capacities	• Ultrasonic sensor will measure this
	• Don´t want to check containers every time	• Wifi module for communication(with web interface)
	• Logistic process	• Web interface will help to create a better logistic and collecting process (overview).
Private consumers	• Information about the container capacity	• Ultrasonic sensor will measure this.
	• Don´t want to check the container every time	• Wifi module for communication (with web interface)

1.3. Competitors

Most of competitors, that you can see in the list (Table 3), are selling the similar product than we do. Those companies first target is to sell their products to professional users- mostly they are process industries. Only Sonotec, has a quite same product like we have. The only difference between our product and this product is that

they don´t have web interface. Main targets (customers) of this company are landlords with heating oil tanks. While, this is not our main target group we don't need to face with them. But, if we had more money, we can enter to this market easily, because our solution has been developed so that it is possible to use it in many places. We also can offer to customers better price and web interface opportunity.

We found out that there are more than 46 competitors in Germany. Even if, Germany is not our first market at the moment, we need to think about it also. Because in the European Union it is not really difficult to enter in a new market which is in another EU country. There comes the second reason why we should know the German market is that, in the second year we would like to sell our product there.

Table 3. Possible Competitors

Company	**Product**	**Price**	**Function**	**Customers**
Sonotec (Germany)	Sonolevel 10	499,99 €	-it can measure the distance from 12 cm to 250 cm. -working with ultrasound -adjustable -only a local interface	-owners of heating oil tanks in -most for landlord
VEGA Grieshaber KG	VEGASON 61 to 63	902,14 €	liquids: 0.4 … 8 m solids: 0.4 … 3,5 m	-B2B Marketing -process industry
Endress Hauser	Prasonic SFD And FMU 90	1090 €		-B2B Marketing -process industry

At the moment we didn´t find out any Portuguese competitors to our product. We think that there must be some companies/products, but probably they are not our direct competitors.

2. Objectives

We set achievable objectives for the first two years.

First – year objectives

In the first year we want to achieve considerable position in Portugal market. Mainly through unit sales volume of 100, but we will try to sale as much as possible. In this year our main problems will be to get well known on the market and to create a good image. This image will be created by good service, good communication with customers and by the trust.

Issues

- Operating goals

Major issue will be to establish a well known brand name. We will have to invest in marketing to create memorable brand image projecting, quality innovation and value.

- Tactical goals (first two years)

To improve our product selection; to correct our existing product.

- Strategic goals

To gain permanent group of customers, to expand our product foreign markets.

3. SWOT-analysis for Portuguese market

Strength	**Weaknesses**
• First in the market/sector • Innovative aspect • Price • Easy to use • Low maintenance cost • Easy to assemble • Adjustable	• Unknown product • Not available in every climates • Battery maintenance • Difficult to get patent • Limited budget
Opportunities	**Threats**
• To find sponsors/investors. • Cooperation with big recycling companies. • Ministry of the environment gives support for our product (promoting).	• Product acceptance • Easy to copy/improve • Market demand can be low

4. Segmentation and Targeting

As a first step, we made the decision to sell our product mainly to two different customer group which have basically same needs-they want to know information about container (is it full or not). These customers may want to buy our product for different reasons: our product will help to save transportation and labour force costs. And as we know petrol is becoming more and more expensive and many companies are trying to reduce their petrol costs.

First Target

We have certain segment to whom we want to reach. They are recycling companies, which are dealing with waste oils. The waste oils are collected by the company from different areas in a city. Waste oils are thrown away after they were used for cooking. Mostly, the bottles are thrown into containers which are in the near areas of apartments. The recycling companies are our first target group. Using our product, companies can collect oils more effectively. Our first market will be in Portugal in the city of Porto and in its districts. We are cooperating with Instituto Superior de Engenharia do Porto (ISEP) and ISEP in turn cooperating with one waste oil collecting company called Egi Energy. This company will have the first right to buy our solution.

The Egi Energy has 36 containers in the city of Porto and in the area around Porto they have 178 waste oil containers.

Figure 1. Container Location of Egi Energy in Porto (www.egi-energy.com)

That is why our product is designed for one specific container at the moment. However, with bigger budget and with some development, we can easily produce measuring system, that can be used for many containers. Thereby, we can offer more products to different clients (product selection).
Possible other clients (companies):

1. *Reciol Reciclagem de Oles Lda*
   http://reciol.pai.pt/
2. *Oleotores Ltd*
   http://www.oleotorres.pt/
3. *Carmona Sa*
   http://carmona.pai.pt

5. Marketing Strategy

The marketing mix is a business tool used in marketing products. We will use 4P system (place, price, promotion, product).

5.1. Positioning

Using product differentiation, we are positioning the *Level1000* as most versatile, convenient, value-added model for professional and personal use. The marketing strategy will focus on the level measuring system with web interface as the main feature differentiating our product from others.

5.2. Product Strategy

The *level1000* will be sold with a one 3 year warranty. Plus in the first year we provide a full service for free. We will also work on a second version of our product, but we don´t release it before the second year. We are trying to upgrade it by using new technologies. Building the *level1000* brand is an integral part of the product strategy. The brand and logo will be displayed on the product and packaging.

To create a good and memorable image we have to provide a very good and well working service to our customers. This service should show the customer that they are not alone and when problems occur they can easily contact us. We want to build the image: “Your problem is our problem” so our client will be loyal to our company. This kind of loyalty will also have a positive effect for our company. Because when our product gives them satisfaction, they will spread a good word of us. Other words it is called mouth propaganda for our company.

5.3. Pricing Strategy

The *level1000* will be introduced to the market with a price of 300 € per unit. This price reflects our strategy. Firstly we want to attract the new customers and secondly, to take a good market position. So it will be difficult for our competitors to aim our

product. Of course we will offer discounts for companies who will buy more than 10 units. Then price will depend on contract terms.

5.4. Promotion Strategy

Before we can choose right marketing strategy for us, we should find out what our goal is and how we would want to reach to our target group. Considering these two aspects, we point out two advertising methods and by comparing them, we can choose which one is better for us.

Above the line (ATL) marketing refers specifically to advertisements related to things people can see - i.e. wide open to your competition. For instance, ATL includes advertising in newspapers, magazines, televisions etc. ATL has a higher public branding effect than below the line. Above the line is often used to generate mindshare.

Below the line (BTL) marketing refers to things that happen in the background. Flyers, email marketing, word-of-mouth, inner circle marketing, etc that is not easily detected by your competition. BTL is used to generate loyalty and repeat readership.

Considering our project, we should choose below the line marketing method for us, because our product is meant for only specific companies and markets, so we do not need to advertise our product to masses.
The main strategy will be to sell our product through our website. Plus we are planning to make some contracts with well-known stores and catalogues. We will also arrange special terms and conditions for customers, which will be placed in a big order.
To advertise our product we are going to use mainly three channels:

- **Internet marketing** - is referred to as the marketing (generally promotion) of products or services over the Internet. Most of our product sales go through Internet.

- **Product demonstration** - is a promotion where a product is demonstrated to potential customers. The goal of such a demonstration is to introduce customers to the product in hopes of getting them to purchase that item. In first year we mainly have to make small demonstrations for companies. But after first year we are planning to use it more. We will participate in different types of fairs all over the Europe. In first year we also have to make small demonstrations for companies.

- **Word-of-mouth** - is an unpaid form of promotion—oral or written—in which satisfied customers tell other people how much they like a business, product, service, or event. Word-of-mouth is one of the most credible forms of advertising because people who don't stand to gain personally by promoting something put their reputations on the line every time they make a recommendation. We are using this method mostly on the second segment (private users).

6. Action programmes (first year)

The level 1000 will be introduced in July. Following are summaries of the action programs we will use during the first 10 months of next year to achieve our stated objectives.

June -Demo at Instituto Superior de Engenharia do Porto (ISEP).

July -We will make official web page and make advertisement in Google. We also pay for Google to show our web page always on top. For instance if someone writes keywords level measuring system to internet, then our web page will be always shown on top. Our web page will be translated to 4 languages (English, Portuguese, German and Polish).

August - Contacting with recycling companies (via email, telephone or face to face). We will also make Facebook page for our product. And working on leaflets.

September - Publish articles in magazines of our field (innovation, recycling, technical).

October - As the publishing articles continue, we will also start to make small an introductory video for our product.

November - We will start taking contact with companies from other countries like Germany, Poland and Estonia.

December -We will make small summary what we have already achieved for that time and we will start analysing those results.

January-March (2013) - After we have looked through the results we can start planning following steps: action programmes, budget, control for next term (medium range term).

7. Budget

Total first-year sales revenue for the *Level1000* is projected at 30 000 €, with average wholesale price of 300 € per unit. We anticipate a first-year loss of up to 25 000€ on the *Level1000* models and 5000€ for marketing (creating working production system and creating reliable brand). Break even calculations indicate that the *Level1000* will become profitable after the sales volume exceeds 30 000€.

Marketing costs:

Table 7.1. Marketing Cost distribution for the first year

	June	July	August	September	October	November	December	January	February	March	April	May	Total
Web Page	400 €	400 €	20 €	20 €	20 €	20 €	20 €	20 €	20 €	20 €	20 €	20 €	1000 €
Video	300 €	0	0	0	0	0	0	0	0	0	0	0	300 €
Leaflets	200 €	0	0	0	0	0	200	0	0	0	0	0	400 €
Contacting	200 €	200 €	200 €	200 €	200 €	142 €	142 €	142 €	142 €	142 €	142 €	148 €	2000 €
Articles	200 €			200 €			200 €			200 €			800 €
Unexpected Coasts													700 €
Total:													3400 €

Table 7.2. Marketing Cost distribution for the second and third year

	June	July	August	September	October	November	December	January	February	March	April	May	Total
Web Page	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	480 €
Video	100 €	0	0	0	0	0	0	0	0	0	0	0	100 €
Leaflets	400 €	0	0	0	0	0	400 €	0	0	0	0	0	800 €
Contacting	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	40 €	480 €
Articles	400 €			400 €			400 €			400 €			1200 €
Unexpected Coasts													1400 €
Total:													4460 €

Model costs

- Production (place, machines etc) 20 000€ / labor force 5000€.

8. Control

We are planning tight control measures to closely quality and customer service satisfaction. This will enable us to react very quickly in correcting any problems that may occur. After six month we will make a small survey to ask from clients what they are thinking about our product. Are they satisfied or do they have some complaints or recommendations for us, so we can improve our service.

Controlling must be continuous process, during which we have to improve our services, products and company structure.

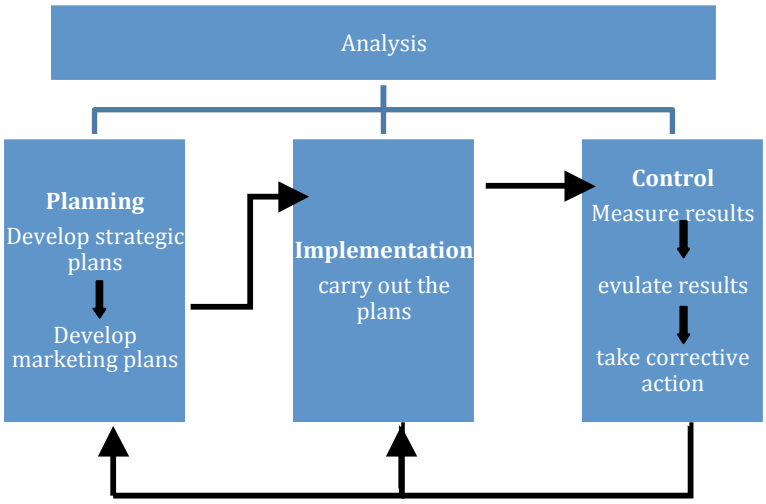

Figure 2. Planning, implementation and control

9. Medium - term plan (2013-2015)

Medium - term objectives

Our second year objectives are to achieve a higher percent (approximately 20% higher) rate in the market. We also will try to achieve the breakeven point so we can start to make profit. During second year we are planning to release new products for new segment (personal usage) and at same time we want to improve our existing products and services.

Second target

Although, the solution we made is firstly for waste oil collecting companies. But we will also create a second segment for this kind of product and third segment.

The second segment will be companies which are collecting the garbage of the inhabitants. Mostly they are same companies who are also dealing with waste oil collection. Which is actually good, because then we don't need to make big advertisements for our product again. Good thing is that our product can be easily implement in different types of container therefore it is good for us.

Third target

Nowadays water is one of the rare sources. To save it, people should think when, where and how much they should use it. This is mainly environment question, but educated people also think about their descendants. Therefore house owners will and should accumulate rainwater to water tanks so they can use it later for watering flowers. This type of water containers collects the rainwater and save it. Mainly these containers are located in underground, so it is inconvenient to check the water level of containers. To make their lives better, we can offer them solution where they can follow their container easily

10. Conclusion

This marketing plan showed us the position where we are at the moment. By analysing our marketing situation and our company SWOT-we can say that we have quite good starting position. In future lot of things will be depend on us- how we will reach to our target groups, how we can advertise our product, how we will organize our production system, where and how much money we will get for advertisement, development and production. Probably first two years will give us pretty good overview how we can and should organize our company steps.

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Sustainable development

Team 4

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Porto 2012

IV. SUSTAINABLE DEVELOPMENT

1. Introduction

The word sustainability is derived from the Latin sustinere. Sustainability as an emergent concept reveals deep concerns about fundamental values and our own continued existence. While each person's definition of sustainability is seen to be the most relevant, the question is a universal one and common to all. There are many meanings for sustain, the main ones being to “maintain", "support", or "endure”.

Sustainability has been used more in the sense of human sustainability on planet Earth since the 1980s. This has resulted in the most widely quoted definition of sustainability and sustainable development (it is a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs).

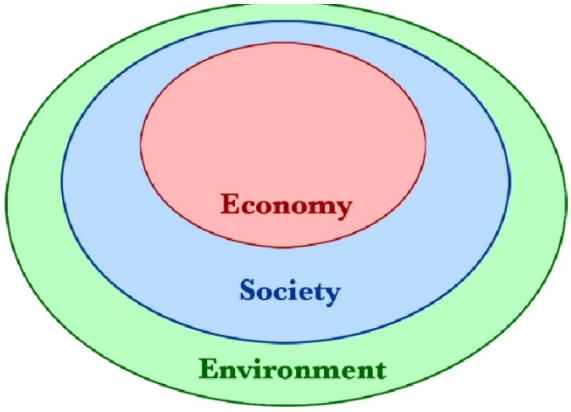

Figure 1. A diagram (shown on the top) indicating the relationship between the three pillars of sustainability suggesting that both economy and society are constrained by environmental limits.

2. Why is Sustainability Important / Our Future Depends Upon It

Sustainability is important because all the choices we pursue and all the actions that we make today will affect everything in the future. We need to make sound decisions at present in order to avoid limiting the choices of generations to come.

For example, if you continue wasting water and polluting the dwindling supply of freshwater that we have today, we leave future generations with no other choice than to desalinate saltwater or treat contaminated water for their consumption and daily use. We can also be assured that, if that happens, all life that depends on clean freshwater will become extinct.

The same goes with the supply of soil that we currently have. Without proper care, our soils can easily lose quality enough that they will no longer be able to encourage growth and sustain life. If that happens, future civilizations will be void of crop and other natural sources of food. They will then have no other choice but to create man-made sources for nourishment and sustenance.

3. The three main aspects of sustainability

In our project we would like to implement sustainable development concepts. For this matter we are going to make a sustainability study for our product. We are searching for the idea of sustainability around the three main parts which are social, environmental and economy. In the environmental part we would like to find and apply environmental friendly solutions, with the main goal of reducing negative human impact, as for example to use recyclable and renewable materials and energy sources. We also think about using everything in the most efficient way.

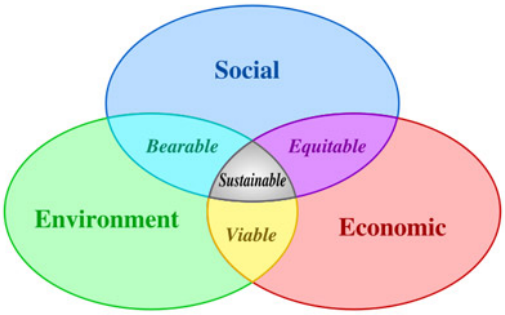

Figure 2.The three E´s of sustainability-Environment, Social Equity and Economy (source Wikipedia).

In our project we are trying to make as low energy consumption system as possible. We will use the lead acid battery which is rechargeable (300 times) and each recharge will last four to five months minimum. The lead acid battery recycling is one of the most successful recycling programs in the world and it was one of the reasons why we chose this type of battery. We also were constrained to our small budget and this battery is one of the cheapest.

We also had another environmental friendly solution which was to use a solar panel attached to the battery in order to recharge it. With this possibility we would be able to save energy and maintenance costs which contribute to the negative human impact. Unfortunately the small budget and logistics for this product don’t allow us to use the

solar panels. For the future projects and with bigger budgets we will try to implement solar panels.

For the energy saving and efficiency our system was developed to save the most energy possible. To achieved that our system, most of the time, will be sleeping and it will wake one time or two times a day to send information about the level of the container and goes to sleep again.

For the enclosure we had two material options, aluminum and plastic. Aluminum is theoretically 100% recyclable without any loss of its natural qualities as for plastic it can only be recycled a certain number of times until it starts loosing its proprieties. Aluminum is stronger than plastic and is easily worked. With all this in mind we though that aluminum would be the best option.

4. Eco-efficiency

Basically, eco-efficiency is an answer to the need of sustainable development to employ quantitative tools and related respective goals compliant with policies. The ultimate aim of eco- efficiency is to achieve significant reductions in the total use of natural resources. According to the laws of physics, the more materials an economy uses, the more pollution and waste it generates. Development of technologies that spare natural resources helps to diminish this generation of waste and pollution. The objective in eco-efficiency is to create more out of less so that the standard of wellbeing remains at least at its present level at the same time as environmental impacts are reduced. Eco-efficiency also offers clear quantitative measures and targets for the attainment of this goal [1].

The main aspects of eco-efficiency are:

- Reduction of energy, water and virgin material use
- Reduction of waste and pollution levels
- Incorporation of life cycle principles
- Consideration of the usefulness and recyclable of products/services at the end of their useful life
- Increased service intensity

5. Cooking oil life- cycle

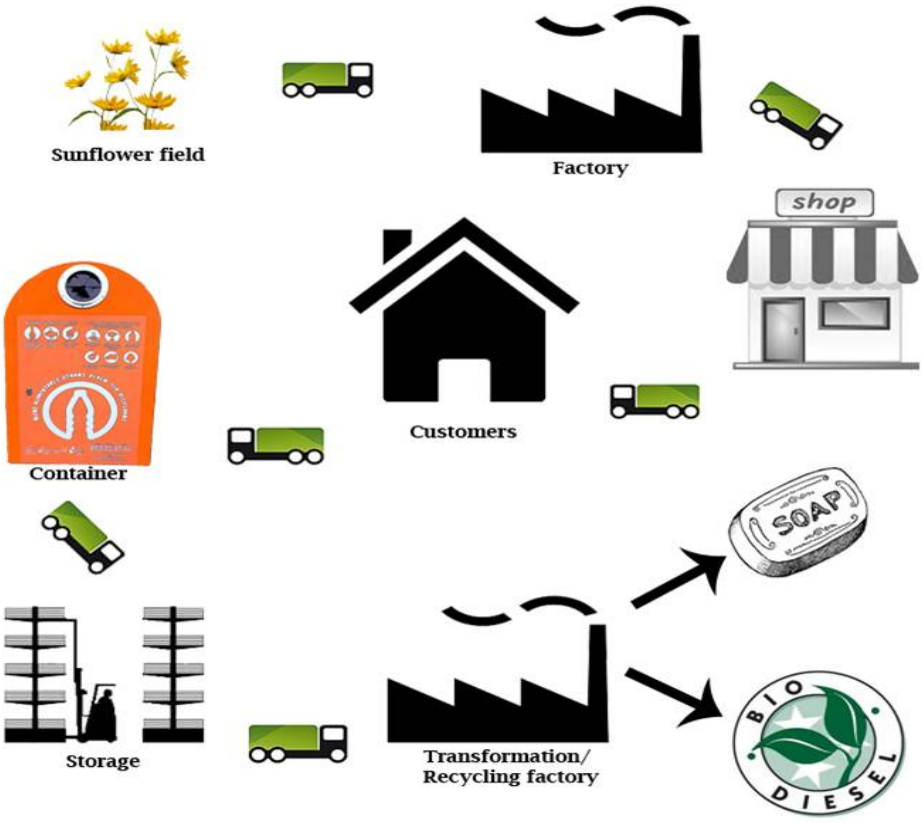

Figure 3. Cooking oil life-cycle.

Above you can see the life-cycle of cooking oil. Our product will be placed into the container, so it is the fifth step in the whole life-cycle.

6. Life-cycle analysis for our product

A product life-cycle approach to sustainability measures a company's total environmental impact—from raw materials, to production, distribution, consumer use, and disposal of the product by the consumer.

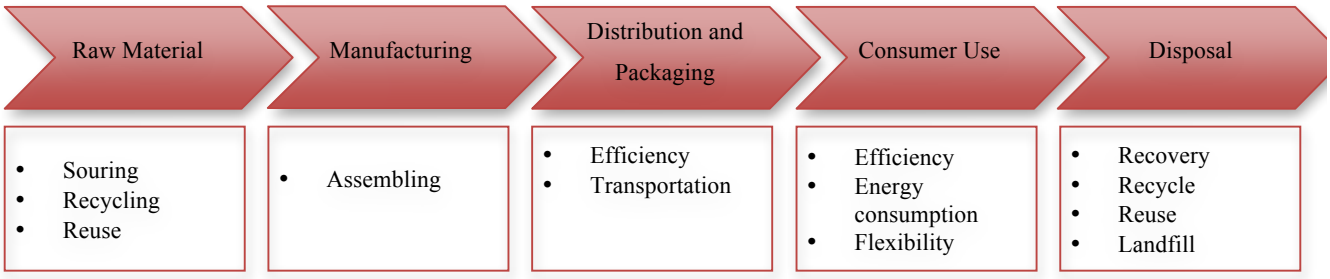

Figure 4. Our product life-cycle.

6.1. Materials

- Aluminum

We choose aluminum for our enclosure, because Al is a durable and sustainable metal: two-thirds of the aluminum ever produced is in use today. Recycling aluminum uses about 5% of the energy required to create aluminum from bauxite; the amount of energy required to convert aluminum oxide into aluminum can be vividly seen when the process is reversed during the combustion of thermite or ammonium perchlorate composite propellant. Second reason of choosing aluminum was because aluminum machinability - we can build this enclosure totally by ourselves that we can make enclosure, which is responding, exactly for our needs.

-PCB

In our product we have a printed circuit board (PCB). The PCB´s are used in many different electronic devices. Printed Circuit boards consist of an insulator (usually fiberglass) and the thread on the surface of a circuit board is copper. Typically PCBs contain 40% of metals, 30% of organics and 30% ceramics [2].

On the following graphic you can see. How the recycling of PCB works.

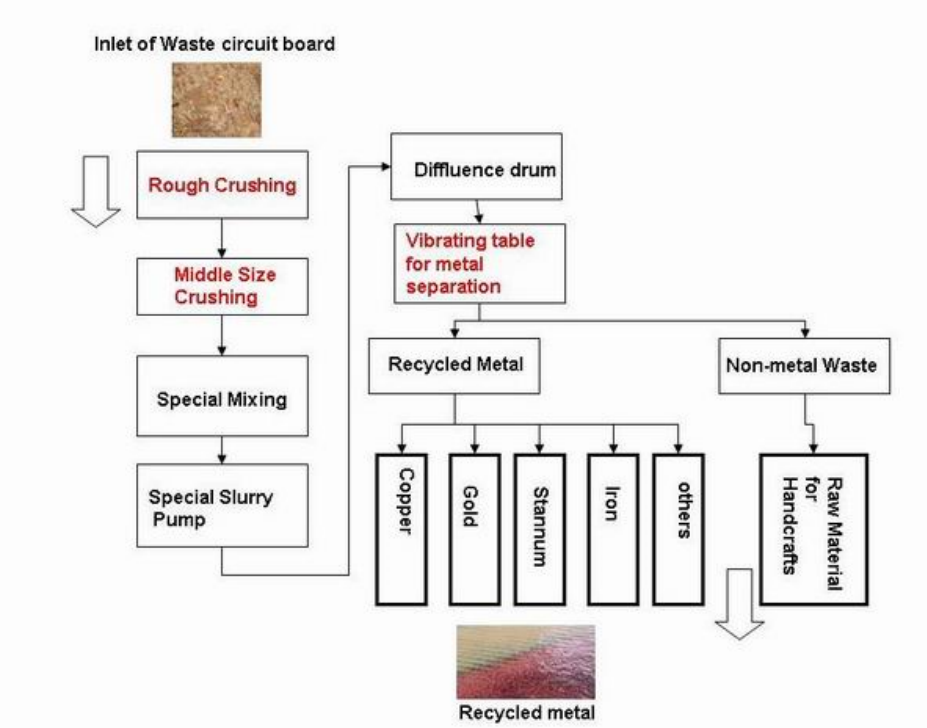

Figure 5. PCB recycling [4].

-Battery (lead-acid)

We chose lead-acid battery mainly because of two reasons: high drain current and low cost. But in environment point of view more than 97% of all lead acid battery is recycled. The lead- acid battery gains its environmental edge from its closed- loop life cycle. The typical new lead-acid battery contains 60 to 80 percent-recycled plastic and lead. When a spent battery is collected it is sent to a permitted recycler where, under

strict environmental regulations, the lead and plastic are reclaimed and sent to a new battery manufacturer. The recycling cycle goes on indefinitely. That means the lead and plastic in lead-acid battery in your car, truck, boat or motorcycle have been – and will continue to be- recycled many, many times. This makes lead-acid disposal extremely successful from both environmental and cost perspectives.

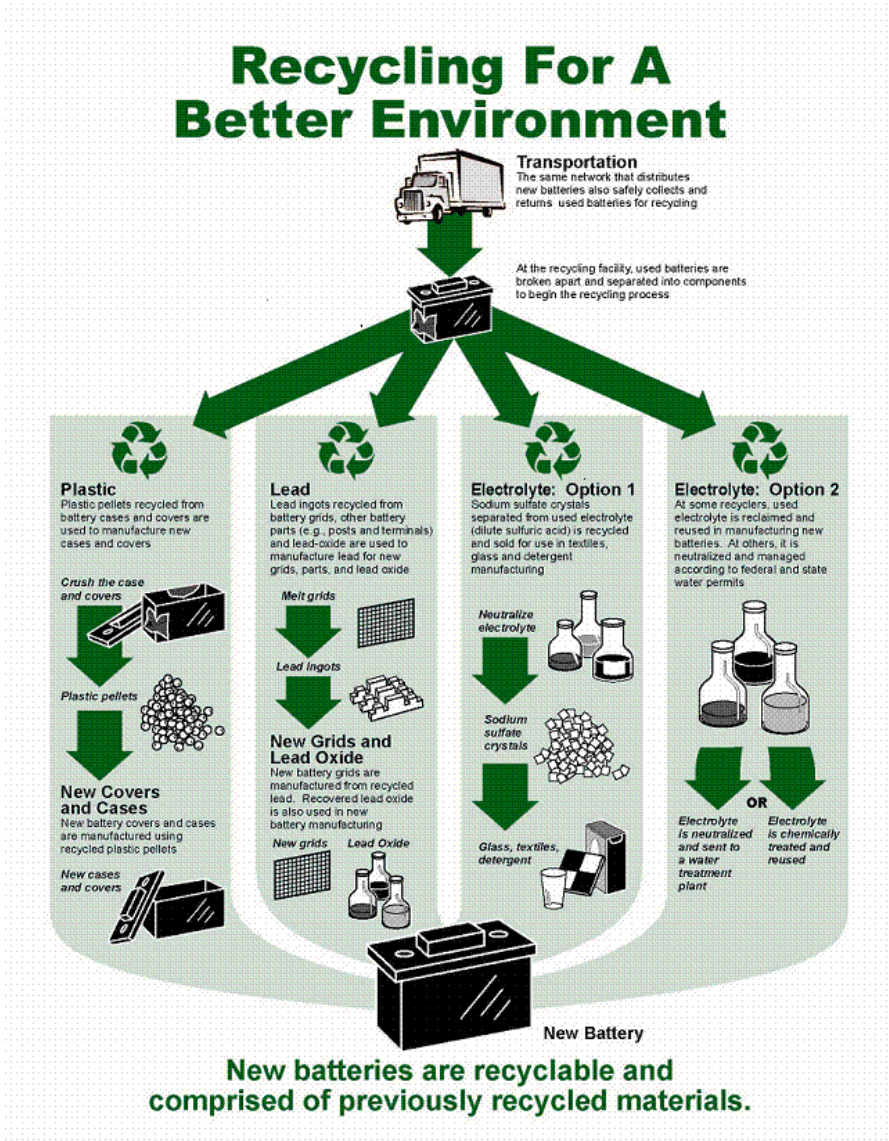

Figure 6. Recycling diagram [5].

6.2. Manufacturing

Sustainable manufacturing is defined as the creation of manufactured products that use processes that are non-polluting, conserve energy and natural resources, and are economically sound and safe for employees, communities, and consumers.
Many facets of manufacturing processes have important implications for the condition of the natural environment. But, many products can be manufactured by use of two or more alternative processes. Often, one of the process types involves the use of substances of less vicious than the others. So we can say that there is usually a choice to make among several sources for the equipment, and one type may be more desirable from a pollution prevention standpoint than others.
Sustainable manufacturing is defined as the creation of manufactured products that use processes that are non-polluting, conserve energy and natural resources, and are economically sound and safe for employees, communities, and consumers.

The good news is that manufacturing engineers already stepping up trying to find new technologies. Every day, engineers design products that conserve energy, reduce waste, and eliminate pollution, and they manufacture those products in a sustainable way. But there's more to do. And the present climate of economic and environmental concerns challenges engineers to optimize manufacturing processes and make them more sustainable.
There are some steps that can help making manufacturing more sustainable.

- **Optimize current use of fossil fuels**

Cutting energy cost is a win-win situation in today's environment. There seems to be little argument that we are close to the "Peak oil", when half the known oil reserves in the world have been consumed. The only argument left is when it will occur but everyday with this new technology we find even more oil but it wont last forever. Save energy by turning machinery off when it is not being used. Replace a single speed motor with a variable speed or servo drive to reduce energy consumption. Use a

variable speed hydraulic pump. Also take a look at other alternative sustainable sources of energy - whether it's wind, solar, or hydroelectric.

- **Eliminate waste**

Only consume what you need for the final product. we think we all know that, in the past, our primary objective was to reduce cost or time to market. Nobody knew or cared whether we were using more than we needed. This applies to every industry … whether it's the amount of metal, paper, packaging material, etc. used. Re-evaluate if investing in precision manufacturing equipment can be justified by waste reduction.

- **Recycle**

Recycling is the collection of a product by the public and the return of this material to the industrial sector. This is very different from reuse, where the materials do not return for remanufacturing. Recycling is beneficial in two ways: it reduces the inputs (energy and raw materials) to a production system and reduces the amount of waste produced for disposal. Recovery differs from recycling in that the waste is collected as mixed refuse, and then the materials are removed by various processing steps.

Lets take a look to the amount of metal chips that are made in metal removal processes. People used to just fill up huge bags/containers, and take them to a recycling facility. Now they're starting to look at the cost of energy involved. And one solution they found is to compress them into small bricks, that are a lot easier to transport and use a lot less energy.

- **Recover energy**

Hybrid cars recover energy otherwise wasted during braking, and other machines can do it too. Power sharing has its roots in machine tools, where the servos used in metal cutting machines and seam machines share power through a single power supply. We can actually take power during deceleration and return it to the main lines. In the past, that energy was wasted, turned into heat, like the brakes on a car.

Another great example is in coordinating the cycles of several metal presses. At first you might think, "Have all the presses go up and down together and then move the

material." But someone found that if you skew the cycles slightly, you can use the decelerated, regenerative power in one to help accelerate the other one. That has no effect on the process time, no effect on the cycle time and it doesn't cost more. But it saves energy.

6.3. Packaging and distribution

Sustainable packaging is the development and use of packaging which results in improved sustainability. Use a kind packaging which reduces the environmental impact and ecological footprint. Sustainability is not necessarily and end state but is a continuing process of improvement and in that matter we will always be looking for new materials and new technologies that we can apply to our product.

Figure 7. The international recycling symbol.

Companies have long been reusing and recycling packaging when economically viable. Using minimal packaging has also been a common goal to help reduce costs.
For packaging we would like to use carton to cover and protect our product. Carton is completely recyclable material. Inside we would like to use polystyrene or bubble wraps which give our product extra protection during transportation. But we though to use plastic warps because they can be recycled which does not happen to the polystyrene.

Distribution refers to the macroeconomic allocation of the objects which are to be distributed while integrating sustainability issues without compromising any of any of the conventional purposes that distribution has to fulfill. Commonly, distribution means all the processes that occur between producers, retailers and customers. The functions of distribution are physical transportation, storage and warehousing, packaging, labeling, and reverse logistics.

In order for distribution processes to be considered sustainable, characteristics of sustainable products and services have to be derived and applied:

1. Recipient's satisfaction: sustainable distribution has to ensure satisfaction of demand by means of time and place.
2. Dual focus: it should tackle social and ecological problems
3. Life-cycle orientation: sustainable distribution processes have to suit the life-cycle approach of sustainability products in order for them to be completely sustainable. There is also a close link to the post-use phase as reverse logistics complete the distribution process
4. Significant improvements: sustainable distribution has to deliver a substantial reduction of environmental and social impacts on a global level
5. Continuous improvement: permanently monitoring and improving socio-ecological impacts of distribution processes is needed in order to implement newest (efficient) technology developments and latest perceptions of the sustainability term.
6. Competitiveness: sustainable distribution has to be at least as competitive as conventional distribution processes in order to be successful in the long run. Environmental and social issues should be tackled without compromising the efficiency of the conventional distribution functions.

For our product distribution we though to use the post office service because it

will be small, light, easy to carry and also because we aren’t expecting a huge sale.

7. Energy consumption

- The arduino pro mini

7mA awake and running some code.
For the sleeping consumption we used the power down mode which is the mode that uses less power and we also disabled all on-board peripherals such as ADC, timers, etc.
1.5mA sleeping in power down mode.

- The ultrasonic hc-sr04 sensors

We have two sensors and they are powered by a digital pin which means we can cut off their power supply at any time.

15mA current draw at 5V when ranging.

0mA when the arduino is sleeping because the power supply is shut down.

- The RN-XV Wifly Module

According to the datasheet, this module has an Ultra-low power: **4uA** sleeping, **15mA** standby**,** **40mA** idle or Rx, **180 mA** Tx at 10dBm.
This means this device will draw around 180mA when transmitting data but it will only happen during a short period of time not more than a minute.

Our battery is a 6v 12000mAh lead acid battery and our system will wake up only twice times a day. With this in mind we can approximately calculate the expected life of the battery under these conditions.
We will read each ultrasonic sensor 30 times and calculate the average value for each one. In the worst case each sensor would take 50ms per reading depending on the distance the objects are from the sensor. So that is 1.5s per 30 readings which brings

us to 3s to completely read and calculate the average values from the two sensors.

This means 7ma plus 15ma during 3s which is 22ma.
After having the ultrasonic sensors distance values we will wake up the Wifly module to start transmitting data. The Wifly is configured to automatically connect to the host after it wakes up so we don't need to consider the standby mode but the idle mode. In this stage the module will draw 40mA and after connected it will start sending data which will draw 180mA.
The device will not take more than 1min to connect to the host and not more than 30s to send that over Wi-Fi connection.
1min at 40mA plus half a minute at 180mA.

After this everything is put to sleep and the ultrasonic sensors will be turned off and the system will then draw around 1.5mA.

In a day the device will wake up two times and the rest of the day it will be sleeping. We will have 22mA current draw during sensor readings for 3sec and an average of 87mA during 1min and half. So let's say in the worst case 2min at an average of 110mA while communicating if the device takes more time than usual to connect to the host and including the sensors readings and processing times in between.
A day has 24 hours which translates in 1440min and our device will only work for 2min twice a day which makes it draw 110mA during 4min and 1.5mA during 1436min.

$$\frac{1436 * 1.5 \ + \ 4 * 110}{1400} = \frac{2594}{1400} = 1.86mA$$

After this we can say that our device will consume an average of 1.86mA. Translating this in battery life we get:

$$\frac{12000mAh}{1.86mA} = 6451h = \ \ 268\ days = 8 - 9\ month$$

The time between charges of the system battery should be around 8-9 months.

8. Conclusion

In the last 20 years we can see changes how people are thinking. They don´t think anymore only about themselves. They have started thinking about the future, offsprings and how they can be more effective. By being effective we mean: not to spend too much energy, time and money for useless things. Even for companies it has become more and more important to think about their products/services as a part of environment. Companies have to be sustainable and they have to think widely to be successful in markets, because nowadays making profit is not an easy task to complete and not all companies can do that. Of course being sustainable is a long term process with big investments. Sustainability from company point of view means that it has no negative impact on the global or local environment, community, society, or economy.

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V. PROJECT DEVELOPMENT

1. Architecture

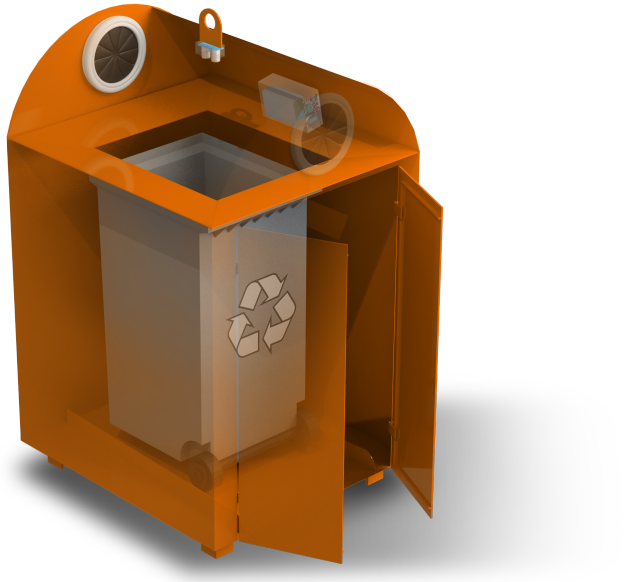
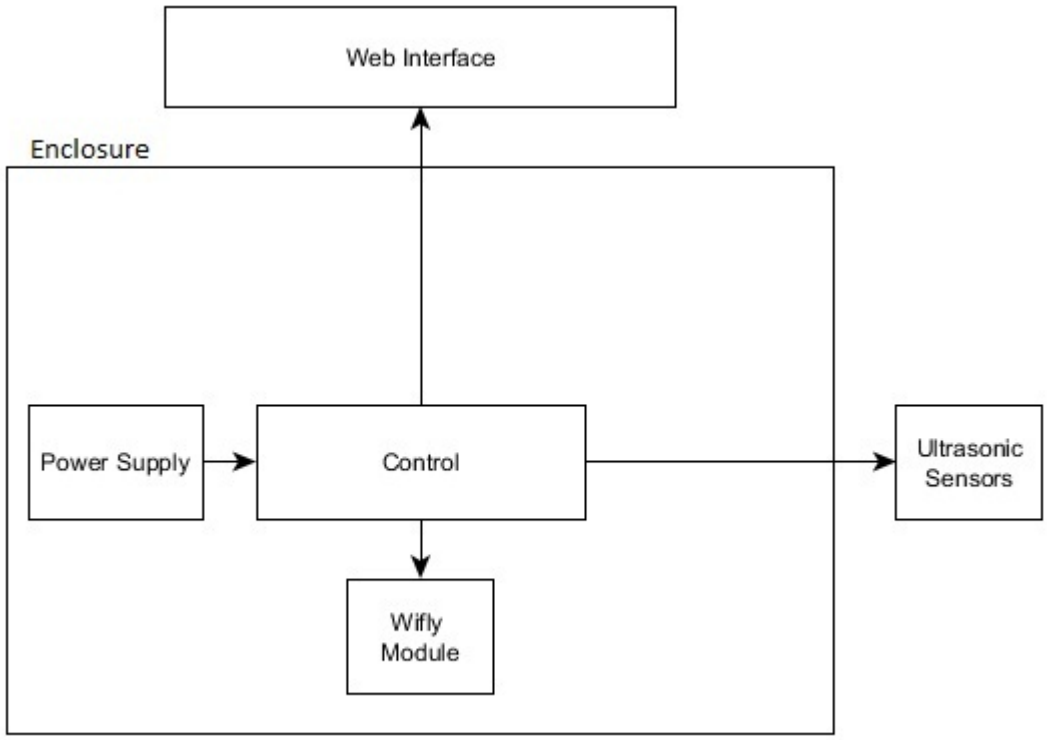


Figure 1. Container with the enclosure and sensor.

Figure 2. Enclosure - inside

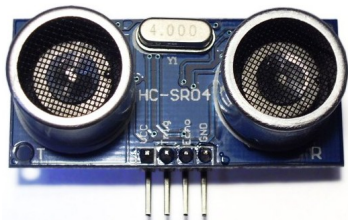
Scheme 1. Scheme showing the contents of the enclosure (Ultrasonic Sensor, Wi-Fi Module, Power Supply, Control).



2. Modules

- Control
  - Read sensors code
  - Sleep code (Watchdog)
  - Send values code (Connection with web server)
- Enclosure
- Schematics
- Web interface
- Ultrasonic sensors
- Wifly Module
- Power supply

2.1. Ultrasonic sensors



The ultrasonic module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach up to 3mm. The modules include ultrasonic transmitters, receivers and a control circuit. The basic principle of work:

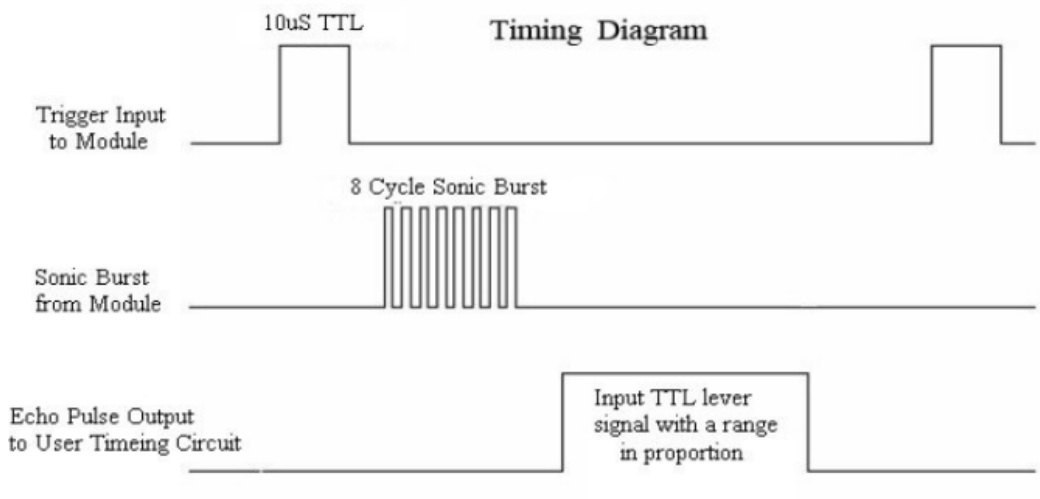
We set IO trigger for at least 10us high-level signal.

The Module automatically sends eight 40 kHz and detects whether there is a pulse signal back.

If the signal returns it will output a high signal and the duration is the time from sending to the returning of the ultrasonic signal.

Timing diagram

The Timing diagram is shown below. It is only needed to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. We can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2;



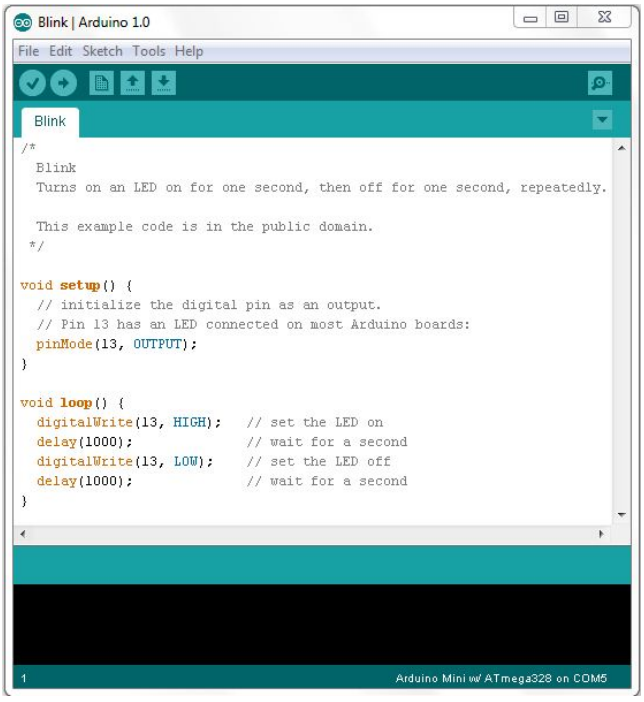
2.2. Control and Programming

As for this Project we have chosen to work the Arduino platform, which has a user-friendly integrated development environment.

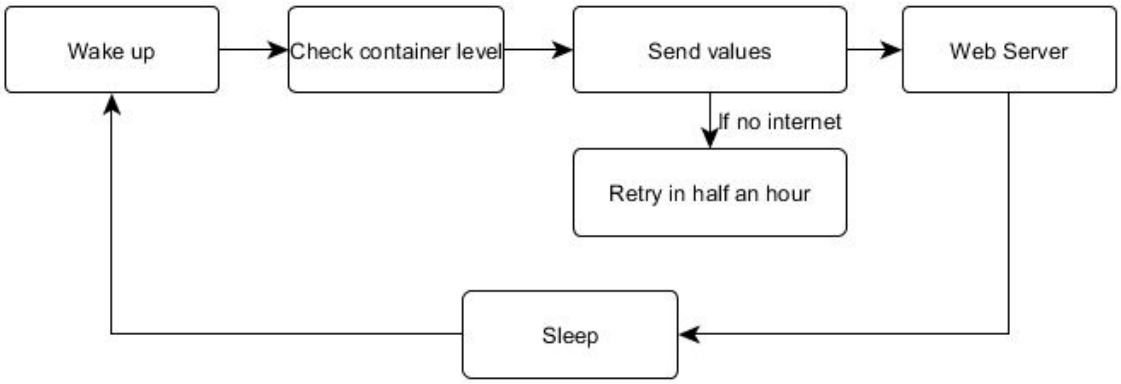
Our system can be divided in 5 parts, which are:

- Reading the ultrasonic sensors;
- The Wi-Fi connection;
- Sleep mode;
- Web Interface;

The main goal of this system is to keep track of the container level and send the sensor readings via a Wi-Fi connection to a server that handles these values and shows them to a user in a remote computer.



Before starting to build the program for the microcontroller first we thought in a general idea of what the microcontroller should be able to do and for that matter we created this simple diagram.



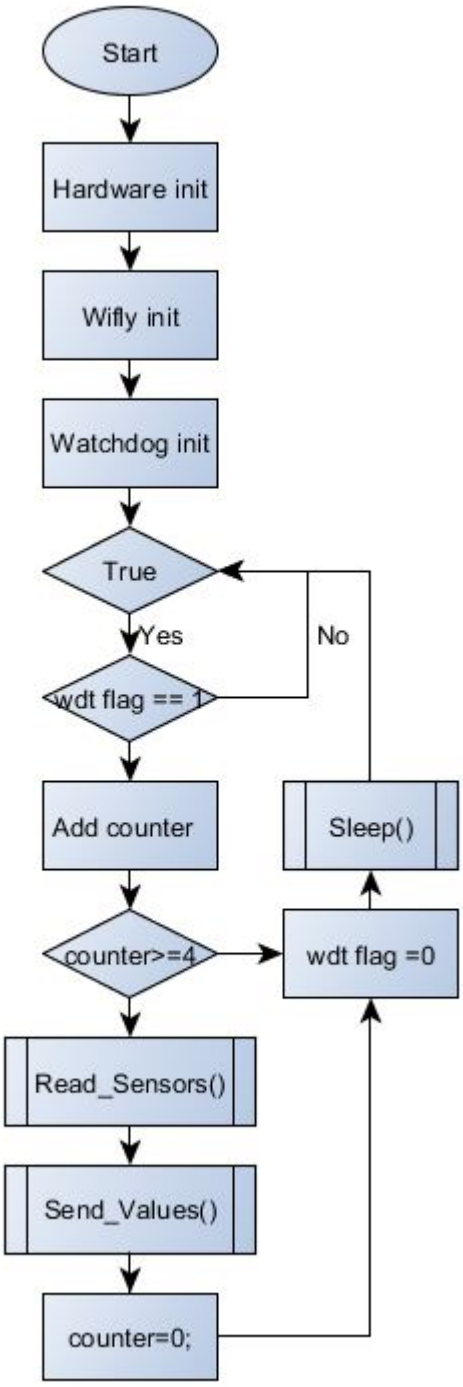
After having this diagram and a general idea of what we should start writing we started to develop a flow chart that could guide us while writing the code for the microcontroller.

This is the main loop of our code, we tried to make it look simple and easy to understand.

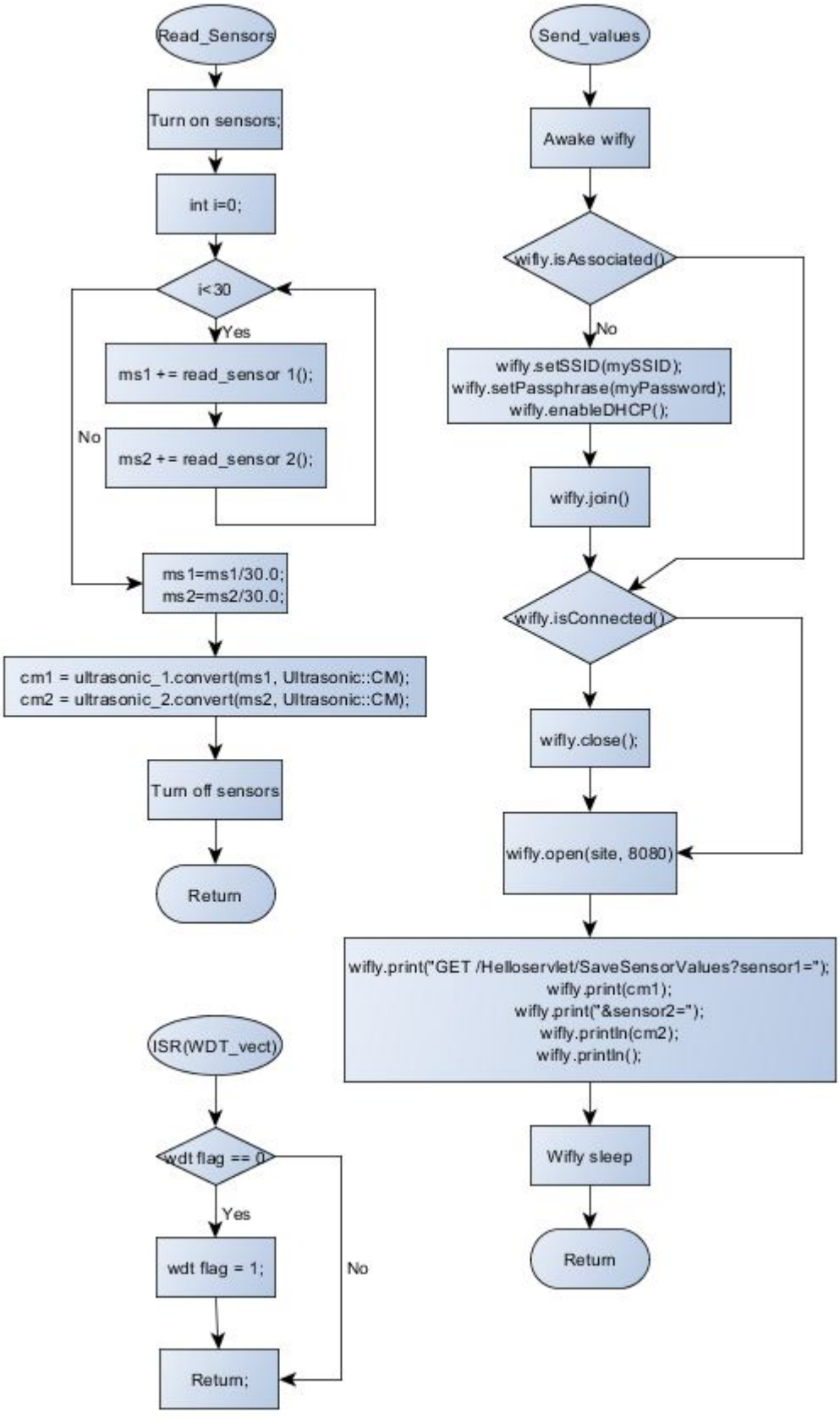
First of all we have the hardware init, which initiates the microcontroller outputs and variables. After we have the Wifly init which initiates the connection to the Wifly module, set the SSID of the wireless access point, the passphrase and also puts it to sleep right away. In the Watchdog init part we set all the Watchdog settings and make it ready to sleep for 8 seconds, which is the maximum for the atmega328p watchdog sleep functionality.

After this we enter in an infinity loop, which only activates when the Arduino wakes up. When it does wake up, every eight seconds it will check for the wdt flag which should always be one after waking up, it will add a counter, set the watchdog flag to zero and go to sleep.

The propose of this counter is to make the system able to sleep for minutes, hours or even days. In this flow chart we have counter >=4 it means it will sleep for 8*4 seconds which is 32 seconds. In our final project we want to make it able to sleep for half a day, 12hours which is 43200 seconds which means 5400 sleep cycles before reading sensor values and sending them to the web server.



For the Read_Sensors(), Send_values() and the watchdog interrupt functions we have also created some simple flow chart diagrams that would guide us while building the code.



For the Read_Sensors() function we start by turning on the ultrasonic sensors because

out system is battery powered and we try to make it as low consumption as possible so we turn on the sensors and the Wifly only when we need them. After this we enter a loop that is executed 30 times and after we calculate the average values because sometimes for some reasons the sensors might return strange values and with this process we make the readings more stable.

The readings are in microseconds because our sensors calculate the time that the sound waves take to return and then we call a function to convert this into centimeters.

All of this happens in less than 3 seconds and after this time we turn the sensors off by pulling their power supply to the ground, which is a digital pin in the microcontroller.

```
void Read_Sensors(void){

  digitalWrite(7,HIGH); //Turn sensors on
  delay(10);
  for (i=0;i<30;i++){ //execute for 30 times

    /* Measures the time the sound waves take to come back to the sensors*/
     microsec_1 += ultrasonic_1.timing();
     delay(10); // The delay is needed otherwise the reading wont be correct
     microsec_2 += ultrasonic_2.timing();
     delay(10);
  }

   microsec_1=microsec_1/30.0; // calculates the average value of both sensors.
   microsec_2=microsec_2/30.0;
   /*Converts the values in microseconds to centimeters*/
   cmMsec_1 = ultrasonic_1.convert(microsec_1, Ultrasonic::CM);
   cmMsec_2 = ultrasonic_2.convert(microsec_2, Ultrasonic::CM);

   microsec_1=0; //reset the values for new readings.
   microsec_2=0;
   digitalWrite(7,LOW);
}
```

This is the function for reading the sensors. Right after reading the sensors we call the function Send_values() that will wake up the Wifly module to send values.

As we can see by looking at the flow chart, first we wake up the module and then we check if it is already associated to an access point. If not then we will set the SSID and passphrase and try to join to the aces point. Then we also check if the module is already connected to a server, if it is then the connection is close and a new one is opened, if not a new connection is opened.

After we are connected to the web server we will send the sensor values in a form of GET request and for this we built a simple GET request with the sensors values. When everything is sent to the server we put the module to sleep and return to the main loop.

```
void Send_Values (void){

 /* Resets the wifi so it awakes from sleep */
    digitalWrite(5,HIGH);
    delayMicroseconds(500);
    digitalWrite(5,LOW);
    delay(5000); //waits 5s to give time for the wifi to wake up

    /* Join wifi network if not already associated */
    if (!wifly.isAssociated()) {
        /* Setup the WiFly to connect to a wifi network */
        wifly.setSSID(mySSID);
        wifly.setPassphrase(myPassword);
        wifly.enableDHCP();

        if (wifly.join()) {
            delay (3000);
        }
    }

    if (wifly.isConnected()) { //if some how the module is already connected, it closes the connection.
        Serial.println("Old connection active. Closing");
        wifly.close();
        delay(100);
    }

    if (wifly.open(site, 8080)) {
        Serial.print("Connected to ");
        Serial.println(site);

        /* Send the values to the server */
        wifly.print("GET /Helloservlet/SaveSensorValues?sensor1=");
        wifly.print(cmMsec_1);
        wifly.print("&sensor2=");
        wifly.println(cmMsec_2);
        wifly.println();
    } else {
        counter=5175;//5400 equals 12h but if it fails to connect it will start at 11.30h
                     // and will only sleep half an our and retry the wifi connection
    }

     while (wifly.available() > 0) {
         wifly.flush();
     }

     wifly.print("$$$");//Enters command mode
     delay(50);
     wifly.println("sleep");//puts device to sleep
 }
```

This is our Send_values() function and basically it works as we have explained in the flow chart. To make the module sleep we start by sending "$$$" which tells the module to enter command mode and then we send the command "sleep" and the device enters sleep mode, we could also control this by setting one pin on the module

to HIGH but then we thought this was the simplest solution. To wake up the module we send a pulse to the reset pin.

Now we have our hardware, Wifly and Watchdog init, includes and also the global variables code which is simple and we will just show it.

```
void setup()
{
  Serial.begin(9600);

  pinMode(7,OUTPUT);

  wifiSerial.begin(9600);

       //Starts the wifly
  if (!wifly.begin(&wifiSerial, &Serial)) {
      Serial.println("Failed to start wifly");
    }
    wifly.print("$$$");//Enters command mode
    delay(50);
    wifly.println("sleep");//puts device to sleep

                    /*** Setup the WDT ***/

  /* Clear the reset flag. */
  MCUSR &= ~(1<<WDRF);
  /* In order to change WDE or the prescaler, we need to
   * set WDCE (This will allow updates for 4 clock cycles).
   */
  WDTCSR |= (1<<WDCE) | (1<<WDE);
  /* set new watchdog timeout prescaler value */
  WDTCSR = 1<<WDP0 | 1<<WDP3; /* 8.0 seconds */
  /* Enable the WD interrupt (note no reset). */
  WDTCSR |= _BV(WDIE);

  delay(100);
}
```

```
include <avr/sleep.h>
include <avr/power.h>
include <avr/wdt.h>

include <Ultrasonic.h>
include <WiFlyHQ.h>

include <SoftwareSerial.h>
oftwareSerial wifiSerial(2,3);

iFly wifly;

define TRIGGER_PIN_1  11
define ECHO_PIN_1     12
define TRIGGER_PIN_2  9
define ECHO_PIN_2     10
define LED_PIN (13)

nt counter=0, i=0, f_wdt=1;
nt cmMsec_1, cmMsec_2;
ong microsec_1=0, microsec_2=0;
har buf[32];

ltrasonic ultrasonic_1(TRIGGER_PIN_1, ECHO_PIN_1)
ltrasonic ultrasonic_2(TRIGGER_PIN_2, ECHO_PIN_2)

* WiFi network SSID and Password */
onst char mySSID[] = "ZONE8D0";
onst char myPassword[] = "1234567890as";
* Website for sending the sensor values */
onst char site[] = "192.168.1.3";
```

We always try to make everything simple and fully working, there are only two more functions left which is the sleep

```
void enterSleep(void)
{
  set_sleep_mode(SLEEP_MODE_PWR_DOWN);

  sleep_enable();

  power_all_disable();

  /* Now enter sleep mode. */
  sleep_mode();

  /* The program will continue from here after the WDT timeout*/
  sleep_disable(); /* First thing to do is disable sleep. */

  /* Re-enable the peripherals. */
  power_all_enable();
}
```

function and the main loop function.

In the sleep function we set the sleep mode, which in our case is the Power Down mode and this mode is also the most power saving in sleep mode. We also disable everything in the microcontroller with the instruction power_all_disable(); and when the microcontroller wakes up it executes the power_all_enable(); function which turns on everything again.

In the main loop as we already explained in the flow chart it checks for the watchdog flag adds the counter, resets the watchdog flag and goes to sleep.

After 12 hours or 5400 times for 8s cycles it reads the sensors, sends the values to the web server and also resets the counter so it can sleep for 12h more.

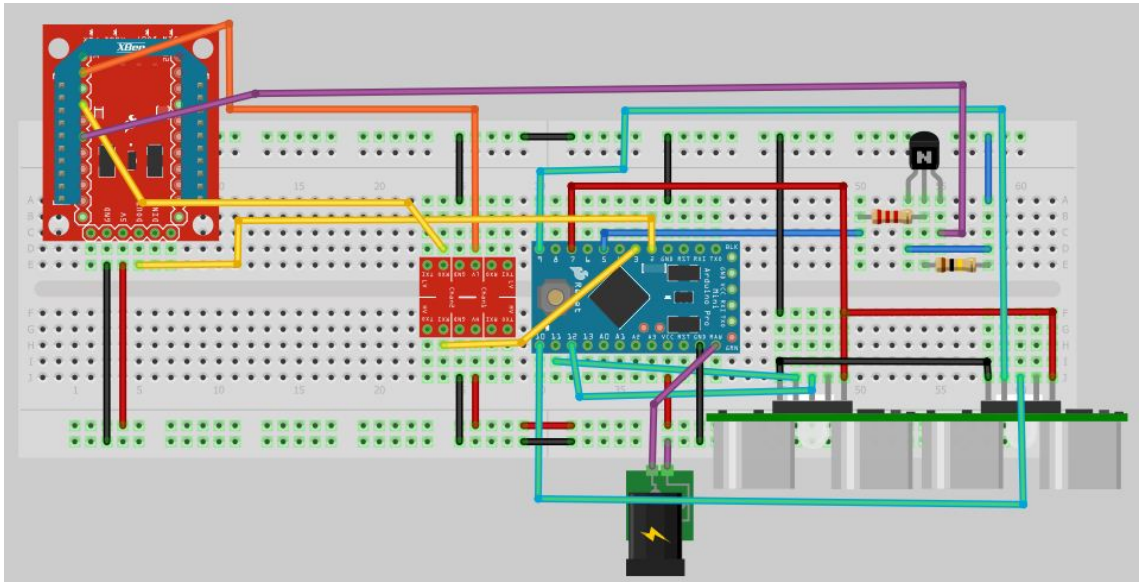
```
void loop()
{
  if(f_wdt == 1)
  {
    counter++;
    // sleeps for 8*counter seconds - 12h
    if (counter>=5400)
    {
    /* Read Ultrasonic sensors */
    Read_Sensors();
    Send_Values();
    counter=0;
    /*Before it goes to sleep gives arduino
     *time to send the data over serial.
     */
    delay(50);
    }
    /* Clear the wdt flag. */
    f_wdt = 0;
    /* Re-enter sleep mode. */

    enterSleep();

  }

}
```

2.3. Schematics of the project

Here we will show how everything is connected and will also explain what might be needed to be explained.

First we will show a breadboard schematic, this is how we had it before assembling and we used this for testing.

Scheme 2. Breadboard schematic

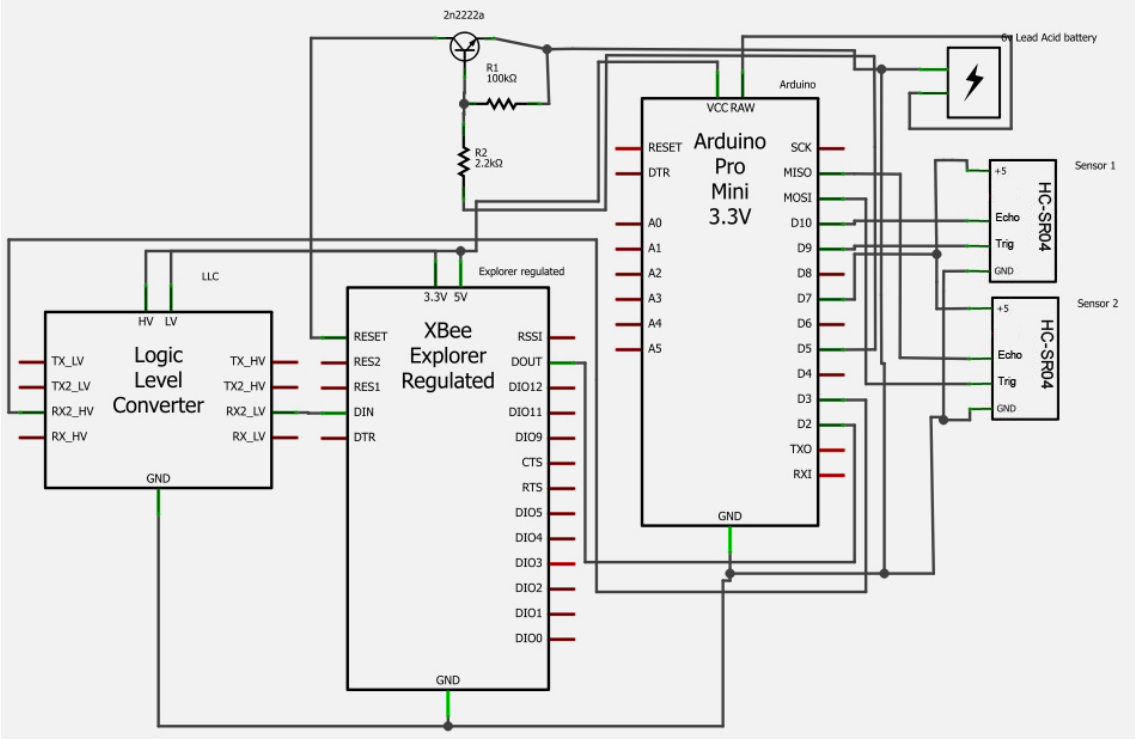


We have the Arduino Pro Mini 5v but the Wifly module on accepts 3.3v Signals, for this we bought a special board “XBee Explorer Regulated” for which out Wifly module was created to work with it but we encountered many problems because we could read serial data sent by the Wi-Fi to the microcontroller but we could not send commands over serial to the Wifly.
After trying many solution and searching online we found that many people had problems with the compatibility and that we had a problem on the Rx line so we had to buy a logical level converter from 5v down to 3.3v and connect the arduino virtual TX pin, which we chose to be pin 3, to the LLC and from the LLC directly to the Wifly RX pin.
After trying this everything seemed to work fine.

For waking the Wifly we also had another problem because none of the pins used to wake up the Wifly were working and we found that we could wake it up by setting the Wifly reset pin to ground by a short amount of time which was not mentioned in the Wifly manual. The Wi-Fi board has 49 pins and the Wifly board only has 20pinout

that are connected to it which does not include the FORCE_AWAKE pin referred in the manual sheet. But with time we solved all this problems.

Scheme 3



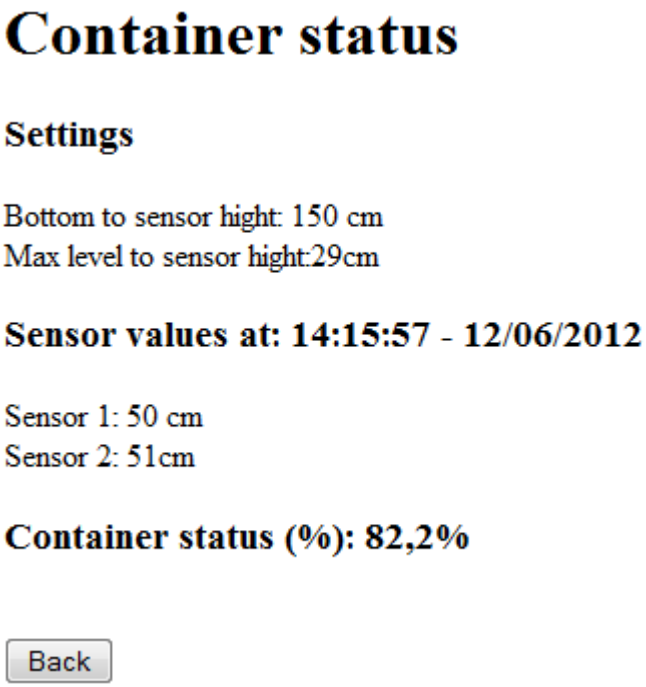
This is our schematic and how everything is connected. As we can see we have a small circuit with a small transistor, which is used to pull the reset pin of the Wifly to ground and wake up the module, the 100kΩ resistor is just to make it stable and the 2.2kΩ resistor only limits the current on the transistor base pin. All of the rest is basically self-explained.

2.4. Web interface

For the web interface we will be working with apache tomcat and use java language for the code.

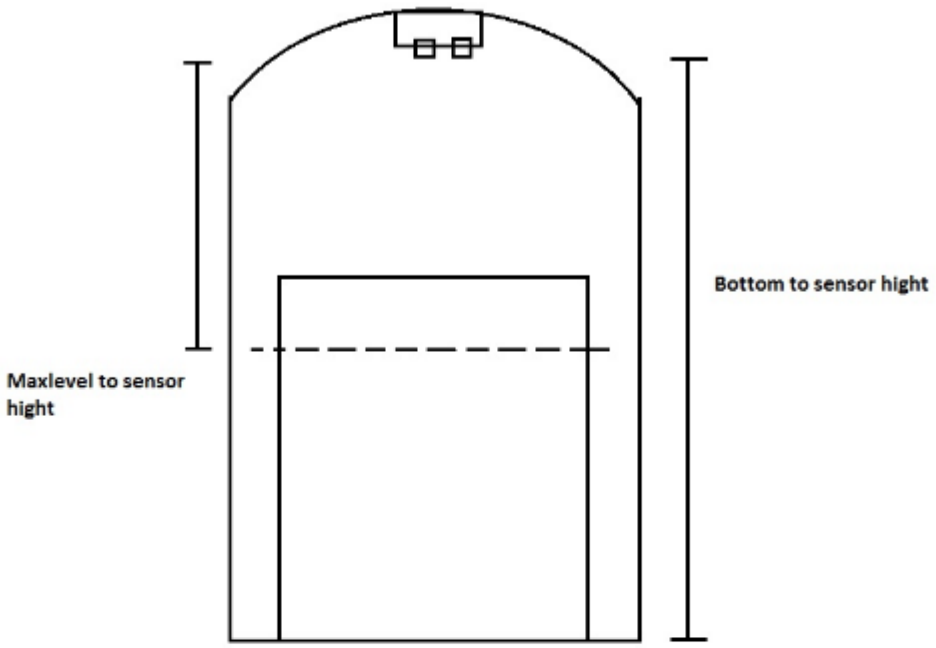
This is our first page index.jsp, here we have two options, one to check the container status and another to edit the container settings.

Clicking the container status button will take use to the ShowSensorValues servlet that reads a file containing sensor data and does



some processing before showing the information to the user.
This is one example of the output and it shows the current container settings, the sensor values and after processing we have the fullness of the container in percentage (%).

Clicking the container settings will take use to another page where we can define the values we want for the container and with this our system is able to handle different size containers.



Container settings

Bottom-sensor hight: cm
Maxlevel-sensor hight: cm

Submit

VI. CONCLUSION

The project title, on which we have been working for three months, is "**Level Monitoring System for a Waste Oil Storage Tank**" and our main task was to develop a level monitoring system for a real world waste oil container.

The first, few weeks we spent on understanding and getting familiar with our project which seems very interesting to us from the beginning. Initially, we looked for a variety of basic information. We reviewed many options to solve the tasks and had a lot of discussion about sensors, communication module, batteries, boxes which would make our ideas become real. Obviously we had to look for the cheapest equipment as possible because the budget was limited.

It has already been really difficult to reach an agreement about a final and appropriate solution.

As the first activity was to prepare the Gantt Chart and the task list inside where we divided the job between each other. We had also a meeting with Prof. Nidia Sá Caetano on which we found out more about what is expected from our project and what it can be. We also had many meetings with the supervisors who lead us and helped to solve our difficulties as well as our doubts.

Secondly, we checked the inside look of the container because in one of our tasks we had to decide where and how the components could be fixed and placed. After it we prepared the prototype of the container to make it easier to check our ideas.

As we have already mentioned to distribute the conception we needed to find a special kind of sensor and we chose ultrasonic one (Ultrasonic Distance Measuring Module HC-SR04). We needed the monitoring system that would automatically send an alert message when the container would be full (Arduino pro min plus Wi-Fi shield). We also chose the battery - the lead acid one because of possibility to recharging it and quite low price. We did the special and necessary box - the one made of the aluminum, which would keep all things together. Finally we finished the programming part of the project too.

Other tasks were also to prepare the marketing plan and sustainability aspects concerning our project.

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