IST

BANCO SOL

Enjoy Solar Energy

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Abstract

The project of Banco Sol addresses the issue of introducing new energy solutions, in form of solar energy, to a wider public. This is a challenge specifically interesting in a multicultural community like Mouraria. Simultaneously the issue of making the neighborhood a more pleasant place through a enjoyable meeting point is considered.

The solution of Banco Sol, is a bench that automatically plays music when someone is sitting down on it. It will also provide information through audio clips and through an information board. The energy will be provided through a photovoltaic solar cell.

As a part of the developing process a prototype of Banco Sol was created. It was constructed with an infrared sensor, an mp3, speakers and an Arduino Uno. It demonstrated how the bench plays music when sensing a person sitting down.

The conclusions drawn from the project are that often the easy solutions are the more effective. A communication channel like this bench could reach a broad public and will introduce the idea of solar energy in a very present and hands-on way.

Índice

1.1 Introduction

Banco sol is the bench that promotes solar energy in a fun and musical way. By seeing the sun giving energy and enabling the music in real time it will introduce the possibility of using solar energy for other things. It can inspire people to learn more and to bring the technique in to their homes by for example installing a panel for their own building.

Banco Sol can also become a natural meeting place bringing people in the community together. It will attract people from all parts of Lisbon wanting to make a small excursion in town and it will also attract tourists. There can be no better way of getting to know the traditional music of Fado then right here at its birth place in the heart of Lisbon. The location chosen for Banco Sol is Moruaria, which happens to be the very district Fado originates from.

This report will present the project of developing Banco Sol. It presents the idea behind the project, the plan for the setup, and the calculations for relevant information for the installation of a Banco Sol. Interviews have been done in the contemplated area and a simple prototype has been designed, built and tested on sight. To show the feasibility of implementing the idea in reality a small business plan has been developed.

1.2 Background

1.2.1 Task

The project of Banco Sol is a result of the class “experimental methods in environment and energy” at IST, Instituto Superior Técnico. The task was to plan and design new sensors in order to help mitigating environmental and energy related risks with emphasis on the urban environment. Emphasis lies on communication, by using for example visualization tools and emerging communication systems to engage stakeholders and allow community based dialogs. The project was to take place in the city of Lisbon and applications for underserved communities like Mouraria was encouraged.

1.2.2 Problem

The problems that this project aims to tackle can be divided in to two main parts. First is the insufficient awareness of environmental and energy solutions available for the public. It is a common misunderstanding that solar energy is an undeveloped and expensive technique and this project aims to make it more assessable to the public through awakens an interest in these questions and through education.

The second problem tackled is the social problems of Mouraria. It is a neighbourhood with a bad reputation and it is in need of more social meeting points. It would also benefit from getting more attractive among people from outside which would make it a more welcoming and warm part of Lisbon.

1.2.3 The idea of Banco Sol

The basic idea of Banco Sol is that when someone sits down on a bench, located in Mouraria (see 1.2.4.) a sensor will feel this and music will start playing. Whenever the person gets up, the music is deactivated. From time to time there will be small segments of fun facts about solar energy in between the songs; these will be of a length of maximum 15 seconds. Another way of

communicating will be through an interface in form of a board next to the bench. On this board you can choose music but also find information about the bench, solar energy and how to find out about installing solar cells on your own building here in Lisbon.

Lisbon is one of Europe's sunniest metropolitan areas. However despite that, Lisbon is far from the top when it comes to take use of the solar energy. To change this it is important to engage the public. Banco Sol could be one way to reach people in order to make this possible.

The goals of the Banco Sol project are based on the above mentioned task goals. It aims to awaken the interest of solar energy in the city of Lisbon through a fun and pleasant way. It will also give the inhabitants of Mouraria a pleasant meeting point where they can enjoy music of their choice in the sun.

1.2.4 Location

The chosen location is situated in Mouraria, more specifically Largo da Rosa. It is chosen for a few different reasons. It is a pretty calm part of Mouraria but still many people passing by, by foot. It is also on the Mouraria's Rota das Tasquinhas e dos Restaurantes, leading tourists past the square. It is a nice open space which has a few trees but also gets a lot of sun. From this spot there is also a good view on the castle up in the hill. The square itself contains a few benches but not much more and Banco Sol could definitely contribute to make the square more attractive. Figure 1.1 shows a picture of Largo da Rosa.

Figure 1.1 Largo da Rosa

2. Prototype

In order to test the basic idea of Banco Sol a prototype was made. Initially the development of Banco Sol was organized in 3 different parts: the power supply for the project, the music part and the interactive mode. Unfortunately to develop the power supply and the interactive mode for the

prototype the budget and the difficulty of the project would increase considerably. The prototype was therefore based on simply designing a bench that would play music when someone sat down on it.

2.1 Sensor and Ipod

A circuit was designed for the project as can be seen in figure 2.1. The prototype was built using a moving sensor, an mp3 player, a breadboard and an Arduino Uno. To connect the system additional wires and a transistor were also needed.

Originally the sensor that would recognize the person sitting down was planned to be a weight sensor, however in order to have a range between 40 kg and 100kg the prices for the sensor would get too high. Consequently an infrared sensor was a better option. The sensor chosen for this prototype was an *Adjustable Infrared Sensor Switch* model: INM-0475. It is for example used for robots to feel their surrounding, so they do not roll in to objects in their way.

The Arduino is the CPU of the project, the place where the program is installed. The program will take the inputs from the infrared sensor and then send a signal to the mp3 to start or stop it. This device needs energy and as mentioned before the supply was not from a solar panel in the prototype, instead it was here to be supplied by a laptop via USB connection. For the mp3 solar energy would be needed, in the initial prototype the internal battery from the device was used.

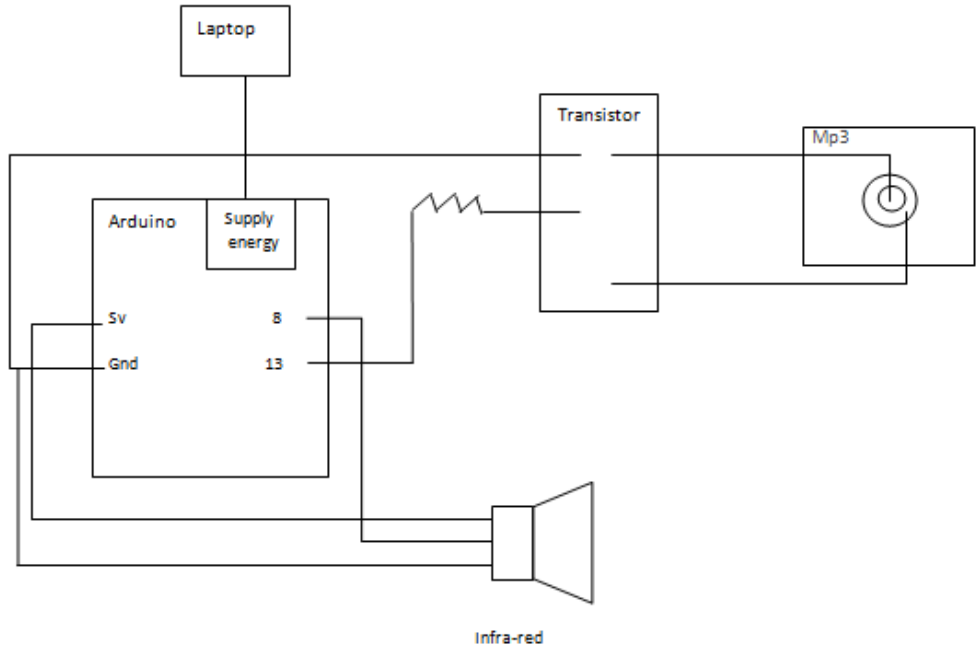


Figure 2.1 The Circuit for the prototype

2.2 Programming

The programming was one of the essential parts of the prototype. A program that would start the music when the sensor felt something was needed, i.e. gave the input signal “high” to the arduino,

and would stop the music again when it gave the signal “low”, i.e. the sensor does not sense anyone anymore.

The difficulty with this was that the exact same signal to the mp3 which starts the mp3, is used to pause it. This means that the program has to register the change of signal (HIGH to LOW/LOW to HIGH) instead of the signal itself. If the code would be based on the signal itself, this would mean that whenever a person sits down, a constant HIGH signal is delivered to the Arduino. As a consequence the start button is continually pressed. Since the mp3 model used is a very simple one, the start button is also the stop button, and music is constantly turned on and off. However when the program is based on a change of the input signal, the start/stop button is pressed only once, whenever the input changes from LOW to HIGH or from HIGH to LOW.

Using this way of programming, it is essential to control the initial conditions. When these are wrong there is a risk that the program works backwards. The music could then play when no one is sitting on the bench and turn off when someone sits down.

The arduino has a particular program language, however with some basic understanding of writing code it can be learned with the help of arduino website. The code written for the prototype can be seen in appendix. A.2.2. A picture from one of the programming and soldering sessions at Junitec is seen in figure 2.2.

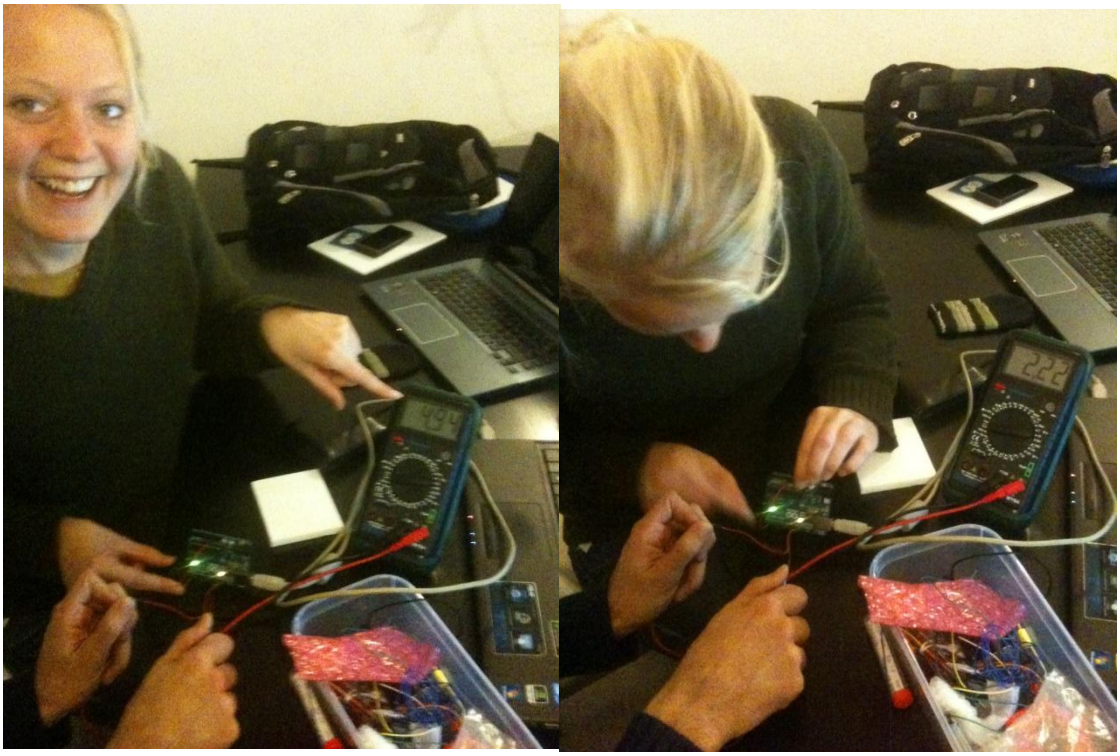


Figure 2.3 Soldering and programming session. The right picture shows that the outsignal gives the right voltage (5V).

2.3 Testing in town

To know the reactions for the Banco Sol idea, it was necessary to interact, show and explain it to locals from Mouraria. There were different stages during the time of the project in which interaction with the inhabitants was relevant. To start off initial interviews were held to find out about

community problems in Mouraria. When the basic idea was formed more interviews were held to get the first feedback and suggestions for the Banco Sol idea and for music to be used. Later on there was more feedback collected at the testing of the bench and at the presentation for the municipality in Mouraria.

2.3.1 Understanding the problem and get suggestions

In the first stage, the group went to Mouraria to get opinions of the inhabitants about the local problems. It quickly became clear that the major concern was security due ethnical reasons. This was not easily covered within the assignment and instead the Banco Sol idea was developed. On a second trip to Mouraria, the idea of Banco Sol was presented to people passing by. Questions were asked like, “What do you think about Banco Sol?”, “What kind of music do you like?” and “Do you know how solar panels work?”.The reactions were positive; especially for the idea of listening to music on sunny days and that the idea was environmentally friendly. The inhabitants suggested jazz and Brazilian music, but most of all Fado since it is the soul of Mouraria.

2.3.2 Testing the Prototype

The prototype of Banco Sol was installed at Largo Rosa, where the real Banco Sol could be placed. The infrared sensor was placed on the bench, so a person sitting down would be sensed. The change in the signal from LOW to HIGH is registered by the programmed arduino and the start button on the mp3 is pressed. The setup is shown in figure 2.4.

For the prototype a basic example for an interactive interface was presented on a laptop. This was working with several buttons which could be clicked for information about solar energy or Banco Sol to appear. It was also shown how to change the music if that feature would have been programmed. This interactive interface was only designed; the functions for the music were not activated.

After the installation of the prototype, inhabitants were invited to sit down and enjoy. When they sat down the music started and different reactions appeared. The group also explained the Banco Sol concept and the green achievements that are wanted. Again the feedback was positive, it was said that it would improve Mouraria with a new fun point, they liked that it was an environmental idea and they thought that it was a charming way to introduce solar energy. Figure 2.5 shows a person passing by testing the prototype. A sample of live reactions in their exact words can be seen in the movie Banco Sol, which can be found on youtube.

Figur 2.4 The prototype is set up and ready to be tested by people walking by.

Figure 2.5 Testing of Banco Sol.

3. Real Banco Sol

3.1 Setup

An image of the setup of the final prototype can be seen in Figure 3.1.

Figure 3.1 Sketch of Banco Sol.

As can be seen in figure 3.1, the interface-information panel will be placed right next to the bench on a height that every person sitting down can reach with his arms. This is important because this will be the main way of interaction with the people. On this board they will be able to control music, and learn more about the Banco Sol concept. The extent of the available options will depend on which kind of interface is implemented. This is further discussed in section 3.3. Interface. Speakers and solar panel are attached on the same pole as the interface but on a height that is not easily reachable, to prevent damage and theft. The exact position of the solar panel is discussed in the next section.

3.2 Solar Panel

In order to find a balance between price and efficient energy supply it is crucial to both choose the best angle for the solar panel and to size it right.

3.2.1 Angle of Solar Panel

If is assumed that the placement of the solar panel will be permanent on a place where the surrounding buildings and trees will not cast a shadow over it. It will not be adjusted with time to maximize the energy each season. Therefore the optimum angle for the two solar equinoxes was chosen. In this angle the panel will have the same angle to the sun at summer and winter solstice as shown in the calculation, Appendix A.3.2.1. This was a compromise based on the facts that in the summer there will probably be light enough to run it anyways and winter there will be less people using the bench and therefore less use of energy. This way it will also optimize the angle for spring and fall when the bench might be used a lot even if the sun is not as strong as during summer.

The angle of the solar panel to the ground will be the same as the latitude at the panel's location. The latitude of Mouraria is about 38º 43´ which corresponds to an angle of 38,72º.

3.2.2 Size of Solar Panel

When sizing the solar panel it is necessary to make a row of assumptions. It is for example important to know what kind of equipment that will need the power. For Banco Sol with a non digital interface the power needed was estimated to 3 watts, 1 W for the mp3 and 2 W for the speakers and the arduino. It is further assumed to be playing 8 hours a day, which is not very likely but it could happen occasionally, which means that we each day would need 24Wh.

The month with the least number of sun hours in Lisbon is December with an average of 5:07 a day (Climatemps, 15 January 2014) Therefore the calculations were made based on a day with 5 hours of sunlight with the conclusion that there is a need of 4.9W from the sun.

The next issue is to size the battery needed for Banco Sol to work at all times desired. This was done with the help of a solar panel page online (rimstar.org, 10 November 2013). Here again some assumptions and decisions had to be made, for example that there will be maximum 1 day without sun, this was decided in order to keep the battery size down and limit the costs. To increase the battery life it was also decided that it should not be discharged more than 50%.

Since the battery will be kept in an unheated place and cold has a negative effect on the capacity it was also relevant to include this in the calculations. The calculated minimum battery needed is after all these considerations 4.44 Ahr.

Both the solar panel and the battery will be for 12V.

The detailed calculations can also be seen in Appendix A.3.2.2.

3.3. Interface

3.3.1 Simple Model

To keep costs down a very simple interface design is preferable. The simple model interface will consist of a simple PVC, or wooden panel with some short information boxes about the project and an introduction to solar energy. This design can be seen in Figure 3.2.

Figure 3.2. First page of simple interface.

Furthermore it will have three buttons on it: a 'previous/yes' button, a 'next/no' button and a 'start' button. With these three buttons, music can be controlled in a very simple way. When a person sits down the system is automatically in 'Normal Mode'. In this mode a person can switch between songs with the 'previous/yes' or 'next/no' buttons. When the start button is pressed, the 'Interaction Mode' is activated. In this mode the listener hears questions about solar energy, instead of music, which he can answer with yes or no pressing the 'previous/yes' or the 'next/no' buttons. In this way the listener can react to the information he receives, by testing him or herself.

3.3.2. Advanced Model

If the budget is big enough a more advanced and interesting interface can be applied. Instead of a simple panel, a touch screen can be used, highly increasing the interaction possibilities. This design can be seen in Figure 3.3 underneath.

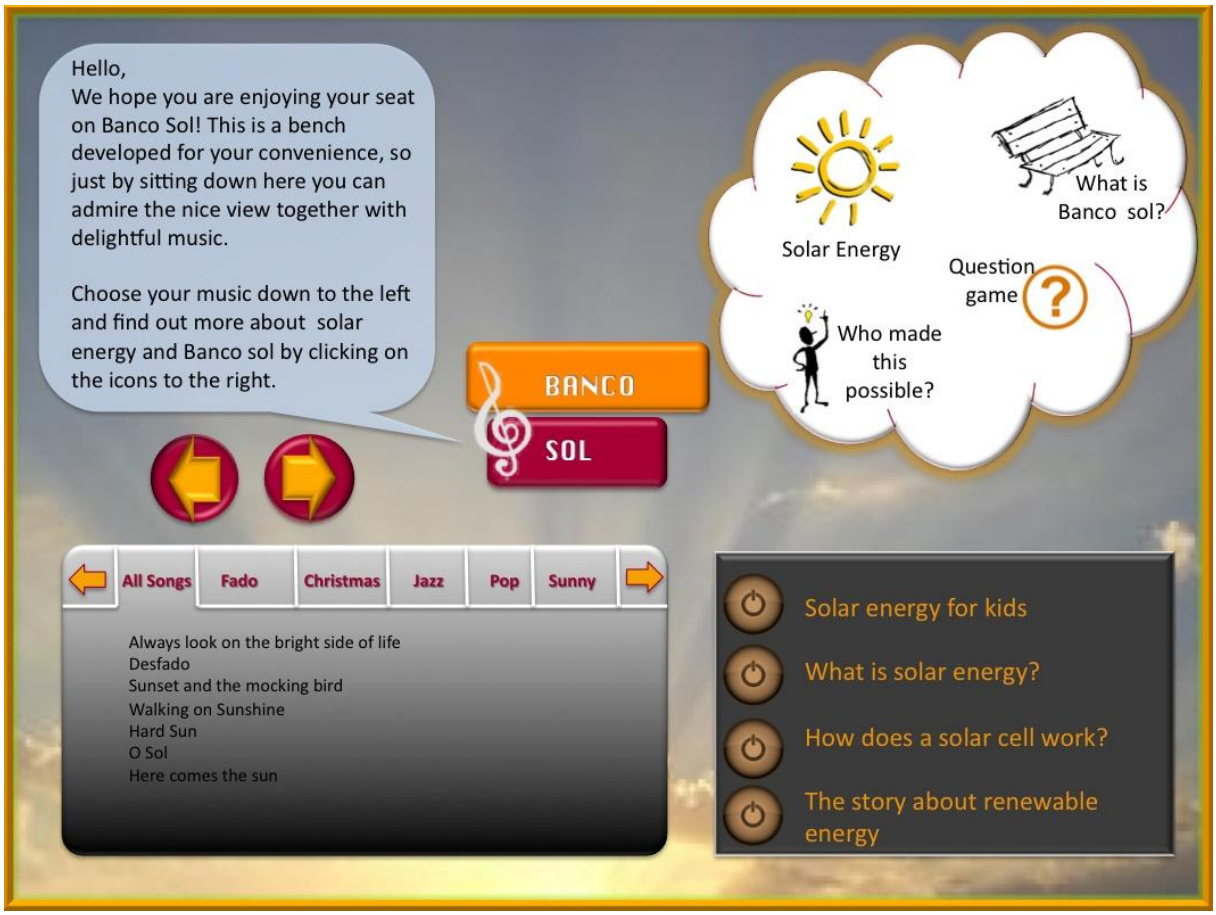


Figure 3.3 First page of digital interface.

The user can scroll through the songs on the screen and also choose between different playlists of different genres. Information can be provided in a more varied manner. Only a short introductive textbox will be shown on the screen, explaining the project and the instructions about how to use the interface.

Other information boxes are not directly shown on the screen. Instead there is an area with icons, representing the different paragraph themes, on which the user can click to open the textbox. In this manner the user can choose which themes interest him and browse through the information clicking around. Furthermore there will be some informational videos that allow the users to learn in a more fun way. This is an important advantage of the more advanced interface model since especially younger generations will be more attracted to use the interface.

4. Business plan

4.1 Costs

For the initial prototype as well as for the final prototype an oversight of expenses can be found in the appendix under A.4.1 and A.4.2. As can be seen in table A.4.1 for the initial prototype, many things was borrowed which made it possible to limit the expenses to 28 euros. Looking at this price, one should take in account the fact that this prototype is not suitable for long term use.

When implementing a more long term installation, the price range could vary from 106,5 to 112,5 euros as shown in table A.4.2. (alibaba.com, 21 November 2013). The difference with the price plan of the initial prototype lies in the fact that all components used must be purchased and the additional purchase of a solar panel. Furthermore there is the need to buy a more expensive battery, which can save excess solar energy produced by the panel on moments of intense solar irradiation, for moments when there is no sunlight. In that way, the installation works also in the evenings.

When installing Banco Sol in a public space, the components should be protected from theft, rain and others by a closed cover of a suitable material. An easy solution would be to create a box made of PVC with little holes one horizontal wall to pass the sound from the speakers. PVC plates can be purchased for a few dollars or euros, so this would not increase the total price immensely. Greater expenses would be concerning about the interface. The simplest model presented in section 3.3 could be manufactured in the same PVC as used for the enclosement box equipment. This would keep the price at an acceptable level.

The digital interface on the other hand makes the expenses rise significantly. A touch screen that it is a rainproof, like M9010 by DAP technologies, costs 3000-4000$. Also for this tablet has to be built in an enclosed PVC structure to prevent it from being stolen.

The ultimate decision will depend on the budget provided, which is discussed in the next section.

4.2 Costs Coverage

Since Banco Sol is a way of promoting solar energy use, it is the ideal advertisement place for solar panel producing companies. For those companies it is utterly useful that more and more people get familiar with the idea and advantages of solar energy, since it might also convince people to get solar panels on their own buildings. Banco Sol works better than any other simple advertisement panel or website with the same purpose, because it informs the users in a stepwise and enjoyable manner. The logo of the solar panel company can be displayed on the interface and there is the possibility of

audio-advertisement in between the songs and information texts. Examples of steakholder companies are Ecoenergias Portugal and Neosolarenergia.

It would also be of interest for other associations working for the energy efficiency in Portugal. One example is ADENE, a center for energy conservation. They work as a mobilizing agent for national energy sustainability through informing, educate, share and implement new ideas and solutions. Joana Fernandes an engineer at ADENE was contacted. She confirmed that she could be interested in cooperating and that the concept may be of good use for promoting the initiation of solar energy.

4.3 Promotion

To promote the concept of Banco Sol several communication channels were to be used. First of all it was very important to stay close to the opinions of the inhabitants of Mouraria, and to speak to them continuously during the development of the project.

This is why at several stages in the development interviews was held.

Second of all modern media was an important mean to reach people's attention. The first social media used was facebook. On this site an event was made for the testing day of the prototype. Readers received a short explanation of the project and were invited enthousiastically to come and try it out themselves.

On the day of the testing itself, every invited person and person passing by, received an extended explanation of the project and was invited to sit down on the bench and interact with the first version of the digital interface.

Finally a representative selection of reactions was asssembled in a short promotion video, which was showed on the presentation day in Intendente and can be seen on Youtube via the following link: https://www.youtube.com/watch?v=2xqK5IYweCo

5 Discussion

5.1 Feedback after Presentation in Mouraria

The idea was presented in Mouraria. Both the prototype and interfaces were shown to the locals and university researchers. After the presentation several ideas for the project was given from the audience.

One problem that was mentioned was the risk of noise pollution. This noise could disturb the people living and working nearby. Another suggestion that partly would take care of this problem was to make Banco Sol without a battery. This would make the function of the sun more obvious and also prevent it from working late at night when it is dark.

Banco sol would be a permanent installation and therefore there is a risk that the equipment would be stolen or harmed. The PVC box would protect the mp3 and speakers. If Banco Sol had a digital interface at Mouraria or another type of equipment with high value, probably the material of the enclosing box will not keep safe the equipment.

After the presentation it was suggested by one of the researchers from IST to make a real version of Banco Sol in Lisbon. It was briefly discussed that it could be a part of a Fado tour in Mouraria but also other locations in the city outside of mouraria was suggested as good spots to make Banco Sol. In this suggestion there might be some help with finances and some simplifications would also have to be done.

Banco Sol was mainly perceived positively by the audience and the participants tried to encourage the project, since it will add value to the Mouraria neighborhood.

5.2 Final Thoughts

The Banco Sol idea was not created from one specific community problem of Mouraria. It is directed toward a more general worldwide problem; the importance of new and sustainable energy solutions. However drawing attention to these problems is specifically difficult in multicultural neighborhoods like Mouraria and for this Banco Sol could be a good communication channel.

Banco Sol should inform about the possibilities of the energy from the sun. After analyzing the feedback, the group realizes that avoiding the battery on the circuit, besides reducing the budget, it will better demonstrate how the solar panel works. It would for example make it clear that a solar panel still can collect solar energy on a cloudy day. This way Banco Sol would also not play at night, avoiding the possible complains about noise at late hours.

Although the simple interface is less informative than the digital one, it would still be the better choice in Mouraria, since a digital one could be more difficult to use for the elderly in Mouraria. It would also be under a lower risk of getting damaged or stolen. If Banco Sol was to be built in another neighborhood the situation could be different. If it was built in Oriente the digital interface would be the more suitable option.

Finally if Banco Sol ever becomes reality is still uncertain, what is sure is that the project presented in this paper has good potential and can contribute with innovative ideas for future projects.

References

Climatemps, accessed: 15 January 2014, http://www.lisbon.climatemps.com/sunlight.php

Rimstar.org, accessed 10 November 2013, http://rimstar.org/renewnrg/sizing_select_batteries_for_off_grid_solar_system.htm

Alibaba.com, accessed: 21 November 2013, http://www.alibaba.com/showroom/pvc-plate.html

Appendix

A.2.2 Programming

This was the code written for the prototype:

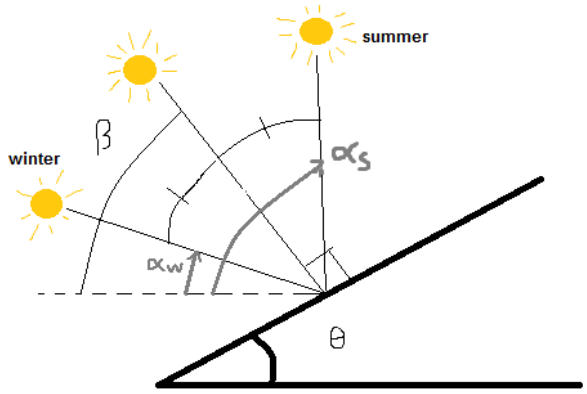
```
const int infraPin = 2;
const int musicPin = 13;
int prevState = 0;
int infraState = 0;
int starttime=0;
int endtime=0;

void setup() {
  pinMode(infraPin, INPUT);
  pinMode(musicPin, OUTPUT);
  infraState = digitalRead(infraPin);
  /* The ipod will allways start with playing so if during he startup noone is sitting on the bench it will
start by pausing the ipod.  later it will pause or plau as a change occur in the sensor input*/
if(infraState==HIGH){
    prevState=HIGH;

    starttime= millis();
    endtime=starttime;
      while((endtime-starttime)<=500) {    //the button has to be pushed for about 0.5 sec
      digitalWrite(musicPin, HIGH);
      endtime=millis();
    }
    digitalWrite(musicPin, LOW);
  }
  else{
    prevState=LOW;
   }
 }
void loop() {
  infraState = digitalRead(infraPin);
if (infraState != prevState) { //when there is a change the ipod will pause or play
starttime= millis();
    endtime=starttime;
    while((endtime-starttime)<=500) {
    digitalWrite(musicPin, HIGH);
   endtime=millis();
    }
    prevState = infraState;
    }
  else {
    digitalWrite(musicPin, LOW);  //if nothing new happend
     }
}
```

A.3.2.1 Angle of Panel

Assuming solar panel facing south:



Find the angle θ such as at noon at winter and summer solstice the angle rays with panel will be the same.

At noon: $\alpha = 90° - (L - \delta_s)$
where L is the locations latitude and $\delta_s$is the solar declination which varies along the year.

Winter solstice: $\delta_s = -23.45°$
Summer solstice: $\delta_s = 23.45°$

Latitude Mouraria: 38.72°

Winter: $\alpha_w = 90 - 38.72 - 23.45 = 27.83^0$ Summer: $\alpha_s = 90 - 38.72 + 23.45 = 74.73^0$

$\beta = \frac{74.73+27.83}{2}$ =51.28° ; $\beta = 90° - \theta$ → $51.28° = 90° - \theta$ → $\theta = 38.72°$

Comment: If it is desired to be more efficient during winter increase θ, to make more efficient during summer decrease θ.

A.3.2.2 Solar Panel and Battery

Table A.3.2.2.1

Avrage sun hours in winter never is under:	5
assume we need (w)	3
hours a day	8
power we want(Wh)	3*8= 24
solar energy we need (W)	5/24= 4.8

Table A.3.2.2.2

battery (assuming 12V):		**AMP Hours**
amp hours/day	24/12=	2
assuming max 1 day without sun:	1*2=	2
dept. of discharge	0.5*2=	4
Temp. Multiplier according to table A.3.2.2.3	1.19*4=	4.76
RESULT (Ahr):		4.76

Table A.3.2.2.3 shows the multiplier to be used corresponding to the coldest average expected several days in a row in the area.

Degrees Fahrenheit	Degrees Celcius	Multiplier
80°F	26.0°C	1.00
70°F	21.2°C	1.04
60°F	15.6°C	1.11
50°F	10.0°C	1.19
40°F	4.4°C	1.30
30°F	-1.1°C	1.40
20°F	-6.7°C	1.59

The multiplier chosen is for the temperature 10.0°C since according to climatemps the lowest monthly average is 11.4°C (January) and the average minimum temperature goes down beneath 10°C.

A.4.1.

Arduino Uno	borrowed
Breadboard	borrowed
Wires, battery	borrowed
Resistor	borrowed
Mp3	11€
Infrared sensor	13€
Speakers	borrowed
Several jaks	4€
Total	28€

A.4.2.

Arduino Uno	8.5€(ebay) 20€(arduino site)
Infrared sensor	13€
Mp3	11€
Solar Panel	8-14€
Speakers	15€
Wires,resistor	5€
Battery	40€
Breadboard	6€
Total	106.5-112.5€