2013

Sunegal project

Sunegal PROJECT

Minor Field Study

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In partnership with InnovEd and Generation Non Violente

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Thanking:

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Abstract:

This report presents the voluntary work of 5 international students completing a master at KTH University about the design and installation of a solar PV system for an educational building in Senegal. The preparation and organization of the team is presented. The design of the system, the communication with the different actors and the fund raising parts are described. The work on the field and the installation is explained step by step. Finally, perspective for future work is proposed and each member of the team gives his own impressions about this great technical and social project.

Contents

Introduction

Everyday violence and energy lack are two major problems in Casamance, Senegal. Since 1982, a separatist movement and the state of Senegal have fought against each other, creating violent conflicts. Since education is not provided for everyone, young people are born in this context of violence and this only makes the conflict continuing. Lack of electricity is one of the reason preventing children to go to school or having good class conditions.

On the other side of the Mediterranean Sea, developed countries have the knowledge and capacity to help Senegal. Five students of KTH University in Stockholm, Sweden decided to create a voluntary project and find a solution to improve the situation. All of them following a master about sustainable energy engineering, they started the project Sunegal in December, in partnership with InnovEd from Sweden and Generation Non Violente from Senegal and France. They were wondering how to improve the social context by improving the energy access in a sustainable way.

During 6 months of preparation, they were designing a solar PV system and looking for funds in order to buy and install themselves this sustainable energy system for an educational building of Generation Non Violente. This paper presents the preparation work of this voluntary project, the installation on the field, the results and finally our personal impressions for this international experience.

1) Context

Figure 1 : Senegal location

Sub-Saharan Africa has the greatest number of people without access to electricity. More specifically, the number of people that experience that basic need are 465 million in rural areas and 120 million in urban areas [1]. In the same time, the high rates of development in Africa result in increased energy needs.

Situated in the region of West Africa, Senegal is a country with a very promising future. It is considered the most developed country of that region while at the same time, it is observed that many industries have been founded through the latest years, while telecommunications and renewable energy are the sectors with the highest potentials of investment and development.

However, Senegal didn't use to be always like that. During the past, it has been suffering by a civil war. In the region of Casamance, in South Senegal, separatist groups had been fighting for many years with the government army in order to establish Casamance as an independent country. That civil war has cost the lives of 5000 people in total [2]. Even though since 2005 the two sides have achieved a permanent ceasefire and a peace treaty that seems to last until today, there are certain groups of rebels in Casamance that are still active. That means that there is still work to be done until the conflict is totally terminated.

Generation Non Violente

Generation Non Violente [3] is a French-Senegalese organization that is active in the whole region of South Senegal and aims to educate people, teach them about the value of peace and teach them how to solve their differences through peaceful and democratic ways, without violence. The role of "Generation Non Violente" is essential and the impact is huge if one consider that usually 300-500 young people participate in the seminars every single time.

The Problem

Even if "Generation Non Violente" (GNV) has a great and wide support by Senegalese people and there are many persons that contribute to the efforts made, the lack of financial support result to the fact that the organization faces obstacles to extent their activities.

In the village of Brin, a small community 7 km far from the capital of Casamance, Ziguinchor, GNV owns an educational building, where many activities take place. However, the building is not connected to the grid and therefore cannot be totally functional for the purposes of 'Generation Non Violente'. Not only educational activities such as film projections and computer rooms cannot be supported, but also there cannot take place evening classes because of the lack of lighting. During summer, ventilation fans would have to be working since the climate is very warm.

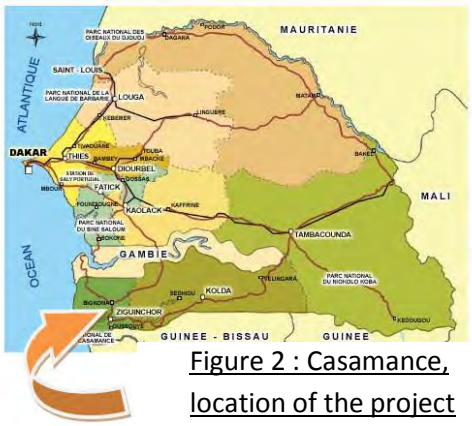


Figure 2 : Casamance, location of the project

The low reliability of the grid, the high cost of power generation and grid connection and the high rates of pollution, make the usage of an energy system for the building that is based on renewable energy essential, it is cheap and able to provide at any moment the needed energy.

The Solution

Five MSc students of KTH in Stockholm, coming from different countries in all around the world, with different engineering backgrounds but sharing their common interest on renewable energy and many hours of higher education on the specific field, decided to solve the problem of lack of electricity that 'Generation Non Violente' has. In order to achieve that, they built a project called "Sunegal Project", through which they would try to find a feasible solution for the respective problem. The project was separated in five different parts at which, each person was responsible. The team work and involvement of all the students to each part was essential in order to accomplish it. The five different parts were:

- Project manager part: Responsible for organization and planning of the project. He is also in contact with the association in Senegal and France.
- Technical manager part: Responsible for the technical part, manage the design of the system.
- Supplier manager part: Responsible to come in contact with the equipment supplier companies and order all the necessary equipment.
- Financial manager part: Responsible for managing the financial part, mainly for finding sponsors, and manages expenses and revenues.
- Logistics manager part: Responsible for planning the trip, accommodation, vaccines and other questions relative to the host country.

After assessment that the team members did, the optimal way to electrify the school was by usage of solar energy. The two major facts that lead to this decision were on the one hand the high solar irradiation (5.65kWh/m2/day) in the area and the relatively low wind that made the appliance of wind turbines not feasible [4].

Innoved Association

Innoved is an organization that was founded by former MSc students of KTH after achieving a similar project that included a wind mill in Namibia, in order to help future projects that would aim to help developing countries. At the same time Innoved would help to build a network for KTH students and create communication paths between different projects.

As far as the Sunegal Project is concerned, Innoved helps through different ways. They guaranteed financial support for the travel tickets that would be needed for transportation to Senegal. Also, they brought different projects in contact in order to exchange ideas and knowledge. Moreover, the attempted to create a network of contacts of companies and persons that would be eager to help their projects.

The help of InnovEd had a significant role in the development and the success of Sunegal project.

2) Preparation

At the beginning of the year, some representants from Innoved came to present their association during a class. As a group of friends, we had the idea of creating a project that would fit in the motivations of this association. We also knew the association "Generation Non Violente" who was teaching people how to solve conflicts using mediation instead of violence and trying to solve the issues in Casamance. That's how we decided to improve education in Senegal by an innovative way using renewable energies.

The first step was to divide the project into several parts in order to split the work and responsibilities and go forward in an efficient way. The project was divided in five different parts described previously. The preparation in each of these parts was essential to realize the project.

Project management:

The first step in the management of the project was to make a plan for the next year coming and be sure that the system would be ready on time. A Gantt chart was made and can be seen in annex 1.

At the beginning of the project, an energy assessment was led with a questionnaire sent to Generation Non Violente in order to get precise values and facts about how they were going to use the school. A discussion was then organized on skype in order to clarify some data. The document can be found in annex 2.

Meetings were then organized regularly, on a weekly basis in order to assess the work done and define the new objectives. During a meeting, each of us firstly presented their work and the issues to discuss. Secondly discussions were made on these precise points and decisions taken. Lastly, new objectives for the coming week were defined for each part of the project, checking that the gantt planning was respected.

In between meetings, the communication was done either directly speaking or by emails. A common database was also used on googledrive in order to share and give access to all documents to everybody. It was also a way to help each other and discuss about the work of the others.

The project manager also kept contact with Innoved and the other projects from Innoved by organizing common meetings and sharing the ideas. This was mainly used for the financial part where we shared our contacts and our ideas of communication to get a sponsor. Contact with Generation Non Violente was also constantly kept by skype meetings and email exchanges. It was even more regularly approaching the date of departure in order to get the last logistic details set.

Technical part:

All the technical aspects of the system needed to be designed and prepared before going to Senegal. The first step was to know the electricity demand of the building via the questionnaire in order to design the system. Parallel with this, the solar potential of the region was studied. The NASA website was used to get data about the resources [4]. Once this information was known the capacity and size of the PV array could be selected. Different consumption scenarios were proposed but according to the budget finally found, it was determined that with a capacity of 1.1 kW the average demand could be satisfied. Eight panels of 145 W each were selected. Regarding the battery bank it was decided to design it for two days autonomy considering a solar irradiation of only 20% during these 2 days (using equivalent number of NO-SUN days given by the NASA [4]). Using the information on the survey for estimating the demand of the building, the capacity of the batteries was determined. Finally, a charge controller and an inverter (DC to AC) that matched the characteristics of our system were selected. The transmission losses on the cables and devices were considered in the calculations.

Suppliers had then to be found according to the technical needs previously stated.

Suppliers part:

A research in the internet was made about available suppliers of photovoltaic systems in Senegal. As intercontinental phone calls are very expensive and skype often does not work well the communication was made with e-mails. Many companies did not reply. Some of them did. One called *Rayon Vert* offered a good price/quality ratio and was very accessible for each query [6]. After having determined the right design several offers were made by the company. A special attention was put on buying components that would be easily exchangeable. That is why the idea of bringing the components to Senegal from Europe by ourselves was rejected. The main advantage of *Rayon Vert* was that they used modules that were manufactured in Senegal with high quality Bosch-cells. Therefore they would be easy to replace in case of failure and in the same time would develop the local economy.

Figure 3 : Supplier company in Dakar

Once suppliers were found, fund raising was our main concern to make this project a reality.

Financial part:

The financial management aimed the finding of sponsors to fund the project. To do so, many skills of marketing and sales were needed. Innoved provided us with many tools to find sponsorships: they organized a Sales Workshop where we learnt many selling tips; they also gave us our own webpage in their domain and email accounts just for the project. We also designed a brochure summarizing the context and goals of the project and stating what we were asking for. We started calling the companies listed on the Armada catalog; these companies had already funded KTH student's activities. Each of us was responsible for calling 30 contact people from the catalog, give a brief presentation of our project and try to get a meeting to give further details. We tried to sell our project offering more visibility among KTH students. Beside these companies, solar technology companies and banks were contacted. We attended to the events organized by KTH in which companies were invited, where we tried to present them our project and try to get more contacts. Even if we tried for more than four months to get sponsors, no company could fund our project, due to differences in the aim of the project or lack of funds. Finally, on April, we applied for a Minor Field Studies grant, a scholarship provided by the Swedish International Development Office that aims to provide an opportunity to students of Swedish Universities to improve their knowledge on a certain subject in a developing country. The purpose of our project fulfilled MFS requirements, so we could obtain the money to afford the solar PV system and realize our project.

Finally, in order to prepare the trip, logistics was anticipated and prepared.

Logistics part:

The logistics part of the Sunegal project, aimed to organize and prepare the travel, before and after the arrival to Senegal. The preparation of the travel, focused mainly on the essential actions that would secure the team members and would provide all the essential information that would be needed.

In order to travel to Africa, it is important for the travelers to take certain protections for their health. Such protections were on the one hand a list of certain vaccines that the students should check if they have taken in the past. If not, they had to have the vaccination at least one month before the arrival to Senegal. Such vaccination included hepatitis A and B, yellow fever and typhoid, while cholera vaccin was optional. All the students had to take some of them, so they attended to the City Accuten Vaccination center in Stockholm. Moreover, the risk of malaria infection in Sub-Saharan Africa is very high, so the students had to be informed about the medication and the side effects of different pills that would provide them a significant protection.

Furthermore, the logistics manager of the Sunegal project was responsible about the tickets research and reservation. Since the students were not able to have the same dates and airports of arrival and departure from Senegal, a research had to be done in order to find the optimal tickets and prices that would minimize the travel cost and which would fit in each ones flexibility.

In addition, the ways of traveling inside Senegal had to be investigated. Since the place of the project was not close to the airport of arrival in the capital Dakar, different ways of transportation from place to place had to be examined in terms of time, cost and safety.

Lastly, a travel to such a different for the European standards place requires information on different things that someone can easily neglect. Such information had to do with the ways of communication, essential equipment, the way of life and traditions, dangers such as smuggling etc.

After these 6 months of preparation, the time arrived to go on the field. Everyone having his flight ticket, the team met in Senegal in the first days of June 2013. The field work started.

3) On the field

Suppliers :

Through our contact Camille in Senegal, who is the head of *Génération non violente* we got another offer of a firm located in Dakar. This company sold only Chinese components. He didn't appear as professional as *Rayon Vert* and the quality of the modules did not seem as good as the German/Senegalese modules. Even though the price was significantly lower (around 4500 euros vs. 5700 euros for *Rayon Vert*) we decided to choose *Rayon Vert's* system. The contract was signed and the company's owner agreed to visit the site once finished to assess the quality of the installation and to assure a guarantee. Afterwards, William was showed how to mount the supporting structure as he stayed longer in Dakar. He was going to travel with the system and Mafer and Foivos down to Ziguinchor. The system was composed of 8 modules of 145 Wp, 8 batteries of 6V and 125 Ah, an inverter of 1,2 KVA, a charge controller of 40 A and 55 V, the supporting structure of aluminum, cables and groundings. This equipment was all transported on a 7 person's car. The 500 km track was through bumpy roads but the system arrived undamaged.

Figure 4 : Signature of the contract

Bring the equipment:

Bringing the equipment was the first step of the field work, and not the easiest one. One morning, we had to fit in a 7-seats car and on its roof: 8 batteries (250kg in total), 8 solar panels (more than 100kg), cables, controller and inverter, some gifts we had to bring for a festival organized in one of the towns before Brin and 5 people whose the representant of the minister of youth.

Figure 5 : Equipment ready for the trip

We did manage to fit everything and started our road trip on bumpy roads through Senegal and Gambia (necessary to cross Gambia and the river). At a checking of passports and visa at the border, we had to wait 5 hours in the sun and 40°C for the ferry to bring us. A long line of vehicles was waiting already. We lost time again when the ferry got stuck in the port because of a wrong movement from the pilot. Fortunately we could get off the boat in another place, directly on the soil.

Proof is that things are hard to plan in Africa.

After this delay, we still had to reach the place. But after 8 oclock in Casamance, roads are closed for security issues because of rebel attacks. It was already 8 and after few kilometers we faced a military barrage. The village didn't have electricity, nothing to propose for eating and we were running out of water. Fortunately, the representative of the minister got some contacts and after some calls, managed to get the road opened for us. We finally managed to reach the place around 10pm, relieved after these "adventures".

We therefore experienced the difficulties for travelling inside the country that people are facing every day. We realized that the sense of organization and service is much different than in Europe. In the middle of the country, there is nothing and sometimes no one to help you and anticipating the unpredictable is necessary… Once on the spot, the field was studied and the installation started.

Location of the panels:

In order to secure the highest energy absorption from the sun during the whole year the placement of the PV panels was carefully studied. Orientation, inclination and height above the ground were key variables for this. Since Brin is located around 13 degrees latitude North, this will be the optimum declination angle if the best performance is desired all over the year. The orientation of the system had to be due south because the solar beams will be reaching the system most of the time from the south.

Initially the system was going to be placed on the ground in a place where no shadows would cover it at any time along the year. However, the area that matched these characteristics was considerably far away from the connection point with the charge controller. This would have increased significantly the cost of the cable going out from the PV and would have implied greater electricity losses in the cable. Outside the technical point of view, the used of this space would have limited the area for activities. A closer place to the charge controller was found between the two buildings but the location required certain elevation above the ground in order to avoid shadows from the buildings during the whole year.

Structure:

This problem was solved with six concrete pillars to place the PV structure. Generation non – Violente had the possibility to make this fast and economically viable.

Figure 6: System location before installation

Figure 7: System location during installation

The first row of pillars was designed to be 2,80 m high, just enough to avoid the shadow from the bathroom building during the winter months. The other row of pillars is 3 m high in order to avoid shadows from the first row of panels in this period also.

In order to keep the photovoltaic panels in a specific position and angle, a metallic structure was essential. The one used in the project was provided by the supplier of the system. Two metallic trusses were used on which were placed four and four panels respectively. The trusses were made by aluminum in order not to be corrupted by humidity and rain.

Mounting the solar array:

The first step was to lift the metal structure to the top of the pillars. It was necessary to use a scaffolder in order to work in a more comfortable way above the ground. To secure the structure on the concrete pillars basically two techniques were used. The first one is to make a rail at the top of each pillar to place the metal structure and limit its movements. A bolt was used to fix it on the rails of the pillars. The array was fixed at its gravity center point and not at the middle of the leg (since the structure was inclined). The second technique consisted on steel profile segments located in the angle between the PV structure and each pillar. Each segment was bended and welded in order to get the desired shape. This would help to keep the balance of the whole array. Once the structure was secure on top of the pillars, very carefully, one by one each PV panel was lifted and fixed with four bolts over the structure.

Figure 8 : Fixation to the pillars

Figure 9 : Structure reinforcement

Communication problems with masons:

Even though French is the official language of Senegal and we had French speaking people in our group, we faced many communication issues. It seems like many expressions or ways or speaking are not well understood. Sometimes, when we made a question, we got the answer for a different question; so we had to ask in a different way several times until we could find the answer to our question. These communication issues create some problems with the masons, since at the beginning we assumed that they had understood what we wanted. Then we decided to repeat several times and in different forms what we needed to ensure we were understood.

Lack of precision:

Probably the masons are not used to work under certain requirements. Usually they build a whole edifice by themselves, so they don't have to integrate their work with somebody else's. In this case, we required a lot of precision in the distance between the pillars, since we needed the structure to fit perfectly over them. We assumed that they would build them at the required distance, but when we measured it they were further than required and the structure didn't fit on the pillars.

First, we tried to modify the rails on the pillars, but they were too close to the edges, so the concrete was breaking. Then, we decided to modify the distance between the legs of the metal structure to make it fit with the pillars, we drilled the wholes for the screws where we wanted them and changed the structure. In this way, we could put the structure over the pillars. After this mechanical work, cables had to be pulled until the inside of the building to connect to the main panel and the battery bank.

Electrical part:

A photovoltaic system is using quite basic electricity principles; the electrical diagram can be seen in Annex 3. The 8 solar panels are arranged in 2 parallel lines of 4 panels in series. Therefore, the voltages of the 4 panels are added up to 38V and the 2 series cumulate a current of maximum 16A. The cables coming from the panels are connected to the charge controller and the ground cable connected to the grounding in case of lightning.

The 8 batteries of 6V are connected the same way as the panels with 2 parallel lines of 4 batteries in series. Thus, we get two lines of 24V batteries connected to the charge controller in order to avoid the overcharge from the panels.

The inverter is then connected to the batteries to convert the direct current of 24V into 220V alternative. The inverter is also avoiding the deep discharge by cutting the load in case of too low battery. The inverter is connected to the grounding in case of short circuit.

The cable coming from the inverter is then connected to the main panel of the building with all the fuses and switches (one per room). Each room can then be connected or disconnected manually if needed or automatically in case of short circuit.

Grounding already existed but was quite old, corroded, outside the building and not maintained. Therefore, a new grounding was installed and the 2 groundings were linked. This assures that the panels, the loads (and people using it) will be protected.

Figure 10 : Inverter and charge controller

Monitoring:

In order to guarantee that the system would work fine, a monitoring of the voltage and current was necessary. This allows detecting a possible malfunction of the batteries and a correct production of the panels. Furthermore, it enables a future historical study of the system. Several options were available [7].

1	Global remote	1000$
2	BMV 600s + RJ45 cable for computer connection	289$
3	BMV 600s	139$

Figure 11 : Solution one, global remote

The 1st option is a wireless connection from the global remote connected to the battery to every device having an internet connection such as a computer and a mobile phone. The price is around 1000$.

Figure 12 : BMV600 from victron

The 2nd option is a display connected to the battery showing the instantaneous value of the current and voltage coming in and out of the battery. Furthermore a cable connected to the computer allows transferring the data. The cable has to be connected constantly. It is a cheaper option but it has two disadvantages: one is that when the computer has to be used for other purposes it can't record and the second is that it has to be on constantly.

The 3rd option consists of only the display without the cable. Therefore in order to obtain the values a person has to write them down in a certain recurring time. This option was the cheapest.

After a democratic decision the 3rd option was seen as being the most appropriate comparing the user friendliness to money relation. The way of installing it is shown on figure 13.

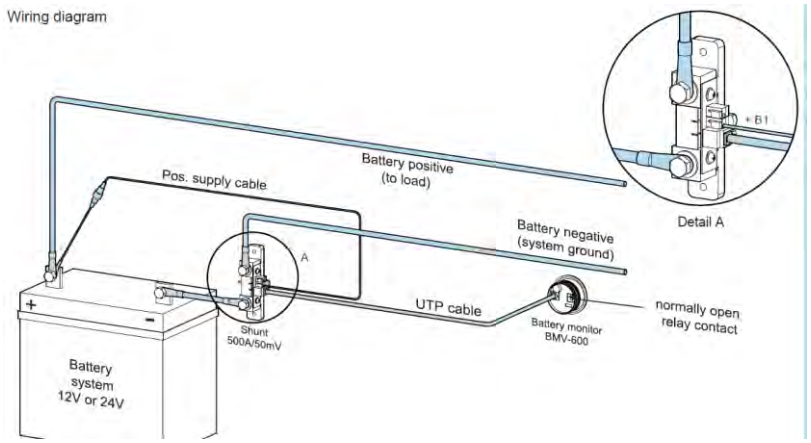


Figure 13 : Diagram for mounting the BMV

As the money of the minor field study was exhausted the team members had to contribute with their own money.

This study was the last step of the work on the PV system. After this one month engineering the PV system on the field, it is suitable to make a point with the achieved goals and outcomes of this project.

4) Outcomes and results

The system installed had finally been successfully tested during the inauguration. People from the association Generation Non Violente, people from the village and people we met were invited for the event. We presented our installation and each of us delivered a speech about their feelings and experience in Senegal. As the building will eventually be used for movie projections in the future, a movie was then projected on a wall in order to show that electricity was effectively provided. A fika completed the evening and allowed us to meet the landlord of a hotel who also wanted to install a solar system.

The system was running well for the inauguration but other tests were made in order to assess its capacity. Lights were turned on in order to get a power of around 800W. We left them on for around 12 hours, representing 9600kWh, waiting for the device to cut the load (deep discharge protection). Our battery bank should be able to handle 10800 kWh and therefore the charge controller should cut the load before that. Since it was not disconnected yet, we left some lights and devices on during few more hours. The charge controller indicated that the battery was low (not critical but low) but it still didn't disconnect the load. Since we would have probably reached the whole capacity of the battery, we decided to disconnect the load manually.

After a discussion with Rayon Vert and its suppliers, it appeared that it was not the charge controller which was supposed to disconnect the load but the inverter by connecting it in a slightly different way (way described in the electrical part. Previously, the inverter was connected at the output of the charge controller and not to the batteries directly). The connections were done but time was missing to test the deep discharge control again.

A maintenance guide was written and in it was precised that the load should be disconnected when the light of the charge controller becomes orange. So that the battery bank is not going to discharge more than around 60% of its capacity, representing already 6480kWh.

In order to get a more precise idea of the capacity of the battery bank and the behavior of the system, the monitoring device described previously has been bought in France after the project. It is going to be sent to Senegal in September 2013 and be installed by a technician.

Usage of energy:

The next step of the project is to find a way to use the solar energy produced during the day when no seminars are organized. One of the proposed solutions was the installation of plugs on the outside wall of the building connected to the panels, where people could go and charge their mobile phones during the day. This would also include a switch to allow the owners of the building to unplug the electricity that goes outside, when they require more inside. Other possible solution was the charging of lamps and rent them to the villagers for lighting and mobile phone charging.

These solutions have not been implemented yet because time and money were missing. But Generation Non Violente is planning to do. A discussion with the population is crucial since social factors should not be neglected here.

The objective of giving electricity for improving education has therefore been achieved in this project. The building of Generation Non Violente will be able to welcome more students during more time for teaching them mediation and hopefully reduce the conflict in Casamance step by step. This project was a great technical and human achievement. Each member has lived this experience in his own way and the last part of this report is giving the opportunity to each one to describe his own impressions.

5) Personal impressions:

William, project manager, French:

This experience in Africa was really intense and rich. The population and the mentality is clearly different than Europe. What is striking is that people are always smiling and ready to help you. Every people you meet, even if you don't know them, will ask you "how are you?". This is the polite way to say "hi" at anytime of the day. They look happy and this makes us, European people, realizing that material things have less importance than relationships. They spend time with their family and friends and this is their main source of happiness.

The climate is obviously way different than the one of Sweden. In June, it is the hot season and the beginning of the rainy season. The temperature is quite hard to live, even more during the night when it does not go down. Therefore, infections happen easily with the humidity and high temperature. Contrary to Sweden where homeless people have to face the cold, here living outside causes less difficulties.

In a technical aspect, the project was also really rich. I improved my skills on solar technology by designing the system and adapting it to the environment. The most complicated part was to face all the unpredictable difficulties on the field and find a solution to each of them. But every time we came up with an idea and managed to solve the problem. We had to face mechanicals problems with the structure and its robustness, electrical ones with the connection of the battery bank, supply issues for making the concrete pillars… This is the reality of the engineering work added to the difficulties of organization encountered in the country that we experienced during one month.

Finally, the communication was also a great deal here. The communication with local people first because tasks have to be clear to make it precise (such as the dimensions and shape of the pillars for the structure). And second inside the team, in an international context. The way of solving the issues was sometimes different for some of us and we had to discuss to find the most suitable one. Discussions happened many times but after giving arguments we always tried to finally choose the best solution for the system.

Luis, technical manager, Venezuelan:

The Sunegal project was a very enrichment experience from the professional and personal point of view. It was an amazing opportunity to be in contact with renewable energy technology and use it to make something useful for those who need it.

Many things are neglected or not considered on paper calculations. Simple things like communication among the staff and personnel, availability of resources or conditions of the site may complicate unexpectedly the development of the project on the field. These were the situations when our team had to come up with new ideas in order to solve the problems. The learning process and experience earned under this situation is very different from the one of the classrooms. Having the opportunity to apply the knowledge acquired in the master program on the field, is without any doubt the best way to complement the academic education.

The people in Senegal are very nice and polite. No matter where we go, everyone was always smiling and happy, ready to offer you help in case you need it. I regret not knowing how to speak French because this could have allowed me a better understanding of Senegalese society. However, I could see they are very hardworking persons with high moral values.

Claudio, supplier manager, German/Italian:

I have always wanted to practice my knowledge in the renewable fields and achieve something beyond the classroom. The Sunegal project was ideal for that. We had to prove skills in search for financing, designing a photovoltaic system, finding suppliers and finally installing the solar system and this in Africa, a completely different environment. The collaboration in a very international team for such a long time was also a challenge that we managed to overcome.

This whole process is extremely diversified and requires a big endurance to solve all sorts of problems.

I think every engineer should try to have such a practical experience as the learning curve is much higher than just sitting in the classroom. It was a perfect example of learning by doing.

Furthermore, it is very different to hear from Africa than to actually go there and experience it. It helped me realize that we live in two diverse societies. In Senegal people have few but are happy with what they have. The potential for renewables such as the photovoltaic there is huge as the electricity price is as high as in Europe but the sun is shining much more.

Maria Fernanda, financial manager, Guatemalteca:

This is the first time I put in practice what I just had learnt theoretically at University about Solar PV systems. Doing this, I realized that in practice, there are many things you cannot plan in advance and a lot of problems that you cannot preview, so a flexible plan is very useful. In our case, it was very difficult to know from Sweden, which tools were available on site, the real location of the building or the availability of space, for example. These are things that made us change our plan and come up with different solutions.

The intercultural experience was a huge learning outcome. It was the first time I traveled to an African country and it was interesting to see how they live and their customs. I also learnt how important is electricity for educational and economical activities, for example the stores with electricity were able to sell cold products (very demanded because of the warm weather) and work until later hours during the night.

On the other hand, I acquired many selling skills; even if we didn't find a company to sponsor our project, I learnt how it is supposed to be done, that it is very difficult to do and that it requires a lot of time and patience.

Foivos, logistic manager, Greek:

For me, visiting Africa was always a dream. After visiting Senegal, one thing is for sure that I want to return one day, back to this amazing continent. The interaction with the locals and the friendships that were developed are one of the most valuable parts of that journey. When someone visits such places, they realize that the dream for poverty elimination and a cleaner and more sustainable world is not something that is written in books but a daily reality for millions of people.

Through the Sunegal Project, I had the opportunity to learn new things also, about the field I have chosen to study. The construction of a solar system in real life showed me not only the theoretical part of such a system but also how it is assembled by what it needs in order to achieve that. It was a way to discover all the different parameters that are not taught in books while one of the most important things was the difficulties that can appear in different parts of such a project.

Moreover, the part of the organization and management of such a project was significant since someone can see in real life that there are always factors that can act like obstacles to that. Furthermore, even if I have been part in numerous projects as a student, the cooperation with other students in the field taught me in a different way how to work together and achieve great results as a team.

Lastly, one of the most priceless things of that journey was the cooperation with four other amazing people with whom I had the opportunity to live, work and travel with them and to share such an incredible adventure.

Conclusion

After a preparation of 6 months, the solar system was fully designed and financed. All team members were able to go on the field and install it themselves. The educational building of Generation Non Violente is now supplied with electricity. Seminars for teaching mediation to people will be more efficient and can now happen at any time of the day. More people will be aware of these pacific solutions and this will help ending step by step the conflict between rebels and Senegalese State. The system has now to be maintained for the next years and other projects have to be developed with InnovEd in order to continue the improvements in this region.

The project was beneficial both for Casamance and us, the students realizing it. The center in Brin has now a clean access to energy at any time and we learnt a lot by achieving this. We improved our technical knowledge by designing the system, our communication skills by contacting companies and sponsors, our organization by working in team, our sense of responsibilities by having each one a part of the system and our determination by achieving all the goals set before the end of the year, in addition to our classes. We also learnt a lot by travelling to Senegal, living in a new culture and meeting new people.

This project was for all of us an unforgettable experience and created strong friendships in between us and the locals.

References:

[1]: IEA, “World Energy Outlook 2011”, http://www.iea.org/papers/2011/weo2011_energy_for_all.pdf

[2]: Aissatou Fall, “Understanding the Casamance conflict: a background”, Kaiptc Monograph No7, December 2010.

[3]: Generation Non Violente, http://www.generationnonviolente.org/

[4]: NASA, solar data on location 12.5North, -16.35East

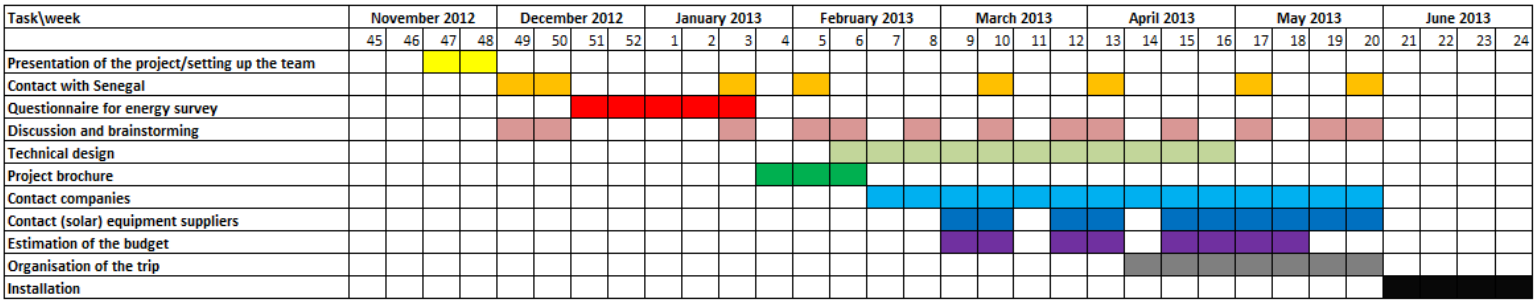
[5]: Innoved, http://innoved.se/

[6]: Rayon Vert, http://www.rayon-vert.pro/

[7]: Victron Energy, http://www.victronenergy.com/

Annex 1: Gantt planning

GANTT planning



Task\week	November 2012				December 2012				January 2013				February 2013				March 2013				April 2013				May 2013				June 2013			
	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Presentation of the project/setting up the team																																
Contact with Senegal																																
Questionnaire for energy survey																																
Discussion and brainstorming																																
Technical design																																
Project brochure																																
Contact companies																																
Contact (solar) equipment suppliers																																
Estimation of the budget																																
Organisation of the trip																																
Installation																																

Annex 2: Questionnaire for Senegal project:

Energy survey:

-How often do you expect that you will use the building in the near future? Tick each day that you think you will use it in the calendar below: cf image

janvier						
lu	ma	me	je	ve	sa	di
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

février						
lu	ma	me	je	ve	sa	di
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

mars						
lu	ma	me	je	ve	sa	di
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

avril						
lu	ma	me	je	ve	sa	di
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

mai						
lu	ma	me	je	ve	sa	di
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

juin						
lu	ma	me	je	ve	sa	di
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

juillet						
lu	ma	me	je	ve	sa	di
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

août						
lu	ma	me	je	ve	sa	di
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

septembre						
lu	ma	me	je	ve	sa	di
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

octobre						
lu	ma	me	je	ve	sa	di
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

novembre						
lu	ma	me	je	ve	sa	di
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

décembre						
lu	ma	me	je	ve	sa	di
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

- For next years, what would be the expected frequency of usage?
E.g. how many days per week? Or per month?

For next years, around the same consumption (see image attached).

- What activities do you expect to be having in the building?
e.g. seminars with discussions, cooking, allow working on computers etc.

Seminars with discussions and movies or power points.
Eventually, project of a computer room.
No kitchen (done outside with fire), 1 fridge, 1 freezer which will almost not be used when no activities in the building. Same for coffee pot and kettle (only used for breaks during activities)

- What kind of equipment is needed (refrigerators, televisions, ventilation fans, projectors), and how much time will they be used? (complete the table below).

Tick the time it will be used in a day.

Device	**Power (in W)**	**Time (in hours)** (1 represents the first hour of the day, from 0 to 1am and 24 represents the last hour, from 23:00 to 24:00)																							**Importance** (1 necessary, 2 less important)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
fridge	?	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Projector	?													x	x				x	x	X					
TV	?													x	x				x	x						
Fans	4 fans per classroom, 24 in total	Only in April, May, June, July, August, September and October.																								
Neon lighting	4 per classroom, total of 24	Only in April, May, June, July, August, September and October.																								
Freezer		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
4 Computers												x	x	x	x	x	x	x	x	x	x					Not everytime
Coffee pot		Depends on needs and seminars… 2 breaks if activities are organised																								
Kettle																										

- Is there a difference of consumption throughout the year? If yes, when is it different and in which proportions? If needed, complete the same table as above for winter case and summer case.

NO

Building and environment Information :

Important: If possible, pictures of the building could be taken and be sent to us

- What are the dimensions of the roof?

Length: 50m, Width of the front roof: 6m, width of the back roof: 4m

- What inclination has the roof (compared to horizontal)?

cf pictures

- Can you sketch a draft of the building? (indicating the north)

cf drawing

- What is the roof made of?

Sheet steel

- Is the roof tough? How is it supported?

Not tough enough for supporting panels

- Are there some trees or other obstacles that make shadows to the building (roof)?

Cf pics. Trees in front of the building will be taken off

- How far is the grid situated (in meters, if possible pictures)

cf drawing

Technical questions:

- Is the grid a three phases electrical system or a single phase system?

Single phase

- What is the voltage and frequency of the grid?

220V

- Are there already electrical cables in the building? Any plugs? (mention it on the building draft if possible)

In every classroom: 4 neon lighting of 100W, and 5 plugs

Social:

- Are crimes frequent in the region; do you think it is necessary to install a security system?

NO

- Can the building be used for another purpose when there are no seminars?

For cinema, only for the association purpose

- Is there any other activity in the village which could be supplied by the solar system, instead of losing the energy when the building is not used?

On the other side of the road, there is a company which crushes cereals for animals feeding (for the moment, they probably have a genset)

Financial:

- What is your current budget for the system?

1000€

Photovoltaic Panels Supply :

- Companies in Senegal and The Gambia that can provide PV panels for the project:

No one knows here. Look on internet first and give us the names, we will contact them directly from here then.

Other questions:

- Is there someone knowing solar technology and able to install and maintain the system?

Nobody, you will have to train 2 young people for that.

Annex 3: Electrical diagram