Playing with water and photovoltaics: a serious game at the developing world

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Abstract. *This paper presents the process of design and realization of an educational experience about the use of photovoltaic energy to provide water for human and agricultural use. The experience has been made on occasion of the declaration of 2012 by United Nations as International Year of Sustainable Energy for All. The paper explains the materials used and the activities that have been carried out for students of different levels and public in general.*

Keywords. Photovoltaic Energy, Water Supply, Education.

1. Introduction

The Alhambra of Granada (Fig. 1) is considered one of the marvels of the ancient world. Since its construction many centuries ago, billions of litres of water came from nearby mountains of Sierra Nevada (where snow lasts almost until summer days) to feed its numerous fountains, pools and water channels. And without a litre of gas, oil or coal, only powered by solar energy. Besides its architectural and artistic value, the Alhambra should also achieve the title of Sustainable Marvel of the World.

Figure 1. Alhambra (Granada, Spain)

As another example, the Roman Empire can be considered a Zero-Emission Civilization, since it was only powered by renewable sources like sun, wind, biomass and bee wax or vegetable oil for lighting. Fig. 2 shows a "renewable lamp" known as *lucerna* at Merida and a saltwork (Salinae Museum, Vigo, Spain). Structures like the well known *Acueducto de Segovia* (Spain) are good examples of sustainable hydraulic engineering, but many other examples can be easily found around the world.

Figure 2. Roman Lucerna and Saltworks

Modern technology should take example of these ancient developments that in many cases are still in use. But in another cases modern technology can provide better solutions to improve the life of persons, like photovoltaic lighting and water pumping in desert areas where there are no mountains or rivers. This paper presents an educational experience that shows the relationship between solar energy, water supply and sustainable development on occasion of the declaration of 2012 by United Nations as International Year of Sustainable Energy for All [1]. The experience has been developed in three stages: the first part is a presentation in which students learn more about the problem of water supply in the world, the second part consists of an explanation of the parts of a solar water

system: solar panel, pump, charger-battery, tank. The last part is a solar photovoltaic fountain designed to explain and test in a funny manner concepts of radiation intensity, the importance of angles of incidence, potential energy, water pressure and flow and many others.

2. The presentation

The first part of the activity was a presentation about the problem of water supply in the world and the health consequences of the use of contaminated sources. Audiovisual materials have been used, like a video by Oxfam about Ethiopia [2], a document from WHO with information about water diseases [3] and some images from Wikipedia of bacterias like E. Coli and V. Cholerae [4]. Students felt very impressed by the living conditions of millions children around the world and the huge efforts they make to have fresh water.

3. The solar pumping system

The second part of the activity was a demonstration of a solar pumping system with a 100W photovoltaic panel, a 12V electric pump and a set of pipes and tanks to show how water can be extracted from the ground using solar energy.

We have chosen a Shurflo pump model 2088-443-144 [5]. This pump (Fig. 3) can be easily adapted to 12V solar systems and has a long operating life. It can be directly connected to a solar panel or a battery for use at night or in cloudy days. To achieve a good performance a 100W solar panel should be used like Photowatt PW6-123 [6]. A lead-acid 7Ah battery can be used instead of heavy batteries of real solar systems.

Figure 3. Shurflo 2088 water pump

For this experience the pipes have been simulated with a garden hose and the well and tank with two plastic containers, one of them at ground level and the other placed at a higher level (over a table or stepladder). Fig. 4 shows the whole set of elements of the solar system, and Fig.5 the system ready for transportation.

Figure 4. The solar pumping set

Figure 5. Packed for transportation

4. The solar fountain

The third part of the activity was a game in which students had to achieve the maximum height of water in a fountain with a small photovoltaic panel.

The fountain has been designed specifically for this experience. In this case a low power pump has been chosen to allow the use of a small photovoltaic panel. Bilge pumps of the type used in small ships were a good choice, and among them we selected the model Rule 500 [7]. This pump has a maximum power of 25W, but can operate with much less power. Nautical pumps have the extra advantage that can be used with salt water and the game can be performed at beach in summer.

A small photovoltaic panel like Atersa A20P [8] is a good option. Its reduced dimensions and weight allow children to move it easily to position it towards the sun.

An important design factor is the relationship

between the electrical power of the panel and the pump. To get a proper operation in different weather conditions, the power of the panel should be 1 to 2 times higher than the pump power. In extreme cases a higher power panel can be used, for example the activity has been succesfully realized at Chano Piñeiro school (Gondomar, Spain) in a rainy day using a 100W Photowatt panel and the Rule-500 25W pump.

Figure 6. Structure with pump and hoses

Figure 7. Pump and connections

Figure 8. Fountain and 3 years old solar researcher at work

The fountain has been made with garden hoses and standard (and cheap) sprinklers. They were mounted on a structure made of pvc pipe, but it could also be done with wood, metal or any other material available. Fig. 6 shows the structure with the pump and hoses, Fig. 7 shows a detail of the pump connection and Fig. 8 shows a view of the complete fountain with a inflatable pool that contains and collects the small quantity of water needed for operation.

There is no need of regulator or battery, but in case of bad weather a battery can be used to power the fountain.

Fig. 9 shows the complete system folded and ready for transportation.

Figure 9. Fountain packaged for transportation

5. Activities

Several activities have been made during the months of may and june: an activity at IES Valadares (Vigo) with students of last courses of secondary school, an activity at CEIP Barrantes (Tomiño) with children between 6-10 years old, an activity at CEIP Chano Piñeiro (Gondomar) for children between 8-10 years old and an exhibition during the "Xornadas Solares Val Miñor" at IES Escolas Proval with students of higher levels and public in general. Fig. 10, 11 and 12 show these activities. In all cases the students kept very interested in the problem of water in the world, and the solar fountain was a center of attraction and an interesting hands-on experience.

Figure 10. Experience at Ceip Chano Piñeiro

Figure 11. Activity at CEIP Barrantes

Figure 12. Exhibition at IES Escolas Proval

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9. References

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