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Solar Festival – Renewable Energy Awareness for Microproduction and Building Integration

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Abstract

In a time were climate changes and its consequences to the environment appear to be more and more evident, it is vital that measures are taken to stop and reverse these changes.
By using renewable energy sources, one can contribute to the reduction of greenhouse gases emissions, namely by installing renewable energy production systems at home and private or public buildings. Nowadays, this is possible without changing the building structure, being simple to integrate systems in old buildings. This is possible thanks to solar photovoltaic panels that can be installed on the roof of the building, but also on the walls, balconies, and so on, and even in windows, using translucent panels.
The objective of this paper is to present an awareness rise action to the renewable energy production sources and its building integration, turned towards the Portuguese young student community, as well as to show in practice how using the microproduction legal frame the energy produced by an energy renewable production system installed in home can be sold to the electric grid. This awareness action was realized through the participation of *Net Plan - Telecommunications and Energy, SA*, in the Solar Festival that occurred on May 2009 at the Electricity Museum, in Lisbon, Portugal.

Key words

Photovoltaic, building integration, renewable energy education, microproduction.

1. Introduction

In a time were climate changes are a reality and its consequences to the environment seem to become clear, it is vital to take measures to stop and invert those changes.

By installing PV systems in our homes we are contributing to reduce greenhouse gases emissions and to a better environment and life quality.
The Solar Festival took place in May 2009, included in the initiative "European Solar Days" whose aim is to promote, among the society in general, specially children and young people, the use of the Sun as a significant energy source in Europe.
Other examples of wide public dissemination of different uses of the Sun as a fuel source where as attractive and effective as the below pictures demonstrate:

Fig 1. Examples of different uses of sun.

2. The demonstration site at Solar Festival

At the Solar Festival, *Net Plan - Telecommunications and Energy, SA*, installed a 3.68 kW photovoltaic production system constituted by a solar inverter interconnected with the power grid, a junction box, and 90 amorphous silicon solar panels.

The material necessary for the installation of the photovoltaic system was the presented in Table I.

Table 1 – List of Material

List of material for the Solar festival installation	
Quantity	Description
90	Solar Plus 44Wp solar panel
1	Junction Box with 16 entrees (8 + and 8-)
1	Solar Inverter with 4kW input and 3.68kW output
1	Electrical counter
1	Modem
240 m	4 mm^2 Solar cable
10	MC connectors
70	BM5258 and BF5258 connectors
58 m	Structures for solar panels support

In figure 2 it is shown a 3D view of the project made for this installation using Autocad Software.

Fig 2. 3D view of the installation

The objective of this installation was to demonstrate a PV installation, simulating a 3.68kW production system mounted on a flat roof top. On figure 3 it is possible to see the final installation (opposite viewpoint), placed at the solar festival.

Fig 3. View of the PV installation

With this application it was demonstrated the technology and equipments that are needed to create an on grid installation.
During the festival the participants had the opportunity to see the instantaneous production of the installation as well as the total energy produced during the festival days.

In was also installed a solar window and a solar balcony, equipped with Portuguese amorphous silicon photovoltaic panels, produced by Solar Plus [1], demonstrating the integration of solar panels in buildings (Fig. 4).

Fig 4. Solar window and balcony

The objective of this solar window and balcony was to demonstrate that it is possible to replace simple glass, by translucent PV panels allowing shadowing and electricity production. With this Building Integrated PhotoVoltaics (BIPV) technologies, the visitors were introduced to the advantages of the BIPV, showing to futures architects, engineers, constructors, etc. that when a new building is being designed, projected, constructed or rehabilitated it is a good choice to implement solar panels with all the economic and environmental advantages.

3. Technologies

A. Solar panels

Thin film amorphous silicon (a-Si, tandem junction cells) panels were installed at the solar festival. These were produced by a Portuguese company (Solar Plus). The characteristics of the panels installed are:

- Rated Power: 44Wp
- Voltage at maximum power: 45V
- Current at maximum power: 0.98A
- Open circuit voltage: 60V
- Short circuit current: 1.2A

Solar Plus Thin film amorphous silicon (a-Si, tandem junction cells) solar modules perform well even with diffuse light, partial shading and high temperatures.

These panels are ideal for several types of applications like Solar Power Plants, Residential & Commercial Rooftops, Building Integrated Photovoltaics, Parking Lot covers, Telecommunication Systems, Water pumping Systems, among others.

Fig 5. View of the solar panel

Fig 6. View of the BIPV solar panel

B. Solar Inverter

The solar inverter is the equipment responsible for converting DC current into AC current.
The solar inverter installed on the solar festival was a custom made solar inverter, for Portugal, by SMA.
This inverter has the capacity to interconnect with a 4kW PV generator and to limit the output power to 3.68kW (value corresponding to the Portuguese legislation limit for microgeneration power).

Fig 7. View of the Solar Inverter

Data acquisition

During the solar festival the production data was shown by a display installed near the PV installation. The data acquisition was made by a "webbox". Through this equipment it is possible to make remote diagnosis, data acquisition and visualization, continually collecting all data regarding the inverter on the system side.

Fig 8. View of the display

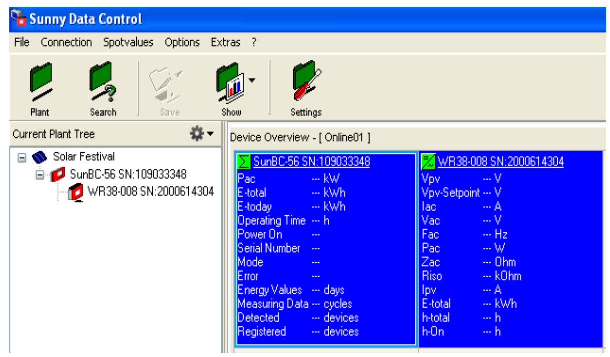

Fig 9. View of the Data

4. Microproduction and Energy Production Forecast for Real Application Project

According to the Portuguese legislation, when installing a renewable energy system for energy production one can chose to be an energy producer, selling the energy generated to the electric supplier. For anyone to become a microproducer it first needs to register as such and needs also to register a photovoltaic installation, with the maximum power of 3.68kW and a solar thermal system for the production of hot water.
If the registration is approved, energy can be sold to the electric grid, and as an incentive measure, at a price above the price of the bought energy. So, instead of reducing the energy that the installation owner buys, through compensating the purchased energy with the energy produced by the renewable energy production, more money can be earned and speed up the recovery of the capital investment in the system installation.

Through the European Photovoltaic Geographical Information System (PVGIS) [2], it is possible to estimate the production of this system, considering the installation in Lisbon, Portugal, as show on Table 2.

Table 2 – Estimated Production for the Installation

Nominal Power = 3.96kW Combined PV system losses = 23.6%		
	Inclination= 35º, orientation= 0º	
Month	Monthly production (kWh)	Daily production (kWh)
Jan	340	11.00
Fev	331	11.80
Mar	517	16.70
Apr	488	16.30
May	549	17.70
Jun	554	18.50
Jul	594	19.20
Aug	598	19.30
Sep	532	17.70
Oct	463	14.90
Nov	320	10.70
Dec	309	9.95
Average (over one year)	466	15.30
Total for year (kWh)	5590	

If the value of 4526 kWh is considered as a benchmark for the annual consumption of an average household in Portugal [3], the energy produced by the photovoltaic installation will be enough to feed 1.24 homes.

5. Benefits

Considering a total cost of 18.000€ for a system of this type, and the actual fee for microproduction in Portugal [4], the payback time will be achieved in 6 years, as shown on figure 8.

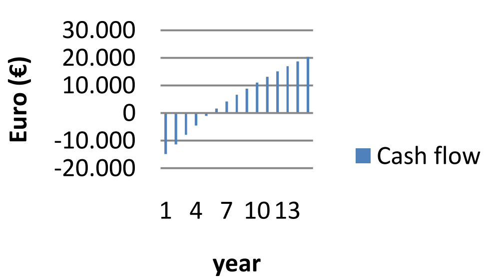

Fig 8. Cash flow of the microproduction investment

The installation of photovoltaic power generation also contributes to the reduction of greenhouse gas emissions.

It was considered that for each kWh of energy produced by conventional energy production systems is emitted into the atmosphere about 470g of CO_2 [5]. In table 3 it is possible to quantify the benefits achieved through the implementation of these systems.

Table 3 – Emissions Avoided

Power System	Annual Production	Emissions Avoided
3.96 kW	5590 kWh	2.63 Ton

Similarly, if it is considered that, on average, per km traveled by car, about 140g of CO_2 [6] are emitted to the atmosphere, by implementing this system the equivalent kilometers that can be driven with the same emissions can be quantified, as shown in Table 4.

Table 4 – Equivalent Kilometers

Annual Production	Emissions Avoided	Equivalent Kilometers
5590 kWh	2.63 Ton	18766 km

Since every tone of CO_2 emitted into the atmosphere, on average, is equivalent to the deforestation of 0.1 hectares per year [7] the implementation of such a system, will avoid the death of a significant number of trees. The values are expressed in Table 5.

Table 5 – Hectares Spared

Annual Production	Emissions Avoided	Hectares Spared
5590 kWh	2.63 Ton	0.26 Hectares

6. BIPV

As BIPV is photovoltaic technologies integration with a building, the solar modules are used directly on the building elements. They can be used as windows or installed on balconies (Fig. 4), as buildings second skin (Fig. 10), Trombe walls, as a roof top, covered car parking (Fig. 11), etc.

Fig. 10 Building second skin (INETI, Lisbon)

Fig. 11 Parking roof top (Ferreira do Zêzere, Portugal)

Considering the installation of 90 Solar Plus solar panels as the ones installed at the solar festival, with the same orientation and inclination, but installed as a roof top, the expected production will be the same as the solar festival installation.
On the other hand, if the same solar panels, with the same characteristics, are installed as a second skin of a building, and considering that the orientation will be South, the expected production would be as shown in Table 6.

Table 6. Estimated Production for a solar second skin wall

	Inclination= 90º, orientation= 0º	
Month	Monthly production (kWh)	Daily production (kWh)
Jan	342	11.00
Fev	288	10.30
Mar	372	12.00
Apr	264	8.00
May	219	7.06
Jun	178	5.93
Jul	199	6.43
Aug	271	8.74
Sep	344	11.50
Oct	383	12.40
Nov	307	10.20
Dec	319	10.30
Average (kWh)	290	9.55
Total for year (kWh)	3490	

As represented in the previous table, the installation of the same solar panels as second skin represents a reduction of production of approximately 38%. If the second skin solar wall is oriented with a different angle then the South (for example due to the building orientation) the reduction will be even more expressive.
For example, considering a West orientation, the expected production will be:

Table 7. Estimated Production for a solar second skin with different orientation

	Inclination= 90º, orientation= 90º	
Month	Monthly production (kWh)	Daily production (kWh)
Jan	273	8.81
Fev	239	8.52
Mar	332	10.70
Apr	278	9.25
May	274	8.85
Jun	258	8.58
Jul	281	9.07
Aug	317	10.20
Sep	327	10.90
Oct	322	10.40
Nov	248	8.25
Dec	254	8.18
Average (kWh)	283	9.32
Total for year (kWh)	3400	

Despite the reduction on the energy yeld, the installation of BIPV system is something to be taken into account at the project stage of new buildings.
As the new architectural tenders lead to an increasing use of glass on the building facades, amorphous silicon modules are an excellent alternative to conventional glass, allowing electricity production, either for internal consumption or for sale, acting as a shadowing to the entry of sun in the buildings.
Besides the benefits described above, the acquisition and installation of a BIPV system costs are not much higher (about 25% more) than those of the glass used in facades (tempered double glass) and the value of the investment can be returned in a few years.

7. Conclusion

In this paper it was described a renewable energy awareness system for microproduction and Building Integration, presented at a Solar Festival that took place on May 2009 at the Electricity Museum, in Lisbon, Portugal. In this awareness action it was presented a full working microproduction installation with some solar technologies and some of its advantages:

- With the installation of a renewable energy production system everyone can give a contribution to the reduction of greenhouse gases, contributing to a better future;

- With BIPV technology, solar panels can be installed in building elements such as windows, balconies, walls etc., without changing the building appearance and producing energy at the same time.

- With the microproduction statute it is possible to sell the energy generated by a renewable energy production system, getting a monetary benefit and a faster return on the investment made.

The presented installation gathered much enthusiasm from the Solar Festival participants and visitors.

Fig. 12 View of the installation during the Solar Festival

References

[1] Solar Plus, Solar panel datasheet, www.solarplus.pt.

[2] European Commission, Photovoltaic Geographical Information System [PVGIS], http://re.jrc.ec.europa.eu/pvgis/ .

[3] Project REMODECE. University of Coimbra, 2008. www.isr.uc.pt/~remodece .

[4] Certiel, Guia para a certificação de uma unidade de microgeração. www.renovaveisnahora.pt (2009).

[5] Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional(MAOTDR) e Ministério da Economia e da Inovação (MEI), 2008. Portaria n.º 63/2008, 21 January 2008

[6] The European Parliament And The Council Of The European Union, Regulation (Ec) No 443/2009, 23 April 2009

[7] Gorav Seth, How to calculate the amount of CO2 sequestered in a tree per year, http://www.treesftf.org/resources/Calculating%20CO2%20Sequestration%20by%20Trees.pdf, 2007