PROPOSAL OF A GRID-CONNECTED PHOTOVOLTAIC SYSTEM FOR THE INTERNATIONAL AIRPORT VAL-DE-CANS IN BELÉM, BRAZIL

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1. Introduction

Photovoltaics is one of the most promising energy alternatives. Brazil has a great potential for the deployment of photovoltaic power generation, but this technology is not wide spread, and does not have sufficient incentives to popularize its implementation, yet.

Airport areas present a lot of features that favor the installation of photovoltaic systems, because it has wide horizontal spaces, with their typically large, sunny areas, free of shades, and buildings to facilitate the installation of photovoltaic modules.

The GCPVS presented here is a pilot study in the Brazilian Northern Region, to be deployed on the roof of the airport terminal of the International Airport Val-de-Cans (Belém-Pará-Brazil), aiming to reduce energy consumption of the airport terminal provided by the power utility, disseminate and encourage the use of photovoltaic technology and contribute to the preservation of the environment.

2. Description of the Grid-Connected Photovoltaic System

2.1. Area of deployment

The international airport complex of Val-de-Cans is located in the city of Belém, state of Pará, Brazil, at the geographic coordinates 01°22'45"S 48°28'35"W, as shown in Figure 1. It has about 33,000 m^2 of constructed area.

Fig. 1: Location of the international airport complex of Val-de-Cans.

The coverage of the airport terminal building was chosen as the area available for installation of modules, being approximately 16,000 m^2, as shown in Figure 2.

Fig. 2: Aerial view of the coverage of the airport terminal.

2.2. Chosen PV Modules and Inverters

For the PV generator, 230 Wp monocrystalline modules were chosen, and for the inverters, 11 kW nominal power devices were selected. They were chosen to be used as reference in this pilot study, because of their good efficiency.

2.3. Sizing Connected Photovoltaic System Design Network

The design was based on the standard conversion efficiency of the inverter, and with the help of a software developed in MATLAB, it was possible to choose a good relationship between the inverter nominal power and the PV generator of approximately 67%. Considering only the available area on the roof of the airport terminal, the system capacity was limited to 1.3 MWp maximum power, consisting of 79 subsystems. This limitation considers the spacing between the subsystems to avoid shadowing and allow the passage of people for maintenance and cleaning. Table 1 shows the composition of the GCPVS and Figure 3 shows its schematic diagram.

Tab. 1: Composition of Project de GCPVS.

Maximum power generated by the system	1.3 MWp
Total PV subsystems	79
Power generated by each PV subsystem	16,560 Wp
Number of strings	9
Number of modules per string	8
Total modules per subsystem	72

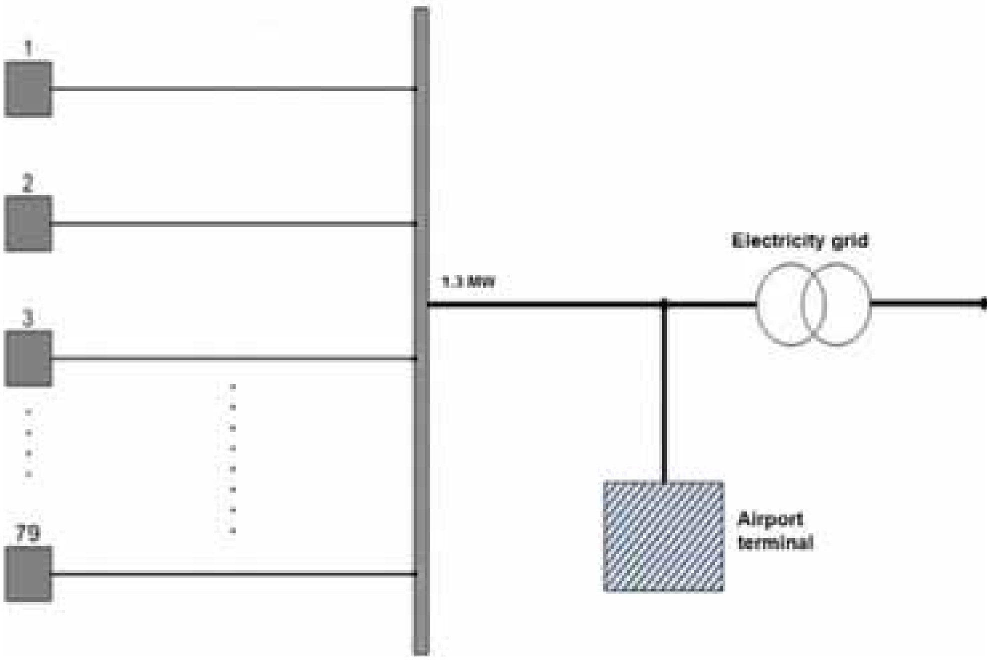

Fig. 3: Schematic diagram of the GCPVS.

3. Performance Analysis of the System

The electrical performance of the system was evaluated with the help of a program that was developed in the MATLAB GUIDE tool, based on the same mathematical model that was used to design the system.

The calculated average daily and monthly energy production along one year are shown in Figures 4 and 5, respectively. The average daily GCPVS production ranges from 4,000 to 5,850 kWh and its productivity from 92 to 135 kWh/kWp, as shown in Figure 6.

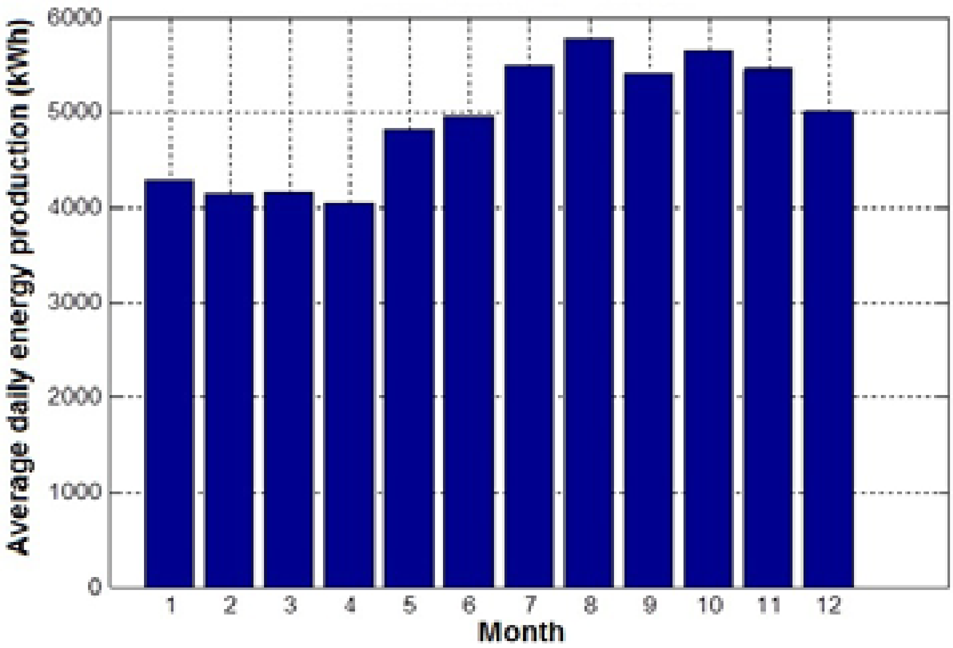

Fig. 4: Average daily energy production of the GCPVS.

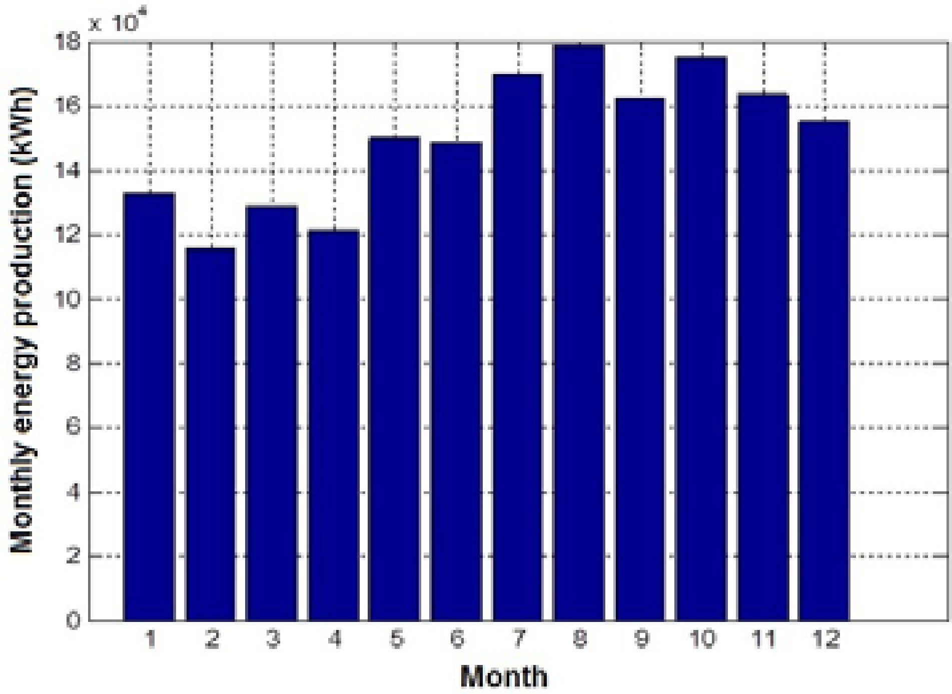

Fig. 5: Monthly energy production of the GCPVS.

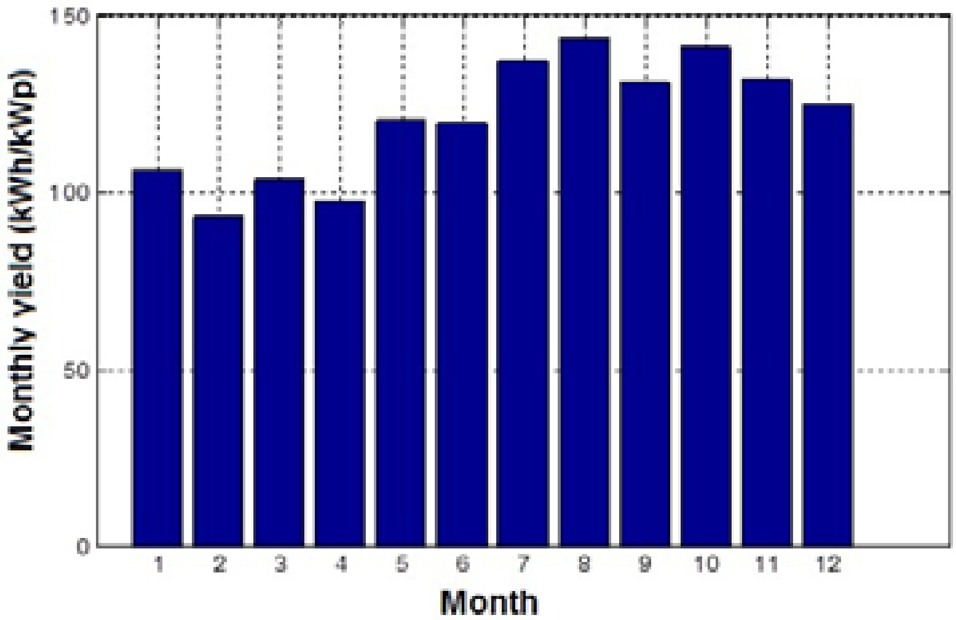

Fig. 6: Productivity of the GCPVS.

The months from January to April have lower production due to the raining season in the region, Figures 7 and 8 show the comparison between the average demand of the airport terminal and the averagepower production of the GCPVS on a typical January cloudy day and a typical August sunny day, respectively.

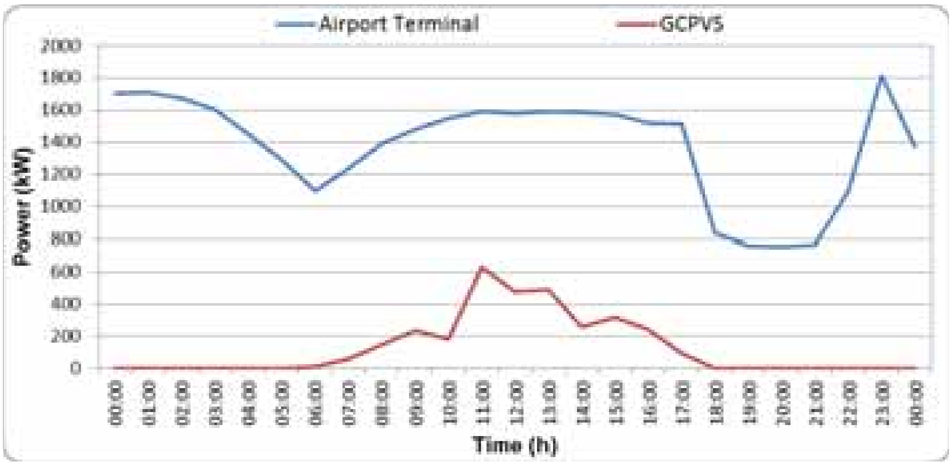

Fig. 7: Airport demand and GCPVS power production on a typical January cloudy day.

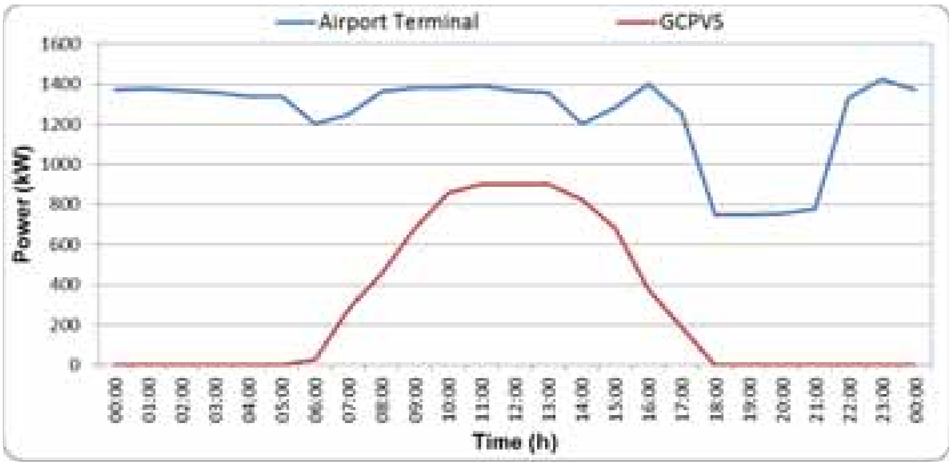

Fig. 8: Airport demand and GCPVS power production on a typical August sunny day.

The GCPVS contribution for the daily energy consumption in the two cases shown in Figures 7 (34,539 kWh) and 8 (31,146 kWh) is 9.1 and 22.7%, respectively. Figure 8 also shows the inverter power limitation process due to daytime hours that have high values of irradiance (10 am to 1 pm). Table 2 shows the power consumption of the airport terminal for the years 2008 and 2009, and the corresponding energy production of the GCPVS.

Tab. 2: Terminal consumption and energy production of the GCPVS.

Month	2008 (kWh)	2009 (kWh)	GCPVS (kWh)
1	901,490	1,009,120	132,300
2	805,816	839,372	115,670
3	859,729	938,822	128,540
4	821,680	840,906	121,230
5	783,631	850,566	149,530
6	888,937	917,450	148,560
7	928,285	930,789	169,900
8	957,786	924,287	178,450
9	987,286	—	162,410
10	1,034,073	—	174,840
11	1,029,083	—	163,640
12	1,062,150	—	155,070

According to the data presented in Table 2, the GCPVS contribution is approximately 19% in the month of highest irradiation (August) and 14% in the month of lower irradiation (February).

Although the energy contribution of the GCPVS does not meet all the energy consumed by the airport terminal, it plays an important role, which is the reduction of peak demand.

4. Conclusion

The use of airport areas for GCPVS applications plays a very important role in the dissemination of photovoltaic technology. In the particular case of the airport complex in Belém, there is a very high demand during the day time. This is associated with periods of higher demand of the airport, especially related to the air conditioning load. The last aspect makes the application of GCPVS more interesting for demonstrating a reduction in demand during the daytime.

5. References

Pinho, J. T., et Alli, 2008. Sistemas Híbridos – Soluções energéticas para Amazônia. MME, Brasília.

Macedo, W. N., 2006. Análise do fator de dimensionamento do inversor aplicados a sistemas fotovoltaicos conectados à rede. PhD Thesis, IEE, USP, São Paulo.

Vasconcelos, F. M., Figueiredo, G., 2010. Metodologia para Projeto e Análise de Sistemas Fotovoltaicos Conectados à Rede Elétrica de Baixa Tensão e Avaliação de Desempenho de um Sistema de 1,575 kWp. Graduation Final Work, Faculdade de Engenharia Elétrica, UFPA, Belém.

Rüther, R., Braun, P., 2005. Solar Airports: A Future Multi-billion Euro PV Market?. REFOCUS, England, p.30-34, July/August.

Ruther, R., Knob, P, Reguse, W., Diniz, A. S. C., Dacoregio, M. M., Salamon, I. T., Jardim, C. S., 2005. The Potential of Grid-Connected Photovoltaics in Brazil. World Climate & Energy Event, Rio de Janeiro.

6. Acknowledgements

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