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HYBRID ELECTRI POWER GENERATOR (PHOTOVOLTAIC – FUEL GENERATOR) FOR REMOTE AREAS

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Abstract. *Nowadays the development of clean and sustainable energy has been growing, the reasons for this growth are related to environmental awareness or to decrease costs. The Sun is one of the most abundant energy resources over the planet. Solar energy is used for several purposes, for example, to produce chemical energy on plants by photosynthesis, as a heat source for many procedures and to produce electric energy. There are two main methods to produce electric energy using solar energy, there are thermosolar and photovoltaic systems. The first one uses solar energy as heat to run a thermal cycle, as Rankine. The second one uses the photovoltaic phenomenon, which uses the light from the Sun to create electric energy through a semiconductor. Despite the utilization of solar energy is increasing, in many countries in development, the use of fuel generator is quite common, mainly in remote areas, where the electric distribution is deficient. Therefore, using a hybrid source of electric energy, such as photovoltaic and fuel generator is a solution for those problems. Studies confirm, in many cases, the hybrid power systems are reliable, efficient, besides reduces impacts on environment and costs with fuel. This work built a structure where contains all the equipment for hybrid power system such as fuel generator, solar generator of 265W, a battery bank for energy storage, charge controller. The structure is mountable, allowing the owner to disassemble it, and assemble where is more convenient.*

Keywords: *Hybrid energy, photovoltaic energy, remote areas, renewable energy.*

1. INTRODUCTION

Brazil electric energy production is mostly from hydroelectric power plants, mainly because Brazil is a country with abundant hydric resources in its territory. Beyond hydric resources, which is a renewable source, Brazil also has a huge potential in others renewable sources, for example, solar energy, wind power and tidal wave energy. According to the Mines and Energy Ministry (2016). In comparison with January in 2015, there was an increasing of 7.676 MW on

January 2016, which 2.873 MW from hydroelectric energy; 1.810 MW thermal power; 2.987 from wind power and 6 MW from solar energy [5]. Therefore, Brazil has a big capacity to produce energy from clean resources, as well as has the potential to grow and develop in this study field.

Recent studies on energy production using renewable resources as the Sun is growing. This growth is more evident when countries in development are applying such technologies, resulting in a better distribution of energy allied with environmental awareness. According to Bhuiyan *et al* (2000), found in rural areas in Bangladesh the usage of systems, which work with renewable energy sources, are cheaper and more possible to be implanted than non-renewable generators. Alazraki and Haselip (2007) concluded the impact of small systems of photovoltaic generation installed in houses with public and private resources has brought development and electric energy for remote communities.

Maranhão is situated on Brazilian Northeast, which is one of the regions with a great amount of solar incidence in Brazil. This fact represents a great potential of implantation of photovoltaic energy power systems. The countryside of Maranhão, when the distribution of energy is deficient, the utilization of fuel generator is common, but the fuel costs and pollution, are negative impacts of these systems. Therefore, hybrid power systems are the solution for that problem, because the power supply relies less on fuel generator when the photovoltaic system is available.

2. EXPERIMENTAL PROCEDURE

Power systems with photovoltaic panels have to be calculated or scaled out according to the loads they will supply. In remote areas which do not have an efficient distribution of electric energy, the main electric devices turned on are television and lights, and in some cases and villages, the generators are turned off at a certain time in the evening because the cost of fuel is expensive.

Therefore, in this study, we established small loads of a house (Tab 1 and Tab 2), for example, a quantity of 10 lights of LED with 15W/12V working for at least 4h in the night. According to these conditions, the photovoltaic generator was calculated (Tab 3).

Table 1: Data to scaled out the Photovoltaic Generator for small loads of a house in remote areas

Loads	10 LED´s Lights of 15W/12V
System Autonomy	1 day
Depth Discharge (DoD)	0,6
Hours of Sunlight	4h
Loss factor	0,9

Table 2: Photovoltaic generator and Batteries specifications

Generator Power [W]	265
Maximum Voltage - V_{mpp} [V]	30,6
Maximum Current - I_{mpp} [A]	8.66
Open Circuit Voltage - V_{oc} [V]	37.7
Short Circuit Current - I_{sc} [A]	9.23
Generator Efficiency [%]	16.46
Battery Voltage	12V
Battery Capacity	70Ah

A. Total Consumption

$$\text{Total Power Rating} = \mathit{Number\ Loads} \times \mathit{Power\ each}$$

$$\text{Total Current Load } (I_L) = \frac{\mathit{Total\ Power\ Rating}}{\mathit{Nominal\ Voltage\ of}}$$

$$\text{Total Consumption} = \mathit{Total\ Current\ Load} \times \mathit{Working\ hours}$$

B. Photovoltaic Generator

$$\text{Photovoltaic Generator Power} = \frac{\mathit{Total\ Consumption}\ [Ah] \times V_{mpp}[V]}{\text{Hours of Sunlight [h]} \times \text{Loss factor}}$$

$$\text{Number of Generator Necessary} = \frac{Phovoltaic\ Generator\ Power\ [W]}{Nominal\ Generator\ Power\ [W]}$$

C. Battery Capacity

$$\text{Battery Capacity Necessary} = \frac{Total\ Consumption\ [Ah] \times Autonomy}{Depth\ Discharge\ (DoD)}$$

$$\text{Number of Batteries} = \frac{Batery\ Capacity\ [Ah]}{Nominal\ Battery\ Discharge\ [Ah]}$$

D. Controller or Regulator

$$\text{I in} = \text{Generator Short Circuit Current} \times Number\ of\ Generator\ Necessary$$

$$\text{I out} = \frac{Total\ Consumption}{Voltage}$$

Table 3: Results for small loads during 4h of consumption

Section A Results	
Total Power Rating [W]	150
Total Current Load (I_L) [A]	12.5
Total Consumption [Ah]	50
Section B Results	
Photovoltaic Generator Power [W]	374.08
Number of Generator Necessary [Unit]	1.41
Section C Results	
Battery Capacity Necessary [Ah]	83.33
Number of Batteries [Unit]	1.19
Section D Results	
I in [Ah]	9.23
I out [Ah]	12.5

According to results found the hybrid power system was calculated, until now, to supply small loads of a house, such as lights or small electronic devices for at least 4 hours during the night. It was utilized a 265W Polycrystalline (1650x980mm) photovoltaic generator, a fuel generator from NAGANO NG3000E 3kVA and a battery bank of two batteries FREEDOM 12V, indicated on Fig 1.

Figure 1: Canadian solar generator 265W (A), fuel generator NG3000E (B), batteries Freedom 12V (C), respectively.
Source: Author

The structure to contain all the equipment was designed to contain all the components needed for the situation and simulated in software (Fig 2), and then built on the area of the Department of Mechanical and Materials of

IFMA/Monte Castelo. The structure has 4 main parts, they have simple shapes and they are easy to assemble with screws and standard tools.

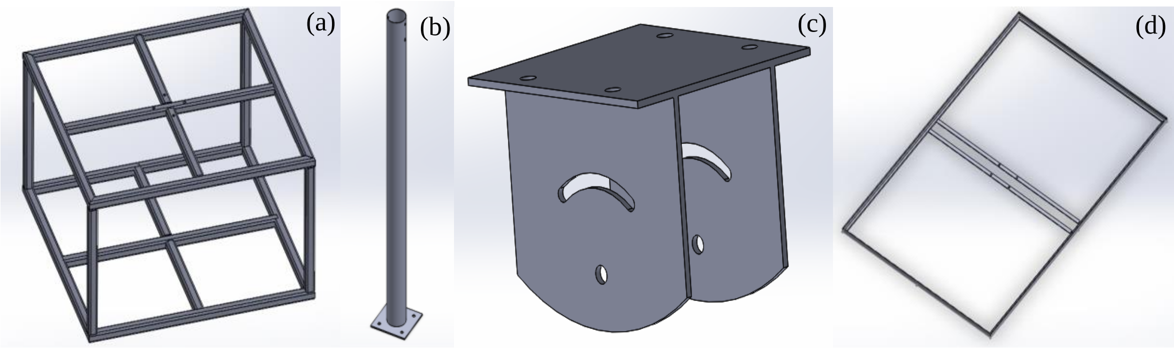

Figure 2: The main parts of the Structure of the Hybrid Generator: (a) Box, (b) Support Collum, (c) Telescopic Adapter, (d) Photovoltaic Generator Support. Source: author

Figure 3: Structure designed on software. Source: author

3. RESULTS AND DISCUSSION

The structure was built in SAE 1010 steel; the weldments were made in DMM/IFMA. The structure can be disassembled and assembled where the user wants, with low difficulty. This was one of the objectives of the research, to build the structure it was necessary to know which materials and components we had to set in the structure. After finding the results of Tab 3 and the designed structure we built the structure as Fig 4 shows.

Figure 4: Structure. (a) Structure with the photovoltaic generator; (b) Structure with the photovoltaic and fuel generator, and batteries organized. Source: author

The results of Tab 3 show the need of 1.41 generator, we could approximate to the number 2, but, this will impact on the final cost of the project, as it is intended to supply remote areas the cost have to be lower as possible. This probable lack of generator can be supplied with an increase in energy storage with 2 batteries instead of 1 (Section C of Tab 3).

4. CONCLUSIONS

Nowadays, the importance of researches on renewable energy is great. Brazil has a huge potential for clean energy sources and needs more development in this study field. The hybrid system has fulfilled its first purposes. The structure has low difficult to be assembled, although, it weights higher than expected. The structure also allows being automatized, with a controlled position of the photovoltaic generator, for example, this will increase the amount of sunlight transformed into energy.

5. ACKNOWLEDGMENTS

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