200 Watts Portable Solar Generator for a Typical Barbing Salon

To cite this article: M. B Edeghe and P. O Babalola 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **413** 012029

IOP Conf. Series: Materials Science and Engineering **413** (2018) 012029 doi:10.1088/1757-899X/413/1/012029

200 Watts Portable Solar Generator for a Typical Barbing Salon

Edeghe, M. B[1*], Babalola P. O[1]

[1]Department of Mechanical Engineering, Covenant University, Ota, Nigeria.
E-mail address: marvelous.edeghe@stu.cu.edu.ng, phillip.babalola@covenantuniversity.edu.ng

Abstract. The need for power alternatives due to the instability of the on-grid supply becomes very essential. A portable solar generator is proffered to solve that problem as it would replace the environmentally unfriendly petrol and diesel generator being used by many in Nigeria today. The main aim of this work is to design and construct a portable solar generator capable of satisfying the load requirements for a typical barbing salon. Two barbing salons, one at Daniel Hall and the other at Chapel in Covenant University were surveyed for this project to determine their load requirements. The survey indicated a barest demand per hour of 215Wh and a peak demand of 525Wh. The peak demand was chosen as the target. The system has features such as metal frame box and wheel to enhance mobility and appropriately sized components such as the inverter, charge controller and battery. Furthermore, the system can be appropriately sized for other load categories not limited to homes as well as industrial applications. On completion, the final product will weight 45Kg that supplies both 230V 1000W AC and a regulated 12V DC power for a maximum time of 3 hours. With the average body weight indicated as 60.7 Kg this device can be conveniently moved by an average adult.
Keywords: solar panel, inverter, battery

1. Introduction

Nations in the developing world are facing the problem of limited access to energy and application, especially in the rural areas and communities. Hence, there is an urgent need to solve this problem. These problems act as a barrier, preventing serious economic and social development. In Nigeria today, the epileptic power supply makes reliance on the electric grid very unadvisable. To solve this problem, petrol or diesel generators are commonly used. These however, consume fuel in large quantities and pollute the environment. Solar energy as a means of solving this energy challenge has proved to be the most promising [1]. Harnessing solar energy in Nigeria is especially advantageous as it is situated on the sunniest place on the planet, theoretically it's estimated that the concentrated solar power (CSP) and photo-voltaic (PV) energy available in Africa is about 470 and 660 petawatt hours (PWh) [2]. Solar technology has come a long way since it was first conceived with the conversion efficiency of recent state of the art PV modules within the range of 15-20%, and a payback period of 2-4 years and improved panel life time of about twenty-five (25) years

2. System Components and Selection

In carrying out the design of a 200 Watts portable solar generator, the following processes are required: load determination for the intended typical barbing salon; component sizing; construction and assembly, and final economic analysis and justification of the project.

2.1 Battery

The batteries enable the PV array to operate at its optimum power output by keeping the electric load nearly constant. For the purpose of this project, a 12V 75AH Deep Cycle Gel Battery (Fig. 1) was selected [2,3].

Figure 1: 12V 75AH Battery

2.2. Inverter

This device is installed in the PV system to convert direct current to alternating current. Several solar power systems generate direct current (DC) which is stored in batteries while nearly all lighting, appliances, motors etc. require alternate current (AC) power to operate. As a result, an inverter is required to switch from battery-stored DC to standard power [3]. A 12V, 1KVA inverter (Fig. 2) was selected for this project.

Figure 2: Intelligent Power Inverter 12V,1KVA

2.3 Charge Controller

A charge controller helps to prevent the solar panels from forcing too much electricity into the battery and overcharging it. Charge controllers (Fig. 3) are connected between the panels and the battery. It works by constantly checking the voltage of the battery. If the voltage gets to high the controllers stops electricity from entering the battery [4,5].

Figure 3: Charge Controller

IOP Conf. Series: Materials Science and Engineering **413** (2018) 012029 doi:10.1088/1757-899X/413/1/012029

2.4 Solar panel

A 200 Watts Monocrystalline solar panel (Fig. 4) was selected for the purposes of this project.

Figure 4: 200 Watts Monocrytalline Solar Panel

2.5 Component sizing and load determination for typical barbing salon

The load used was selected from the table below. This table indicates the typical load values for different domestic appliances.

Table 1: Typical load table for a household

Electrical Appliance Typical Energy Consumption Table

Appliance	Consumption (Watts)	Appliance	Consumption (Watts)
Toaster	800-1500	Television - 25" color	150
Popcorn Popper	250	Television - 19" color	70
Blender	300	Television - 12" black and white	20
Electric cooker with oven	1000-2500	VCR	40
Microwave	600-1500	CD player	35
Waffle Iron	1200	Stereo	20
Hot Plate	1200	Clock radio	1
Frying Pan	1200	AM/FM auto cassette player	8
Dishwasher	1200-1500	Satellite dish	30
Sink waste disposal	450	CB radio	5
Washing machine - Automatic	500	Electric clock	3
Washing machine - Manual	300	Radiotelephone - Receiving mode	5
Vacuum cleaner - High Power	1600-2000	Radiotelephone - Transmitting mode	40-150
Vacuum cleaner - Upright	200-700	Lights:100 watt incandescent	100
Vacuum cleaner - Hand	100	Lights:25 watt compact fluorescent	28
Sewing machine	100	Lights:50 watt DC incandescent	50
Iron	1000	Lights:40 watt DC halogen	40
Clothes dryer - Electric	4000	Lights:20 watt DC compact flourescent	22
Clothes dryer - Gas heated	300-400	Lights: Compact fluorescent 40 watt Incandescent equivalent	11
Heater - Electric water heater	4000	Lights: Compact fluorescent 60 watt Incandescent equivalent	16
Heater - Engine block	150-1000	Lights: Compact fluorescent 75 watt Incandescent equivalent	20
Heater - Portable	1500	Lights: Compact fluorescent 100 watt Incandescent equivalent	30
Heater - Waterbed	400	Electric mower	1500
Heater - Stock tank	100	Hedge trimmer	450
Furnace blower	300-1000	Weed eater	500

From the table the load required for barbing salon was selected. The items selected include the following; a television set, standing fan, Clippers, energy saving bulbs and a radio [6,7].

IOP Conf. Series: Materials Science and Engineering **413** (2018) 012029 doi:10.1088/1757-899X/413/1/012029

Table 2: Load calculation to determine panel size and number

S/N	ITEM	QUANTITY	SIZE (Watts)	HOURS IN OPERATION (HRS)	TOTAL (Watts-hour)
1	Television	1	60W	3	180Wh
2	Fan	1	50W	3	150Wh
3	Clippers	2	30W	1	30Wh
4	Bulbs	3	45W	3	135Wh
5	*Radio*	*1*	*30W*	*3*	*90Wh*
TOTAL			215W		525Wh

2.5.1. Calculation of Solar Panel Size and Number

The panel that would have to supply 525Wh to satisfy the watt-hour per day for each appliance.

525Wh × 1.3 = 682.5 Wh

The panel must provide at least 682.5 Watt-hour per day

Panel Generator factor supplied by textbook for sunny areas is 3.43

= 198.97 Wh

The peak solar panel available to me is 200W

= 0.99

=1

Hence, the number of solar panel required is one.

2.5.2. Load Sizing for the Battery

The size of the battery required is obtained by determining the Watt-hours per day used by all appliances.

682.5Wh × 5 = 3,412.5Wh

Step iv:

= 284.375Ah

However, the actual battery size is a fourth of the indicated value as the value required. Hence a battery of 12V, 75AH is used.

2.5.3. The Charge Controller

In selecting the charge controller, it should have enough ampere capacity to pass the current that the panel can provide [8]. The minimum ampere capacity of a discharge controller should be equal to the sum of the ampere from all appliances without motors times by 1.5**.**

IOP Conf. Series: Materials Science and Engineering **413** (2018) 012029 doi:10.1088/1757-899X/413/1/012029

Table 3: Charge controller load values

S/N	ITEM	QUANTITY	POWER (Watts)	CURRENT (A)
1	Television	1	60W	5
2	Fan	1	50W	4.17
3	Clippers	2	30W	2.5
4	Bulbs	3	45W	3.75
5	Radio	1	30W	2.5
TOTAL			215W	17.92

Hence the charge controller required;

17.92 x 1.5 = 26.88A at 12V

3. Construction and Assembly

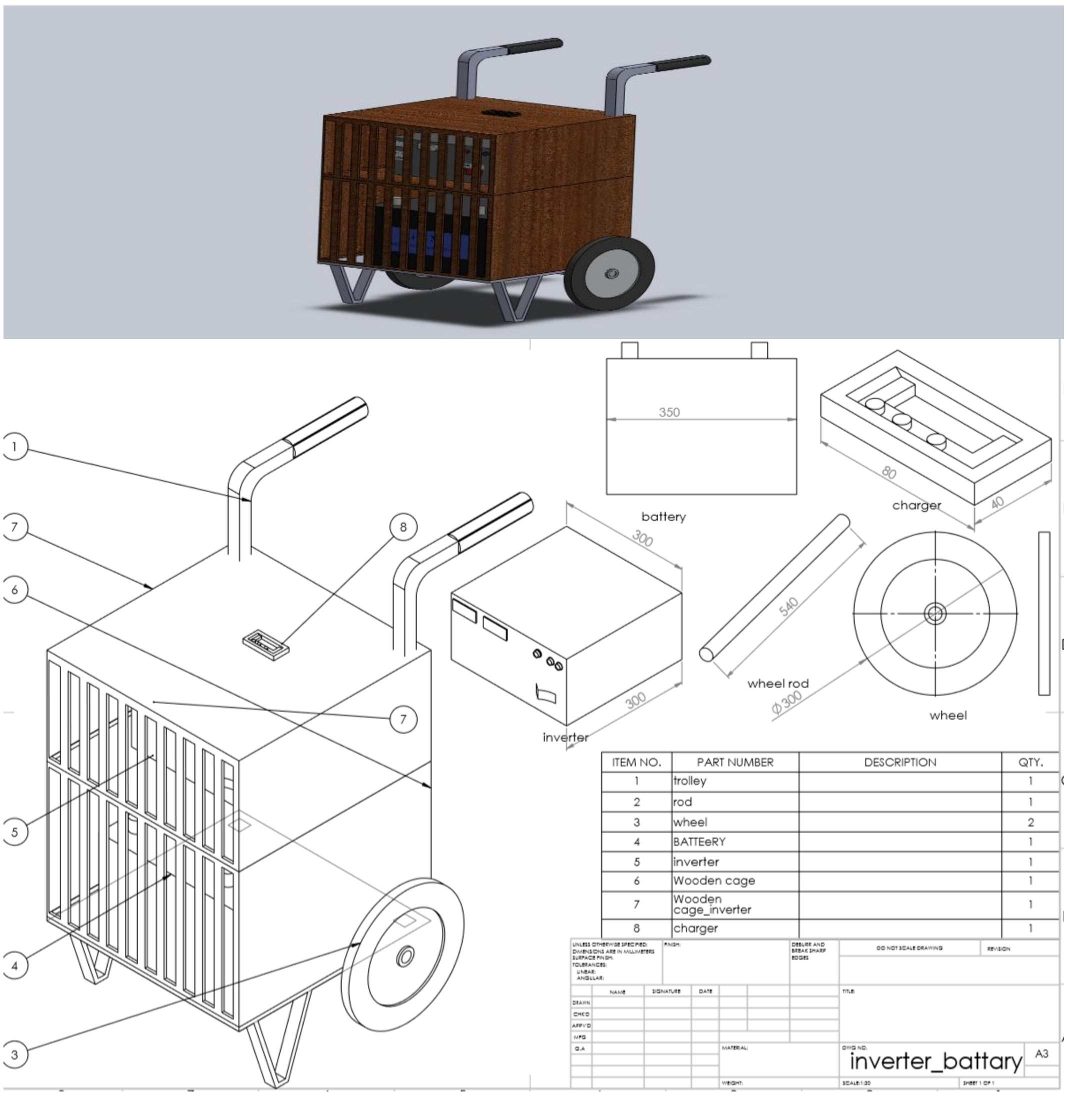

Figure 5: Assembly drawing of portable solar generato

IOP Conf. Series: Materials Science and Engineering **413** (2018) 012029 doi:10.1088/1757-899X/413/1/012029

4. Results and Discussion

During preliminary inspection of the barbing salon, it was discovered that the barber spent an average of 11 minutes per haircut. However, the time spent is determined by the complexity of the haircut, the rapport the barber has with the customer etc., below is a table indicating actual time spent per haircut on each customer.

Table 4: Time per haircut

S/N	TIME (Minutes)
1	04:58
2	18:11
3	27:11
4	15:11
5	21:11
6	09:11
7	10:10
8	15:00
9	06:00
10	09:00
11	14:00
12	12:00
13	05:00
14	06:15
15	05:11
TOTAL	178

IOP Conf. Series: Materials Science and Engineering **413** (2018) 012029 doi:10.1088/1757-899X/413/1/012029

Table 5: Typical values of time against solar panel voltage

S/N	TIME	VOLTAGE
1	11:50	20.00
2	12:00	19.00
3	12:10	19.70
4	12:20	20.40
5	12:31	19.70
6	12:40	19.20
7	12:50	19.40
8	1:00	19.50
9	1:10	19.79
10	1:20	19.20
11	1:30	19.10

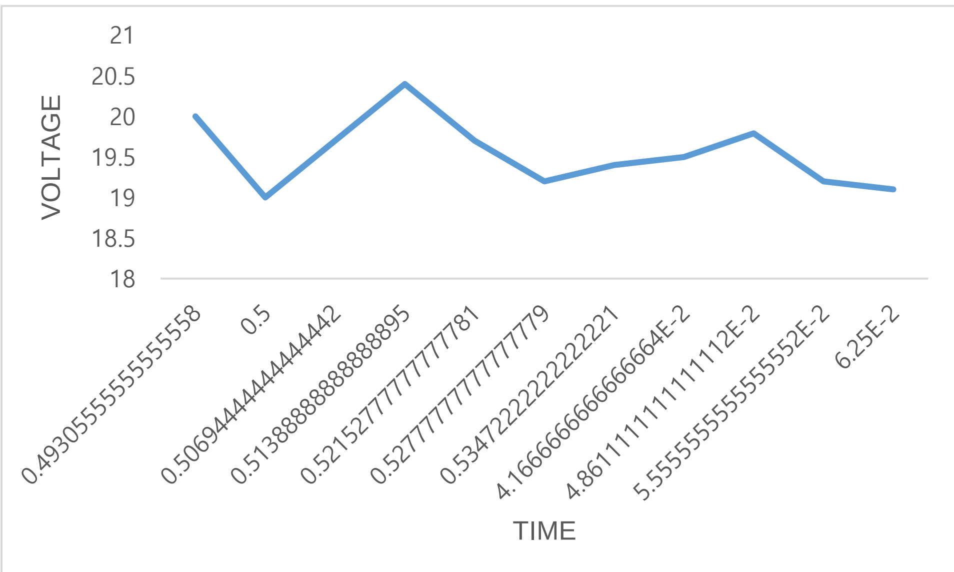

Figure 6: Graph of solar panel voltage against time at noon (typical)

Hence, from the graph we can determine the voltage being supplied by the solar panel at any time of the day. Where Y is voltage and X is time. The polynomial model for the system is denoted below;

$$y = 0.0008x^6 - 0.03x^5 + 0.4416x^4 - 3.1793x^3 + 11.507x^2 - 19.09x + 30.362 \quad (1)$$

At full load placed on the battery, the Table 6 and Figure 7 showed the results.

Table 6: Voltage against time at full load on battery

S/N	TIME	VOLTAGE
1	11:46	12.76
2	11:57	11.64
3	12:05	11.50
4	12:10	11.35
5	12:15	11.20
6	12:20	11.00
7	12:25	10.63
8	12:30	10.4

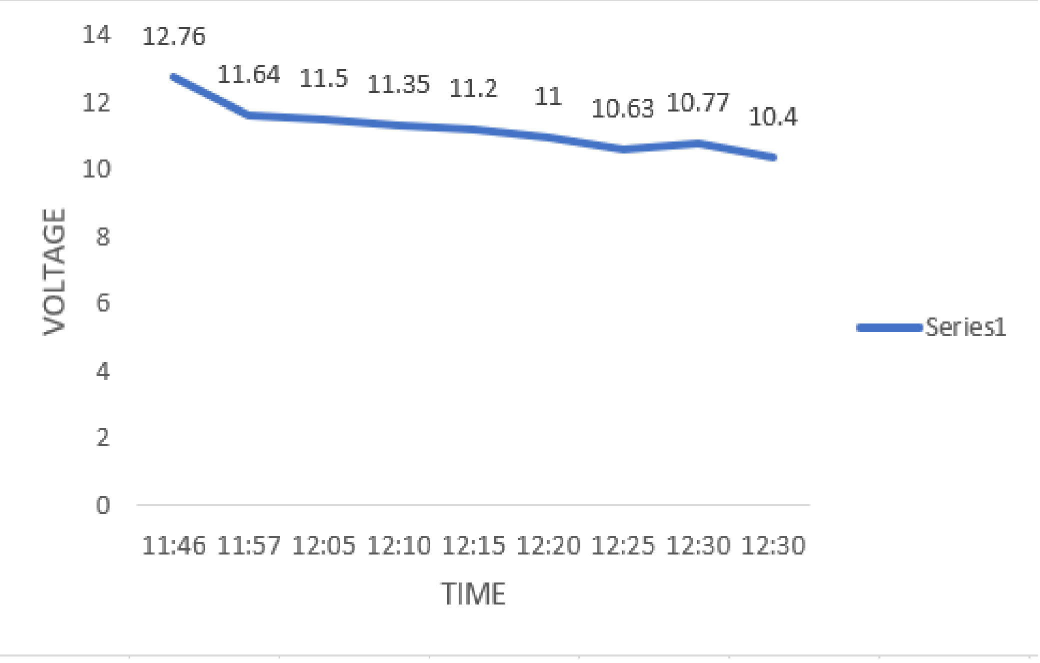

Figure 7: Graph of voltage against time at full load on battery

Microsoft Excel software was used to plot the graph and also to arrive at a model for the system. Where Y is voltage and X is time. It is denoted by a linear equation below;

$$y = -0.2357x + 12.428 \quad (2)$$

5. Conclusion

In this project a portable solar generator was presented, the typical load demand for a barbing salon was considered and the system was designed to address this load. After the experiments was completed, a model indicating voltage variation with time of day was arrived at when on battery and when under direct sun light collected for the 200W solar panel installed. The product components included a charge controller to monitor the charging process of the rechargeable 12V battery, and an inverter that can safety switch between a 12V DC supply to 230V 1KVA AC supply. The system weight is 45Kg.

References

[1] Kumar, V., Shiravastava, R.L and Untawade, S.P. (2015). Solar Energy: Review of Potential Green & Clean Energy for Coastal and Offshore Applications. *International Conference on water resources, coastal and ocean Engineering* (ICWRCOE).

[2] Kabir, E., Kumar, P., Kumar S., Adelodun, A.A., Kim, K. (2018). Solar energy: Potential and future prospects, *Renewable and Sustainable Energy Reviews Elsevier*.

[3] Li, Q., Liu, Y., Guo, S., Zhou, H. (2017). Solar energy storage in the rechargeable batteries, *Nano Today*, 46-60 https://doi.org/10.1016/.nantod.2017.08.007.

[4] Soh, L. and Tiew, C. (2014). Building of a Portable Solar AC & DC Power Supply. *Fifth International Conference on Intelligent Systems, Modelling and Simulation*. pp. 445-451.

[5] Majid, Z.A., Hazali, N., Hanafiah, M.A., Abdullah A.A., Ismail, A.F, Ruslan, M.H., Sopian, K. and Azmi, M.S. (2011). Design and Performance of 20 Watts Portable Solar Generator. *1st International Conference on Mechanical Engineering Research (ICMER2011)*. pp. 1-6.

[6] Fraas, L., Minkin, L., Avery, J., Huang, H. X., Fraas, J., Uppal, P., JX Crystals Inc. U.S Army Research Laboratory. (2014) Portable Concentrating Solar Power Supplies. *IEEE Photovoltaic Specialists.*

[7] Riyanto, I, Octaviano, A. Suparmoko, Obara, K (2016). Portable Photovoltaic Powerplant with Solar Tracker for Disaster Affected Area Emergency Power Supply. *Indonesia Japan Joint Scientific Symposium.*

[8] Walpole, S.C., Edwards, P., Cleland J., Stevens, G., Roberts, I. (2012). The weight of nation: an estimation of adult human biomass. *BMC Public Health*.