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DESIGN AND CONSTRUCTION OF 500W SOLAR GENERATOR KIT

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ABSTRACT

In response to the unreliable electricity supply in Dutsin-ma, Katsina State, this study proposes a clean and sustainable alternative to petrol and diesel generators widely used across Nigeria. The aim is to design and build a 500W solar generator kit that is cost-effective, eco-friendly, and capable of meeting typical household energy needs. The system is designed to power essential appliances such as a DC fan, mobile phones, a laptop, and five DC bulbs. The solar generator kit includes a 100W photovoltaic (PV) panel, a 12V 20Ah battery, a 20A charge controller, and a 500W inverter. These components are housed in a compact, custom-made metal frame measuring 14" x 9" x 7", with both AC and DC output ports for versatile use. Weighing 20kg, the unit is portable and ideal for off-grid environments. Performance tests showed that the generator could provide continuous power for up to 6 hours under a 450W load, delivering stable 230V AC and 12V DC outputs. It charges fully in 6–8 hours of direct sunlight, achieving an average efficiency of 85%. This project offers a sustainable power solution that can improve energy access while reducing environmental impact.

Keywords: Solar generator kit, Renewable energy, Portable power, Inverter, Portable Generator

INTRODUCTION

Access to reliable electricity remains a significant challenge in many parts of Nigeria, including Dutsin-Ma in Katsina State. Traditional sources of power, such as petrol and diesel generators, are extensively used to compensate for the unreliable grid supply. However, these generators consume fuel in significant quantities, are often noisy, and pollute the environment due to their carbon emissions. Solar energy as a means of solving this energy challenge has demonstrated to be the most promising (Oluwasegun, A., Awolala, E. O., Ayodeji, T. P., & Akinyemi, M. L. (2025). Harnessing solar energy in Nigeria is exceptionally 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) (Rahman, M. M., Zhang, W., Zheng, Y., & Pearce, J. M. (2025). As global awareness of environmental sustainability grows, renewable energy sources have become increasingly important in addressing energy challenges, particularly in off-grid and underserved areas.

Among numerous renewable energy options, solar energy is one of the most accessible and sustainable. It harnesses energy from the sun—an abundant and free resource—and converts it into electricity without producing commotion or pollution. Solar power systems can be deployed in remote locations, require minimal maintenance, and contribute significantly to reducing greenhouse gas emissions. For communities with limited or no access to the national infrastructure, solar energy offers a practical and long-term solution.

Solar generator kits are particularly valuable for users who need mobile, quiet, and environmentally favorable power solutions. They are ideal for powering basic household appliances, such as fans, mobile phones, laptops, and lighting systems, particularly in rural or off-grid areas. In contrast to fuel-based generators, solar generator kits offer secure and reliable operation without the ongoing cost of fuel or the hazards of toxic fumes.

The objective of this project is to design and construct a reliable, cost-effective, and portable 500W solar generator system. The system is intended to provide clean and efficient energy for powering essential household devices, thereby offering an alternative to conventional generators and supporting the broader adoption of renewable energy in Nigeria.

In many regions of Nigeria, particularly in Dutsin-Ma, Katsina State, access to a stable and reliable electricity supply is a persistent issue. Frequent power outages and inconsistent service from the national grid have forced residents to rely significantly on petrol and diesel-powered generators as alternative sources of electricity. While these generators provide only a transient relief, and also pose several significant problems;

Firstly, they contribute to environmental degradation by emitting harmful gases such as carbon monoxide and other pollutants. Secondly, they produce high levels of noise, making them unsuitable for residential use, particularly in densely populated areas. Moreover, the cost of fuel is rising, and the operation and maintenance of petrol generators have become increasingly costly for average households.

These challenges drawn the urgent need for a cleaner, quieter, and more sustainable power solution that is affordable and accessible to the people residing in that area. The ideal concept to solve this problem is developing a solar generator kit.

This solar generator kit offers a practical alternative that addresses the shortcomings of those generators, while, leaving a gap in the availability of low-cost, efficient, and user-friendly to the average requirements of people in that community.

MATERIALS AND METHODS

Selection of component is essential in this research as it would determine the size of the system.

Solar Energy Generation System

A definition of a photovoltaic (PV) system is a system that converts directly solar radiation into electricity (Jamil, M., & Shah, K. (2015). The most bountiful renewable energy source is solar energy from the sun (Munshi, N.A., Reavis, M., Richardson, D., Taylor, R., Tupper, M.L. and Fabian, P., Composite Technology Development Inc, (2016). Solar Energy Generation Systems utilize sunlight that has been converted to electricity to charge the batteries, and this charge is then provided to the user when required (Widyartono, M., Aribowo, W., Rahmadian, R., Wardani, A. L., & Hermawan, A. C. (2024). The battery power either straightforwardly works the Direct Current (DC) loads such as DC lights or operates the power inverter that turns over the DC to AC power to power the machine such as water pump, lighting appliances, fridges, and so on (Kumar, V., Shiravastava, R.L and Untawade, S.P. (2015). This form of system is followed for any independent system whether it is a stand-alone device. Solar Energy Generation systems are relatively compact and simple (Kabir, E., Kumar, P., Kumar S., Adelodun, A.A., Kim, K. (2018). Figure 1 depicts the basic concept of a Solar Energy Generation System.

Table 1: System Solar energy generation

Quantity	Comments
Power	500 Watt
Supply	15 – 21 Voltage Output
Appliances	Standing/Ceiling Fan
	Laptop
	Phone
	5 DC Bulbs
	300W DC Iron
Solar Pane Power	100W
Duration	24 hrs.
Battery	12V 20Ah
Power Output	500 Watt

System comprises several components

These elements are selected based on the structure type, location, and purposes (MUSA, M.N.B., 2018). The components of solar energy generation system are:

i. Solar Panel (PV)
ii. Charge Controller
iii. Battery
iv. Inverter
v. Load

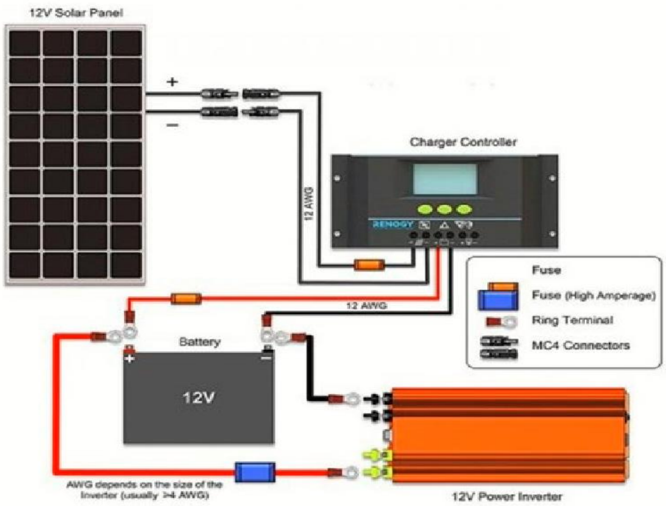

Figure: 1: Solar Energy Generation System

Table 2: List of Materials

S/N	Components	Function
1.	100W Solar Panel polycrystalline	Convert sunlight to electrical power.
2.	Solar Charge Controller	Control current and voltage input for the battery.
3.	Power Inverter	Convert DC power to AC power.
4.	Lead-Ion Battery	Store electrical energy.
5.	Frame	It gives the shape of the generator.
6.	Handle	To ease the transport of the project
7.	DC ON/OFF Switch	To on or off the DC power.
8.	PV Supply Port	Used to Charge the battery from PV.
9.	DC Power Output	Supply DC energy.
10.	Digital display	Help users understand battery levels, load consumption, and charging efficiency.

System Components and Selection
In carrying out the design of a 500 Watts solar generator kit, the following processes are required:

i. Load determination for the intended average loads of persons
ii. Component sizing
iii. Construction and assembly, and final

Figure 2: Solar Panel. A 100 Watts Monocrystalline solar panel (Fig. 2) was selected for the objectives of this project

Table 3: Solar panel specifications

Photovoltaic Module	SA – 100
Maximum Power (P_{MP})	100 W
Open Circuit Voltage (V_{OC})	21 V
Short Circuit Current (I_{SC})	6.4 V
Voltage when maximum power (V_{MP})	17.6 V
Current when maximum power (I_{MP})	5.71 A
Maximum Voltage System	1500 VDC
Size	1020 mm x 670 mm x 35 mm

Battery
The battery enables the PV array to operate at its optimum power output by maintaining the electric load nearly constant (Kumar, V., Shiravastava, R.L and Untawade, S.P. (2015), LiFePO4 batteries are highly suitable for solar applications due to their superior Depth of Discharge (DOD) (Edeghe, M. B1, Babalola P. O (2018). For the objective of this project, a 12V 20AH Deep Cycle Thailandia Pussance Battery (Fig. 3) was selected

Figure 3: Thailandia Pussance Battery

Inverter
This device is installed in the PV system to convert Direct Current (DC) to Alternating Current (AC). Several solar power systems generate Direct Current (DC) which is stored in batteries while virtually all lighting, appliances, motors etc. require Alternate Current (AC) power to operate. As a consequence, an inverter is required to switch from battery-stored DC to standard power (Kumar, V., Shiravastava, R.L and Untawade, S.P. (2015). A 12V, 500VA inverter (Fig. 4) was selected for this undertaking.

Figure 4: Power Inverter

Charge Controller
A charge controller serves to prevent the solar panels from forcing too much electricity into the battery and overcharging it (Kumar, V., Shiravastava, R.L and Untawade, S.P. (2015). Charge controllers (Fig. 5) are connected between the panels and the battery. It functions by constantly checking the voltage of the battery. If the voltage goes to high the controller stops electricity from entering the battery

Figure 5: Charge Controller

Component Sizing and Load Determination for an Average Load of People
The first step in designing a solar PV system, is to determine the total power and energy consumption of all loads that need to be supplied by a solar PV system. The calculations required are (Kumar, V., Shiravastava, R.L and Untawade, S.P. (2015), (Z A Abdul Majid, N Hazali, M A K M Hanafiah, A A Abdullah, A F Ismail, M H Ruslan, K Sopian and M S Mohd Azmi (2012):
The load used was selected from the table below

Table 4: Typical load table for the appliances

Appliances	**Consumptions Watt**
Standing/Ceiling Fan	15W
Laptop	60W
Phone	7.8W
DC Bulb	3W

Table 5: Load calculation to determine panel size

S/N	**Item**	**Quantity**	**Size (Watt)**	**Hours In Operation (Hrs)**	**Total (Watts-Hour)**
1.	Standing/Ceiling Fan	1	15W	3	45
2.	Laptop	1	60W	3	180
3.	Phone	1	7.8W	2	15.6
4.	DC Bulbs	5	15W	3	.45
TOTAL			**97.8 W**	**11 hrs**	**285.6 Wh**

Calculation of Solar Panel Size.
The panel that would have to supply 285.6 Wh to satisfy the watt-hour per day for each appliance is;
285.6Wh × 11 = 3, 141.6Wh (1)
The panel must provide at least 3,141.6 Watt-hour per day.

Load Sizing for the Battery
The size of the battery required is obtained by determining the Watt-hours per day used by all appliances which is 285.6Wh
Where;

$$Battery\ Capacity = \frac{Total\ Watts-hour}{Battery\ Voltage\ System}$$

$$= \frac{285.6\text{Wh}}{12\ V} = 23.8\text{Ah} \quad (2)$$

Hence a battery of 12V, 20 AH is used.

Charge Controller Sizing
In selecting the charge controller, it should have enough ampere capacity to transmit the current that the panel can provide. The minimum ampere capacity of a discharge controller should be equal to the sum of the ampere from all appliances without motors multiplied by 1.5 (Kumar, V., Shiravastava, R.L and Untawade, S.P. (2015).

Table 6: Charge controller load values

S/N	Item	Quantity	Power (Watts)	Current (A)
1.	Standing/Ceiling Fan	1	15W	1.25
2.	Laptop	1	60W	4.5
3.	Phone	1	7.8W	1.55
4.	DC Bulbs	5	3W	0.25
TOTAL				**7.55 A**

Hence the charge controller required;
7.55 x 1.5 = 11.325 at 12V Or

$$Solar\ Charger\ (Amps) = \frac{100\ W}{8.8\ W} = 11.325\ \text{A} \quad (3)$$

Hence a charge controller of 12V, 20 AH is used.

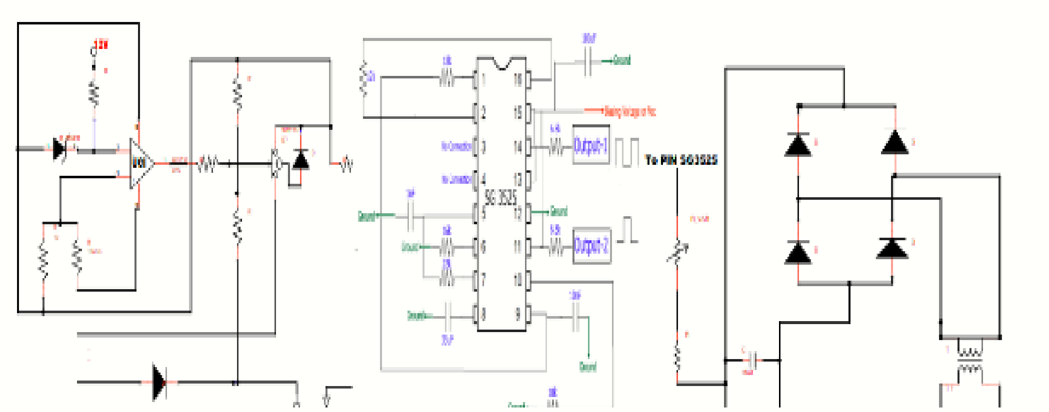

Figure 6: Solar Charger with the charge controller circuit and filter circuit

Inverter Sizing
The inverter is required to generate AC output, in order to ensure that the input rating of the inverter is not below the total watt of the appliances, the inverter size considered was made 3 times the capacity of those appliances.Inverter power = Total Load Wattage × 3
Inverter power = 97.8 W × 4= 391.2.4W (4)

Hence an inverter of 12V, 500 W is used.

Frame Sizing
The enclosure for this Solar Generator kit was made using a custom-designed 3D rectangular metal frame box measuring 14 inches in width, 9 inches in height, and 7 inches in breadth.

Construction

Figure 7: Metal Frame Box

Figure 8: Front View

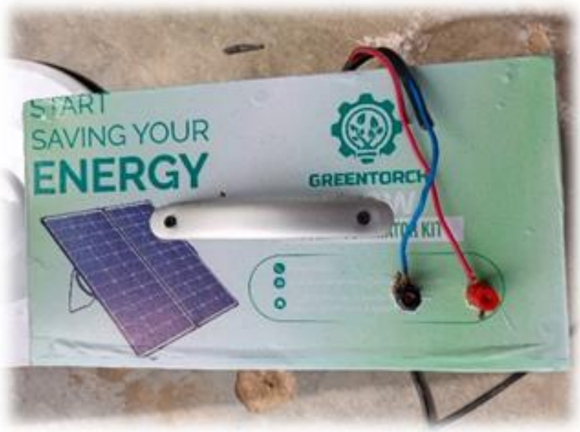

Figure 9: Top View

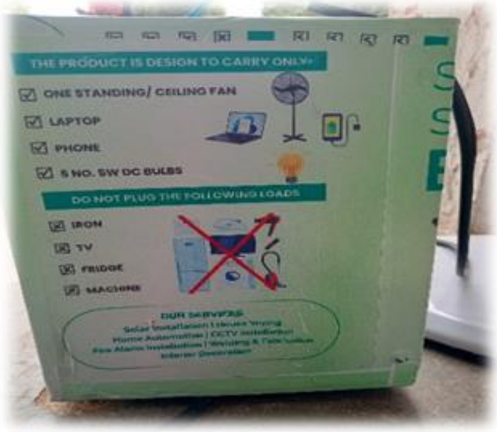

Figure 10: Right side View

Figure 11. Left side view

RESULTS AND DISCUSSION

Results

The performance evaluation of the 500W solar generator kit was conducted under typical meteorological conditions in Dutsin-Ma, Katsina State. The system was tested using a 100W photovoltaic panel, which under full sunlight exposure, provided a maximal energy gain of approximately 680Wh per day. This value was recorded during periods of maximal solar radiation between 11:00 AM and 3:00 PM, when solar irradiance reached an average of 5–6 hours daily.

The battery charging duration ranged from 6 to 8 hours under direct sunlight. During testing, the battery was able to power a standing fan (15W), a mobile phone (7.8W), a laptop (60W), and five DC bulbs (3W each, totaling 15W), for a total capacity of approximately 97.8W. Under this burden, the solar generator kit supplied power continuously for up to 11 hours, indicating high energy conversion efficiency and suitable energy storage performance.

The generator's inverter provided a stable 230V AC output, while the DC outputs supplied a consistent 12V, regulated by a 20A charge controller. This ensured both AC and DC devices could operate simultaneously without significant voltage drops or safety hazards. Load duration tests demonstrated that lower power loads significantly extended the operating time. For example, with a 60W load, the generator operated for approximately 10 hours, while a full 450W load reduced the duration to just over 1.5 hours.

Figure 12 demonstrate how lower load would increase the duration of the solar generator operation time. This can be explained by the gradient of the graph which increases by increasing the burden. For 5 Watts load, the solar generator can be operated up to 96 hours, but reduces to 2 hours for capacity of 150 Watts. The energy generated by the battery cannot be wholly discharged. It can reduce the battery life, and typically the battery should remain for at least 30 % of energy. The battery can be protected by using an inverter because the threshold voltage is set at 10.5 V, which will cease operating if the voltage of the battery drops lower than the set value. For DC power, the battery is protected by the solar charge controller which will cease operating if the voltage drops to 8 V (Chen, C.G., International Development Corp, 2008). The solar generator is suitable for illumination at night market using a 40 Watts energy which can last for 3 to 4 hour.

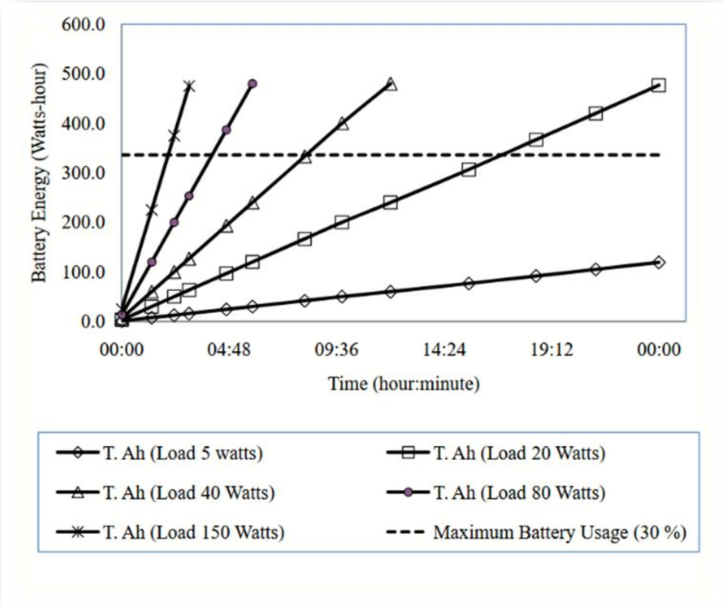

Figure. 12: Load and time of operation of the solar generator kit

To protect battery lifespan, the system includes a low-voltage cutoff at 10.5V through the inverter, and 8V through the charge controller for DC outputs. This prevents deep discharge, which is known to significantly reduce battery life. The solar generator is housed in a metal casing for durability and ease of portability, weighing approximately 20kg**.**

From a cost-performance perspective, the generator presents a viable alternative to petrol-powered systems. Compared to a 650W petrol generator that consumes up to 4 liters of fuel per 8 hours (with a fuel cost of over ₦ 940/litre and ₦ 3,760/day or ₦ 1,372,400/year), the solar generator only requires sunlight. While the initial cost of the solar system is comparable to that of a petrol generator, the operational cost is negligible**.** The payback period for the solar generator is under 12 months**,** making it a more economical solution for rural and off-grid users.

The generator is suitable not only for residential use but also for small-scale commercial activities, such as night markets, where quiet and smoke-free operation is essential. It is also ideal for outdoor settings like camping, farming huts, and emergency backup in health posts or schools.

CONCLUSION

To sum up, everything that has been stated so far, the development of this solar generators kit is to function as a backup supply that is portable and can be used whenever and wherever electricity is not there. It presents a promising alternative to petrol generators, particularly for the average load of people—lighting and powering small household appliances. Its minimal maintenance requirement—mainly replacing the battery every three to four years—makes it both cost-effective and user-friendly. Its compact, lightweight, and design allows for simple storage and transportation, making it ideal for home use, night market vendors, or as an emergency backup power source. This system offers an environmentally friendly, noise-free solution that meets the energy needs of small-scale users, particularly in areas where electricity is unstable or unavailable.

The kit's technical design includes a stable 230V AC output via an inverter and a regulated 12V DC output managed by a 20A charge controller. This allows for the safe and simultaneous use of both AC and DC devices without voltage fluctuations or system instability. Importantly, protective measures are in place to enhance battery longevity: the inverter halts discharge at 10.5V, and the charge controller for DC power shuts off at 8V, ensuring the battery retains a minimum 30% charge to avoid deep discharge and degradation.

This system was also field-tested to simulate typical real-world applications such as powering a 15W DC fan, charging of laptop, phone, and illuminating a 3W bulbs. The system provided illumination for 3 to 4 hours—ideal for evening trading and emergency installations.

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