A Portable Modified Power Supply Unit for High-Rated Power Consumption Domestic Appliances Suitable for Solar Power System and Small Generators

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Abstract

Despite several attempts made by the government to stabilise electricity in Nigeria, most homes in Nigeria either provide their electricity through a small generating set or solar power system but these solutions can only power few appliances excluding electric iron, cooker, roasters in most cases. This paper presents an innovative and home-grown product for harnessing the most out of the power generated through the design and construction of a modified AC power supply (MPS) unit for different electrical heating appliances such as Iron, Cooker and Roasters. The modified power supply unit would either be powered by 500W/24V solar panel, a 20A charge controller, 24V/200AH batteries and a 2.5KVA inverter or a 750VA-2.5KVA generator. The result reveals that the device provided a 50% reduction of rated power of any heating appliance connected to it. The device will provide a full power AC or a half power Modified AC to any load connected via a simple switch selector, making it possible to use a 2200W electric oven, cooker or iron at half power modified AC and full power AC. The result obtained shows that this device can be deployed at homes, offices, indoor and outdoor events.

Keywords: Portable**,** Modified AC, Power Consumption, Solar Power System, Generator, Domestic Appliances

INTRODUCTION

The Nigerian economy can be disaggregated into industry, transport, commercial, household, and agricultural sectors, with the household sector dominating energy consumption (Akinbami, 2001; Oladosu & Adegbuluge, 1994). The energy consuming activities in the house- hold sector still remain mainly cooking, lighting, and operations of electrical appliances (i.e. non-substitutable electricity). The percentage distribution of the total final consumption in 1989 in this sector and in terms of the major energy carriers is Kerosene (13%), Electricity (4%), LPG (1%), and Wood/others (82%) (Oladosu & Adegbuluge, 1994). Nigeria's economy face deepening challenges: a widening trade imbalance, growing competition from developed countries, a collapse of big manufacturing companies, and a sharp increase in the cost of doing business, allowing basically to energy and its related infrastructural costs. Energy demand far outweighs the supply which is epileptic in nature.

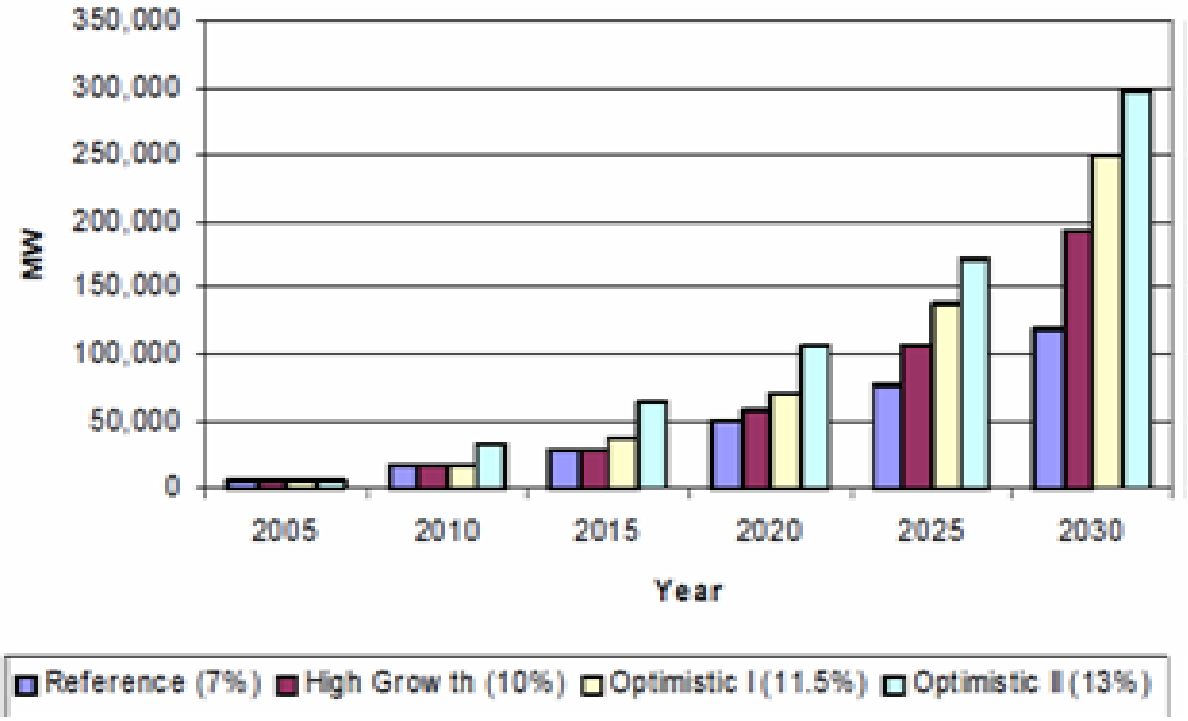

Figure 1: Electricity Demand Projection in Nigeria. Source (Sambo, 2008)

It is still pertinent to note that our energy consumption is projected to grow geometrically (Figure 1) while our ability to sustain our growth through energy generation, transmission and distribution continues to dwindle (Figure 2). Our capability to continue the trend for affordable energy will be severely tested in the coming decades.

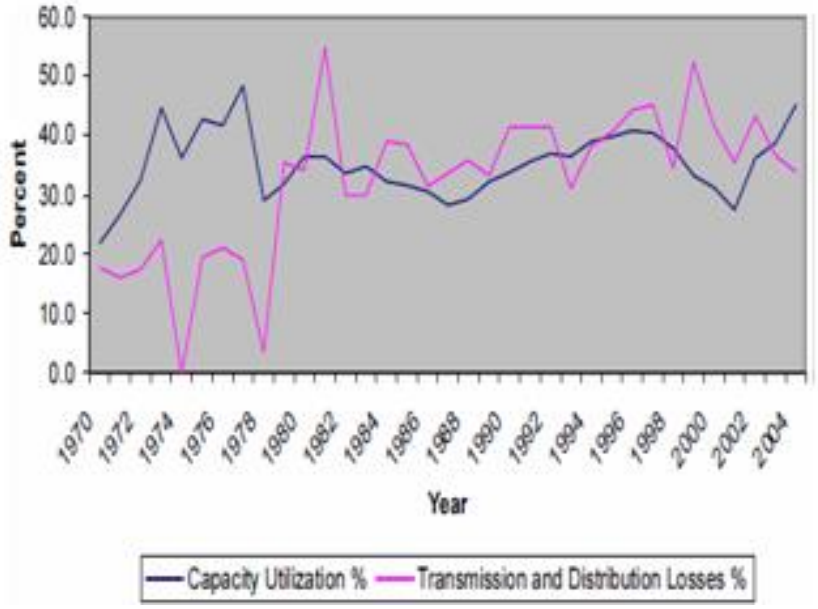

Figure 2: Indicator of Electricity Crisis in Nigeria 1970 to 2004 Source (Iwayemi, 2008)

At present, a litre of premium motor spirit (PMS) for running a generator (commonly called petrol) is sold at ₦145 per litre. Bearing this cost in mind and the United Nations estimates that 51% of the Nigerian population lives in urban areas (United Nations Population Division, 2018); a cost estimate for powering a 3-bedroom and 2-bedroom is presented in Table 1.

Table 1: Cost estimate of powering a 2-bedroom and 3-bedroom apartment with generator for 1 year in an urban area.

	3-Bedroom Apartment		2-Bedroom Apartment	
	Description	Amount (₦)	Description	Amount (₦)
Cost Price	Generator	55000	Generator	15000
Fueling	8 hours/day @ 8 litres/day	423400	8 hours/day @ 3 litres/day	158775
Servicing	15,000.00/year.	15000	5,000.00/year.	5000
Total		**₦493,400**		**₦178,775**

From the table it can be shown that cost estimate for powering a 2-bedroom and 3-bedroom apartment with generator for 1 year in a rural area not connected to the national grid is put at ₦178,775 and ₦493,400 respectively. (Hankins, 1995) in a paper has opined that the total cost for solar powering a 3-bedroom flat apartment is estimated to be ₦738,375.30 while that of a 1-bedroom apartment, comprising of 4 lighting points, 1 Television set, 1 Fan and a VCD is ₦172, 349. From the above it can be deduced that in three years the individual utilizing solar energy will break-even for his energy needs. This is not even taking

cognizance of efficiency of the generators which are on the downward trend as utilization increases. The foregoing is in consonance with the assertions that there is the major impediment militating against the widespread use solar energy and its related technologies are the Initial Capital Outlay (ICA) (Sambo, Renewable energy for rural development: the Nigerian perspective, 2005).

PROBLEM STATEMENT AND JUSTIFICATION

Despite several attempts made by the government to stabilise electricity in Nigeria, most homes in Nigeria either provide their electricity through a small generating set or solar power system but these solutions can only power few appliances excluding electric iron, cooker, and roasters in most cases.

OBJECTIVES OF THE STUDY

The objectives of this project are:

1. To design and construct a modified power supply unit
2. To connect the constructed modified power supply unit to a renewable power source
3. To test the complete MPS unit for both indoor and outdoor activities
4. To use the complete unit for Electric Ironing and Roasting purposes.

IMPLEMENTATION

Material needed

The device consists of the following major components:

1. Electric Socket Outlet
2. Switch
3. Silicon rectifier
4. Jumper wires and clips

Figure 3: Block Diagram of the MPS Unit

The figure 3 above indicates the process involved in achieving the proposed device. The modified power supply unit would either be powered by 500W/24V solar panel, a 20A charge controller, 24V/200AH batteries and a 2.5KVA inverter or a 750VA-2.5KVA generator.

Design and Construction of Modified Power Supply Unit

The figure 4 illustrates the internal circuitry of the modified power supply unit operating at full power. The supply is feed directly to the load via a switch.

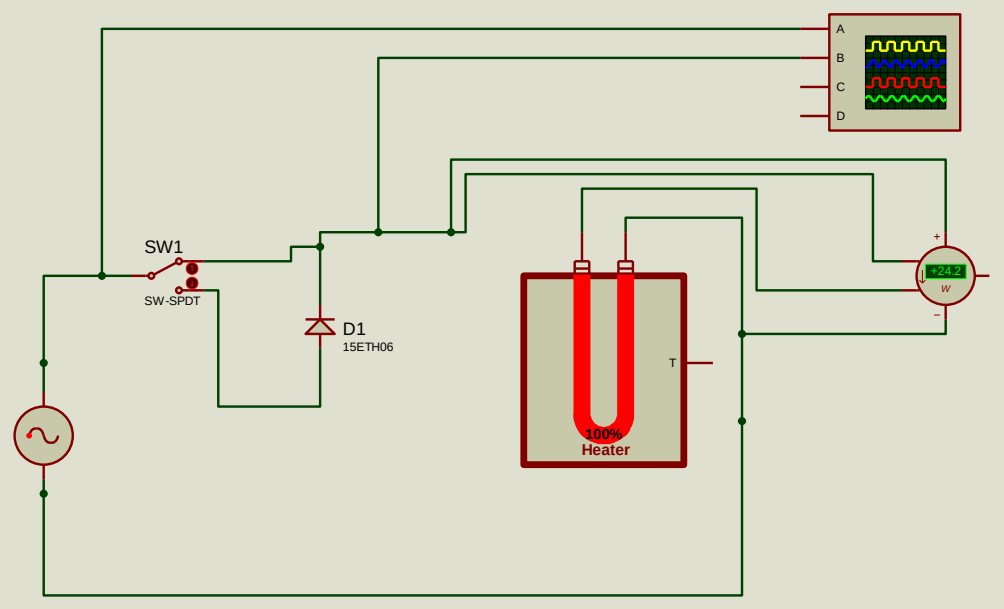

Figure 4: AC full power connection

The figure 5 below illustrates the internal circuitry of the modified power supply unit operating at half power. This is achieved by passing the supply through the silicon rectifier to the load.

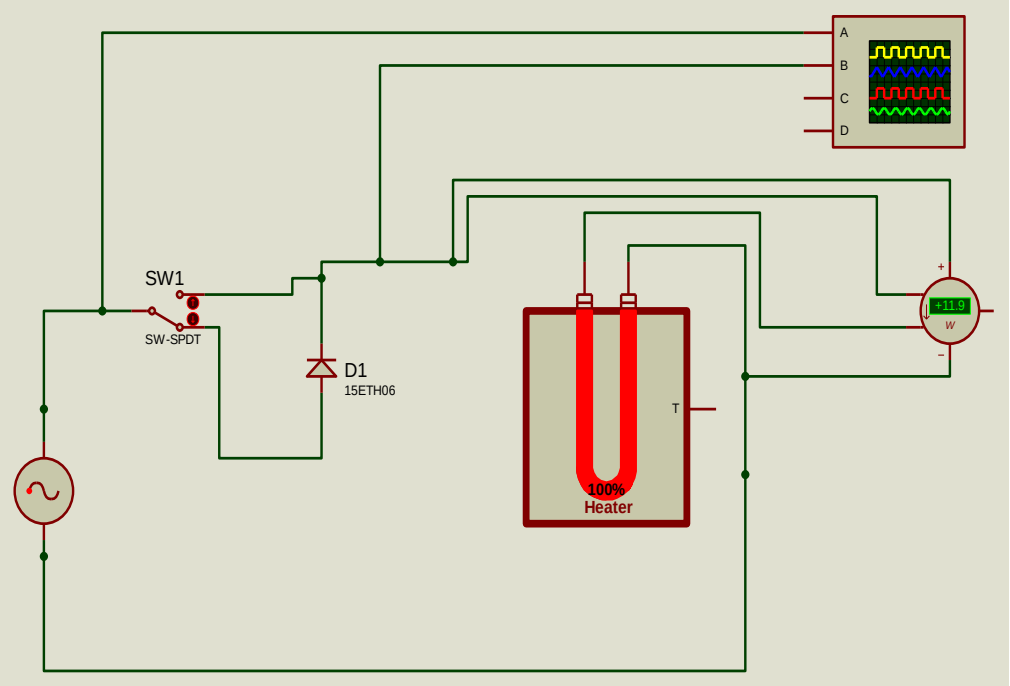

Figure 5: Modified AC half power connection

Figure 4 and 5 clearly indicates the schematic diagram including the wattmeter that displays the reading while switch is directly connected to the heater in figure 4 and when it connected to the heater through the silicon rectifier. The following is the waveform generated respectively.

RESULTS

The outcome of this project is a tested, trusted, portable, reliable modified power supply unit that can function for both indoor and outdoor activities for the purpose of ironing, cooking, roasting etc. It can even be used with small generating sets (750W – 2.2KW) for these activities.

Figure 6: No Load

Figure 7: Full Power

Figure 8: Half Power

Figures 6, 7 and 8 indicated the parameter readings at No Load, Full Load and Half Load respectively.

Table 2: Summary of Test Result

Item	Status	Volt	Current	Power	P.F.	Freq	Temp. of Silicon Rectifier
Steam Iron	Full Power	234V	6.36A	1.49KW	0.99	50Hz	32ºC
	Half Power	239V	3.47A	756.3W	0.90	50Hz	45ºC
Dry Iron	Full Power	237V	4.56A	1.08KW	0.99	50Hz	32ºC
	Half Power	241V	2.50A	550W	0.90	50Hz	40ºC

Note: No Load Voltage= 245V

CONCLUSION

Many homes currently possess alternative power supply for lighting and temperature control but cannot fully utilize its potentials, this unit will provide the opportunity to fully harness the power generated.

RECOMMENDATIONS

The following recommendations are made:

1. A lot of work still needs be done regarding this area so that it can be pushed to its limit.
2. The rated power of the device should not be exceeded; therefore, it should be properly fuse protected.
3. Due to the heat that will be generated by the device at half power, the vents should not be covered.

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