

Inverters: A More Effective Alternative Compared to Petrol Powered Generators for Meeting a Residential Load Demand In Nigeria

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ABSTRACT: Inadequate and erratic power supply, especially with the fluctuating price per litre of Premium Motor Spirit (PMS), has made most of the occupiers and owners of domestic residences as well as small businesses in Nigeria to resort to the use electric generators, strangely, as its most popular alternative for power supply. The authors' goal in the study described here was to compare the overall cost of meeting an average load demand of 3 kVA using petrol powered generating set against serving the same capacity with an inverter within Nigeria. PMS consumption rate was measured at maximum operating mode, for 4 specific brands of 3.5 kVA generating set over 18 months, for a daily duration of 2 hours, 5 times a week for an identified array of household electrical appliances (EA). Similarly, a 3 kVA inverter was used to power the same set of electrical appliances for the same daily duration, the same number of times a week for 18 months. The data acquired was analyzed using Microsoft Excel Spreadsheet and a value of 2.2 litres/hour was identified as average for a 3 kVA load demand. Comparison was made on meeting the specified load demand using a petrol powered generator and an inverter based on specific parameters. This research revealed that the petrol/gasoline powered generator used as an alternative source of providing electricity for an average of 2 hours daily will have utilized ₦ 12,804. The running cost over a maximum of 5 months will be ₦ 64,020- an amount more than enough to replace the generating set. This is apart from the cost of maintenance and other significant factors which could impair the health condition of the populace such as CO₂ dispersal and noise level, all of which the inverter alternative presented with better techno-economic indices and minimum carbon footprint.

KEYWORDS: Erratic power supply; premium motor spirit (PMS); electrical appliances (EA); 3.5 kVA petrol powered generator; 3.0 kVA inverter; CO₂ dispersal; noise level; load demand; techno-economic indices; carbon footprint..

I. INTRODUCTION

Electricity, which is one of the benefits of industrialization, has become a major priority for most people in LDCs as they try to meet their domestic, commercial, and industrial needs. In Nigeria, most of the cities and towns are connected to the national power grid for electricity supply, which is used for domestic, commercial, and industrial purposes among other uses [1]. Unfortunately, supply and demand are not balanced; in general, electricity supplies in Nigeria have historically been limited, and thus the supply of electricity nationwide has been a persistent high-priority issue among the Nigerian population [2]. Due to the unavailability and unreliability of electric power supply in Nigeria, the use of electric power generators has become widespread among occupants of residential households and small scale business operators as an alternative power source. Very few individuals consider the inverter as a sole alternative to power supply outage from the national power utility company. These power generating sets are usually located at close proximity to their workplace and produce noise at levels that potentially pose risks to human health, as well as incomplete combustion pollutants like carbon monoxide.

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Noise has been recognized as a serious health problem in modern society [3]. It has also emerged as an urban environmental problem both at work and at school [4]. [5] emphasized noise sources were domestic as well as industrial. Nevertheless, environmental noise pollution is, at present, of relatively lower policy importance in less developed countries (LDCs) like Nigeria where standards for monitoring pollution are not enforced or are nonexistent. This may be because many LDCs are encumbered with problems of insecurity and corruption while noise is less noticed.

Definitional information of an electrical load on a feeder was provided in [6] as the sum of all individual customer loads. Furthermore, an electrical load of a customer was explained as the sum of the load drawn by the customer's individual appliances. Customer loads have many common characteristics. Load levels vary through the day, peaking between 7-9 am and between 7-10 pm for a typical Nigerian residential area [6]. Additional information was provided in [7] on the sub-division of power systems loads into industrial, commercial, and residential. Industrial loads are composite loads, and induction motors form a high proportion of these loads. These composite loads are functions of voltage and frequency and form a major part of the system load. Commercial and residential loads consist largely of lighting, heating, and cooking. These loads are independent of frequency and consume negligibly small reactive power [7]. Demand was also explained in [3] as the load average over a specified time period, often 15, 20, or 30 min. Demand can be used to characterize real power, reactive power, total power, or current. Peak demand over some period of time is the most common way utilities quantify a circuit's load. In substations, it is common to track the current demand [6]. Residential load in Nigeria is largely proportional to the size of the house and the electrical appliances (EA) installed within the building. The demand range, for this load category, typically varies from 1 kVA to a maximum of 15 kVA.

II. METHODS

Premium motor spirit (PMS) consumption rate was measured at maximum operating mode, for 4 specific brands of 3.5 kVA generating set (Gen 1, Gen 2, Gen 3, Gen 4) over 18 months, for a daily duration of 2 hours, 5 times a week for an identified array of household electrical appliances (EA) as contained in Table 1. Similarly, a 3.0 kVA inverter was used to power the same set of electrical appliances for the same daily duration, the same number of times a week for 18 months. The total active power (kW) rating for the selected appliances against the 3.0 kVA load requirement column were summed up and converted to the apparent power (kVA) equivalent using the relationship in the equation (1)

$$\frac{kW}{kVA} = \text{Power factor} = \frac{\text{Active Power}}{\text{Apparent Power}} \quad (1)$$

[8]

Adopting a power factor value of 0.8 and making kVA the subject of formula, equation (1) becomes equation (2):

$$\text{Apparent Power (kVA)} = \frac{\text{Active Power (kW)}}{\text{Power factor}} = \frac{\text{Active Power (kW)}}{0.8} \quad (2)$$

III. RESULTS

The data acquired was analyzed using Microsoft Excel Spreadsheet and a value of 2.2 litres/hour was identified as average consumption value for a 3 kVA load demand. An operational cost analysis for meeting the target load demand as contained in Table 2. It compares the cost implication of meeting this load demand with a generator, and with an inverter at maximum operating mode-assuming every appliance is switched on.

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Table 1: Household appliances and their corresponding active power rating (kW)

S/N	Household Appliance	Active Power Rating P (kW)	Quantity (q)	Total Power Rating (P*q) (kW)	Load Requirement (kVA)			
					1.2	2.4	3.0	5.0
1	Fridge	0.90	1	0.90		√	√	√
2	Microwave	1.20	1	1.20		√	√	√
3	Water Pump	1.50	1	1.50			√	√
4	Bedside Fridge	0.30	1	0.30				√
5	Energy Saving Luminaries	0.02	10	0.15	√	√	√	√
6	Freezer	0.70	1	0.70			√	√
7	Washing Machine	0.55	1	0.55		√	√	√
8	Blender	0.75	1	0.75		√	√	√
9	Steam Pressing Iron	1.20	1	1.20			√	√
10	Perimeter Lighting	0.03	1	0.03			√	√
11	Travel Steam Iron	0.60	1	0.60		√		
12	Upright Fridge	0.65	1	0.65		√	√	√
13	Domestic Printer	0.06	1	0.06	√	√	√	√
14	Flat Panel Television	0.88	1	0.88	√	√	√	√
15	Laptop	0.04	1	0.04	√	√	√	√
16	Air Conditioner	0.75	2	1.50				√
17	Home Theatre	0.20	1	0.20	√	√	√	√
18	Ceiling Fan	0.06	1	0.06		√	√	√
19	Standing Fan	0.06	1	0.06	√	√	√	√

Item 6 in Table 2 reveals an average consumption value of 2.2 litres/hour for a 3 kVA brand new petrol/gasoline powered generating set. A product of that figure and the present official unit cost of fuel (in Nigeria) is 213.4 kWh- a result of equation (3).

$$2.2 \times 97 = 213.4 \text{ kWh} \quad (3)$$

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Table 2: COMPARISON BETWEEN TWO SOURCES OF MEETING A 3 kVA LOAD REQUIREMENT.

Items	Parameters	Inverter	Petrol powered generator
1	Capital cost and haulage (for 3 kVA demand) in	470,000	60,000
2	Ease of meeting the demand in phases	A part of the total load demand can be met immediately while provision can be made for the remainder at a future date without additional charges apart from the Capital Cost.	It is possible to purchase more than one generating set to meet the demand in phases. However, this will be accompanied by very significant implications due to items 5, 7, 9,10,11,14 apart from Capital Cost.
3	Fuel type	Chemical energy	Petrol powered generator
4	Fuel accessibility	Battery Banks	Obtainable at filling stations
5	Unit cost of fuel	Nil	97
6	Fuel Consumption at Maximum Operating Mode (Litres/hour)	Maximum demand	2.2 (Average Consumption)
7	Fuel consumption per kWh (at maximum operating load)	Nil	213.4
8	Nominal duty cycle at full load operating mode (in hours)	10,000	11.9
9	Frequency of maintenance (per annum)	once in six years	6
10	Cost of full service (In Naira)	520,000 for replacement of 8, 100 A batteries	6,000
11	CO ₂ dispersal rate/Pollution level	Nil	Very high because of the density of hydrocarbon content in Premium Motor Spirit (PMS)
12	Noise level (Db)	Nil	Significantly for the capacity considered- 65 decibels for a brandnew set- despite silencing technology.
13	Preferable Location Spot	Indoor	Outdoor
14	Requirement for Installation	Nil	Generator house
15	Cost of lubrication: friction of	Nil	Very Significant.

Observing the contents of the columns from left to right, the first cell in the first row of Table 3 reveals the duty cycle value in hours for a 3 kVA generating set. This value is multiplied by the consumption per kWh in column 2. This value is obtained as a product of the prevailing unit cost of fuel (₦ 97) and the fuel consumption at maximum operating mode (2.2 litres per hour). The product of values in column 1 and 2 are recorded as daily consumption in column 3.

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Results obtained and recorded in column 3 are multiplied by 30 days to arrive at the monthly consumption value detailed in column 5. Values recorded in the fifth column corresponds to a specific daily duty cycle for a 3 kVA generating set.

Table 3: Financial Value of Electric Power Utilization at Maximum Operating Mode per Daily Duty Cycle

Daily duty cycle (hrs)	Consumption per kWh (₦)	Daily Consumption (₦)	Total working days in a Month	Monthly Consumption (₦)
2	213.4	426.80	30	12,804
4	213.4	853.60	30	25,608
6	213.4	1280.40	30	38,412
8	213.4	1707.20	30	51,216
10	213.4	2134.00	30	64,020
12	213.4	2560.80	30	76,824
14	213.4	2987.60	30	89,628
16	213.4	3414.40	30	102,432
18	213.4	3841.20	30	115,236
20	213.4	4268.00	30	128,040
22	213.4	4694.80	30	140,844
24	213.4	5121.60	30	153,648

IV. DISCUSSION

Other items contained in Table 2 clearly demonstrate an obvious advantage of an inverter option over a generator option for meeting a 3 kVA load requirement. Reading from left to right, the first row of Table 3 also reveals that for any petrol/gasoline powered generator being used as an alternative power source of providing electricity for an average of 2 hours daily will have utilized ₦ 12,804. The running cost over a maximum of 5 months will be ₦ 64,020. This amount is more than enough to replace the generating set with a capital cost of ₦ 60,000 as identified in item 1 of Table 2. This is apart from the cost of maintenance and other significant factors which could impair the health condition of the populace such as CO₂ dispersal and noise level, all of which the inverter alternative presented with better techno-economic indices and minimum carbon footprint.

V. CONCLUSIONS

Upon concluding our findings and analysis, it can deduced that a generator technology, no matter how noiseless, synchronized with other sets, purchased with a relatively low capital cost, is a less effective choice in the long run compared to the use of an inverter for meeting load demand for domestic utilization.

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