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Research Article

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Evaluation of Electrical Services using Energy Efficient Load

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Abstract The energy efficient load is considered as an important tool for efficient management of available electrical energy in Nigeria because it allows electricity utility to meet the power demand of many consumers with little or no increase in power supply generation. This paper discusses the technical and economic benefit of using energy efficient load for electrical services design considering a four-bedroom apartment in Nigeria as a case study. Load analysis and evaluation were carried out using both conventional load and energy efficient load for electrical services. The technical benefits were determined by calculating the total energy demand, apparent power and current drawn by the four-bedroom apartment. Apparent power and current are important tools to determine Transformer capacity, Cable capacity and Generator capacity for the apartment. The economic benefits were determined by calculating the daily energy consumption by the four-bedroom apartment and this is a great tool in computing the daily cost of electricity by the apartment. The result shows that 41.26% of total energy demand is saved and 32.96% of daily energy consumption is saved if the energy efficient loads were used as an alternative to conventional load for that four-bedroom apartment.

Keywords Energy Demand, Energy Consumption, Current, Cost of Electricity, Load Analysis

1. Introduction

Electricity is important for our Economic growth and since it cannot be stored in bulk, it should be generated, distributed and consumed immediately [1]. The rise in population has led to an increased gap between power demand and supply in many countries, Nigeria been the most populated country in Africa is not omitted from this challenge. An increase in the Nigerian population has led to a corresponding increase in electricity demand without continuous and quality electricity to meet such [2]. To meet the increase in electricity demand, the nation need to increase the installed capacity or effective use of available capacity.

Nigeria's government attention is focused on increasing power generation and not much attention is being given to how the available power could be managed effectively to serve the consumers [3].

The poor and unstable electricity supply in Nigeria has forced many industries, businesses, and households to rely on diesel and petrol generators as primary or back-up sources of power. Therefore, the utility company is facing problems to deal with the ever-increasing electricity demand which results in load shedding and low voltage at the consumers' end. As a result, Energy efficient load will enhance and also go a long way to redress the issue of power supply shortage in Nigeria [4].

This paper presents the technical and economic benefit of using the energy efficient load over the conventional electrical loads for electrical services design of a four-bedroom apartment in Nigeria.

Methodology

After study many literature reviews on the present practice of electrical services design, the inefficient practice was identified and an efficient method was suggested for designing electrical services. In this section of thework, we estimate total energy demand, reactive power, apparent power, current, daily energy consumption

and daily consumption costfor conventional loads and energy-efficient loads. This involves the calculation and analysis of all electrical load employed for the work by the following equations:

Diversity Factor = $\frac{\text{Energy Demand}}{Connected\ \ Load}$

EnergyDemand = (Connected Load × Diversity Factor) W

Active Power $(P) = Energy\ Demand(W)$

Energy Consumption per Day = (Energy Demand × Usage Time per Day) kWh

Power Factor (PF) = Cos θ = 0.8

θ = Cos^{-1} 0.8

Reactive power (Q) = P × tanθ= $P \times \tan(Cos^{-1}\ 0.8)\ (VAR)$

Apparent Power (S) =$\sqrt{P^2 + Q^2}(VA)$

Apparent Power (S)= $\sqrt{3}$ VI(VA)

Current I = $\frac{S}{\sqrt{3}\,V}$(A)

Voltage = 415 V (Nigeria three Phase Voltage)

Cost of Electricity per Day = (Energy Consumption per Day ×Nigeria Electricity Price) ₦

Nigeria Electricity Price for households = ₦25.731/kWh

Table 1: Number of Points of Electrical Load for Four-Bedroom Apartment

Room Type	Ceiling Fan	Electric Cooker	Water Heater	15A Socket Outlet For AC	Extractor Fan	13A Socket Outlet	Indoor Lighting	Outdoor Lighting	Mirror Lighting
Bedroom 1	1	-	-	1	-	3	3	-	-
Bedroom 2	1	-	-	1	-	3	3	-	-
Bedroom 3	1	-	-	1	-	3	3	-	-
Bedroom 4	1	-	-	1	-	3	3	-	-
Toilet 1	-	-	1	-	1	1	1	-	1
Toilet 2	-	-	1	-	1	1	1	-	1
Toilet 3	-	-	1	-	1	1	1	-	1
Toilet 4	-	-	1	-	1	1	1	-	1
Living Room	2	-	-	2	-	4	5	-	-
Dinning	1	-	-	1	-	2	3	-	-
Kitchen	-	1	1	-	1	4	3	-	-
Store	-	-	-	-	-	-	2	-	-
Lobby	1	-	-	1	-	2	3	-	-
Balcony	-	-	-	-	-	-	2	-	-
Outdoor	-	-	-	-	-	-	-	10	-
TOTAL	**8**	**1**	**5**	**8**	**5**	**28**	**34**	**10**	**4**

Table 2: Load Analysis Using Conventional Load

S/N	Load Type	No Of Points	Connected Load Per Points (W)	Diversity Factor	Energy Demand (W)	Usage Time Per Day (Hrs.)	Energy Consumed Per Day (kWh)
1	Ceiling Fan	8	100	0.80	640.00	8	5.12
2	Electric Cooker	1	6000	1.00	6000.00	4	24.00
3	Water Heater	5	4000	0.80	16000.00	2	32.00
4	15A Socket Outlet For Air Condition	8	1000	0.80	6400.00	12	76.80
5	Extractor Fan	5	100	0.80	400.00	3	1.20
6	13A Socket Outlet	28	300	0.80	6720.00	10	67.20
7	Indoor Lighting	34	24	0.80	652.80	15	9.79
8	Outdoor Lighting	10	100	1.00	1000.00	12	12.00
9	Mirror Lighting	4	18	0.80	57.60	1	0.06
	TOTAL				**37,870.40**		**228.17**

Table 3: Load Analysis Using Energy Efficient Load

S/N	Load Type	No of Points	Connected Load Per Points (W)	Diversity Factor	Energy Demand (W)	Usage Time Per Day (HRS)	Energy Consumed Per Day (kWh)
1	Ceiling Fan	8	80	0.80	512.00	8	4.10
2	Electric Cooker	1	3000	1.00	3000.00	4	12.00
3	Water Heater	5	2000	0.80	8000.00	2	16.00
4	15A Socket Outlet For Air Condition	8	746	0.80	4774.40	12	57.29
5	Extractor Fan	5	40	0.80	160.00	3	0.48
6	13A Socket Outlet	28	220	0.80	4928.00	10	49.28
7	Indoor Lighting	34	15	0.80	408.00	15	6.12
8	Outdoor Lighting	10	20	1.00	200.00	12	2.40
9	Mirror Lighting	4	10	0.80	32.00	1	0.03
	TOTAL				**22,014.40**		**147.70**

Table 4: Comparison of Energy Demand with Conventional and Energy-Efficient Load

S/N	Electrical Load Type	Energy Demand with Conventional Load (W)	Energy Demand with Energy Saving Load (W)	Energy Saved (W)
1	Ceiling Fan	640.00	512.00	128.00
2	Electric Cooker	6000.00	3000.00	3000.00
3	Water Heater	16000.00	8000.00	8000.00
4	15A Socket Outlet For Air Condition	6400.00	4774.40	1625.60
5	Extractor Fan	400.00	160.00	240.00
6	13A Socket Outlet	6720.00	4928.00	1792.00
7	Indoor Lighting	652.80	408.00	244.80
8	Outdoor Lighting	1000.00	200.00	800.00
9	Mirror Lighting	57.60	32.00	25.60
	TOTAL	**37,870.40**	**22,014.40**	**15,856.00**

Table 5: Apparent Power, Current and Cost Analysis for Four – Bedroom Apartment

	Total Energy Demand (W)	Reactive Power (VAR)	Apparent Power (VA)	Current (A)	Total Energy Consumed Per Day (kWh)	Daily Energy Consumption Cost (₦)
Conventional Load	37,870.40	28,402.80	47,338.00	65.86	233.29	6,002.77
Energy-Efficient Load	22,014.40	16,510.80	27,518.00	38.28	147.70	3,800.47
Reduction	**15,856.00**	**11,892.00**	**19,820.00**	**27.58**	**85.59**	**2,202.30**

Percentage Total Energy Demand saved = $\frac{15414.40}{37356.80} \times 100$

= 41.26%

Percentage Total Energy Consumed per day saved = $\frac{71,93}{218.24} \times 100$

= 32.96%

Results and Discussion

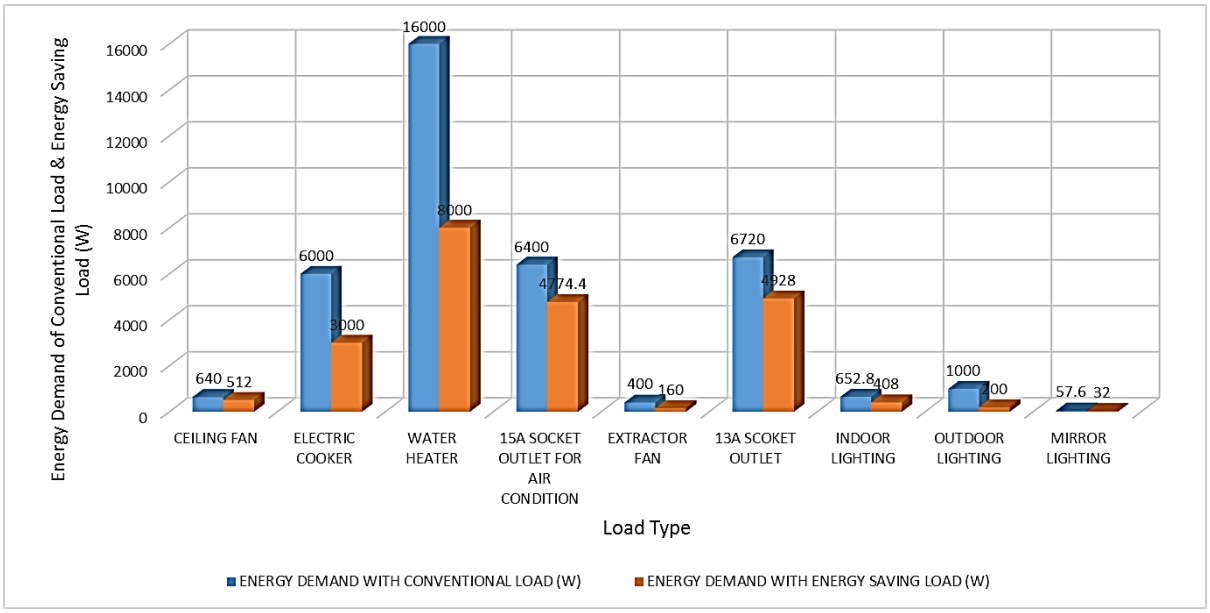


Figure 1: Comparison of Energy Demand with Conventional and Energy-Efficient Load

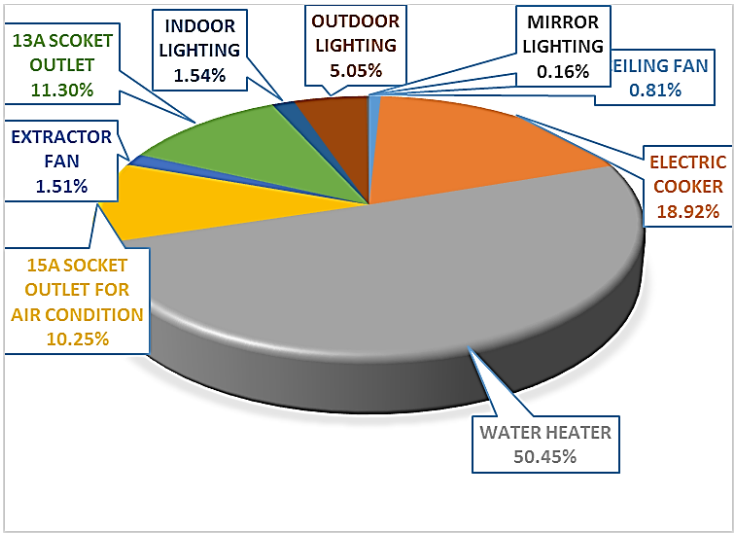
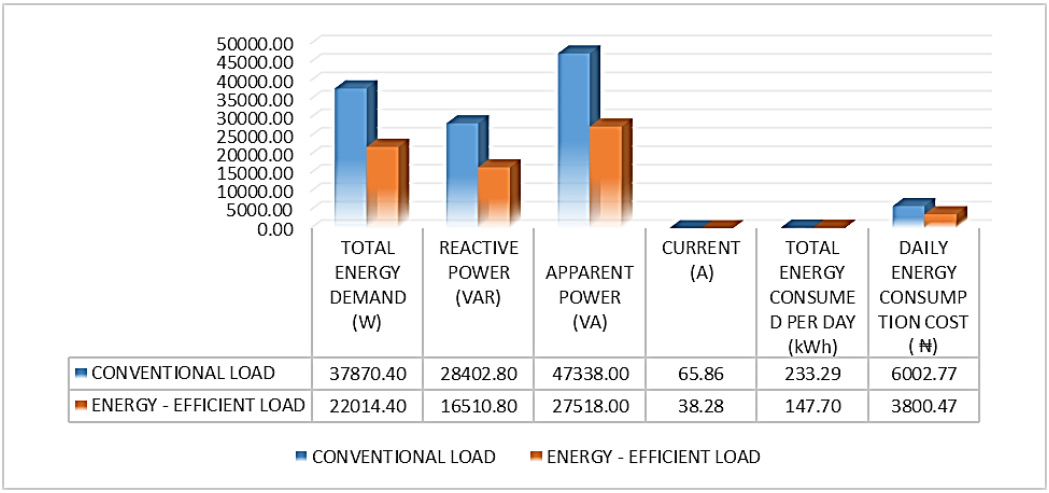


Figure 2: Percentage Energy Saved by Each Electrical Load



	TOTAL ENERGY DEMAND (W)	REACTIVE POWER (VAR)	APPARENT POWER (VA)	CURRENT (A)	TOTAL ENERGY CONSUMED PER DAY (kWh)	DAILY ENERGY CONSUMPTION COST (₦)
CONVENTIONAL LOAD	37870.40	28402.80	47338.00	65.86	233.29	6002.77
ENERGY - EFFICIENT LOAD	22014.40	16510.80	27518.00	38.28	147.70	3800.47

Figure 3: Comparison of Conventional Components and Energy Efficient Components

Load evaluation of four-bedroom apartments in Nigeria with conventional load was used to estimate energy demand, reactive power, apparent power, Current and daily energy consumption when compared with load evaluation of the same apartment using an energy efficient load. It is observed that there is a significant decrease in energy demand and daily energy consumption by using energy efficient load for electrical services, and result of the analysis shows that the Total maximum demand saved 15,856W (15.86kW), Reactive power saved 11,892VA (11.89kVAR), Apparent power saved 19,820VA (19.82kVA), Current saved 27.58A and Energy consumed per day saved 85.59kWh. The cost of electricity per day is ₦6,002.77 using conventional load and ₦3,800.47 using an energy efficient load. The energy efficient loads have saved the occupant of the apartment ₦2,202.30 electricity bill. Hence, 41.87% of total energy demand is saved and 36.69% of daily energy consumption is saved if the energy efficient loads were used as an alternative to conventional load for that four-bedroom apartment.

Conclusion

Evaluation of Electrical services using energy efficient load for four-bedroom apartment has been attempted and carried out. The positive impact of using energy-efficient load will produce a very favourable result because it reduces energy demand and energy consumption. It is an important method of using available electrical energy in a more efficient way and it will benefit not only the consumers or Utility companies but also the nation as well. This paper suggested proper awareness of using energy-efficient load by electricity customers because it reduces electricity bill, it enables utility companies to meet the power demand of many consumers, it reduces the number of blackouts due to overloading, it improves network reliability, it delays construction of new power plant and it reduces Cable, Transformer and Generator capacity. Hence, proper energy efficient culture should be embraced to boost the nation's energy needs as well as provides energy independence.

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