

Minimizing the cost of energy consumption for public institutions in Nigeria

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Abstract: Energy and humanity are superimposed. Its importance to humankind and indispensable nature to the world cannot be overemphasized. Public institutions and households need energy to carry out their daily activities. The increase in the demand for energy in public institutions can be traced to technological advancement, which has resulted in a sharp rise in energy consumption, increasing the energy monthly utility bill astronomically. These have put pressure on public institutions in Nigeria and across the globe, as most are heavily indebted to energy companies. Due to constant electric power failure in Nigeria, public institutions rely heavily on diesel generators to argument their daily energy need. Cost minimization and sustainable clean energy have become a priority for the managers of our public institutions. This study was carried out to establish the exact amount of energy consumption at the Federal Polytechnic Bida, Nigeria, and fashion out ways of reducing the cost burden for the institution. The study was achieved by installing "Efergy Meter" to understudy the energy audit of the institution. Based on the result obtained, the exact amount of energy consumption was established. The solar photovoltaic (P.V.) system was considered a clean and cost-effective option for our public institutions in the long term.

1. Introduction

Energy is key to the social-economic development of all nations around the world (Adenikinju, 2003; Ghadi et al., 2018). Public institutions, such as Polytechnics, Universities and all other forms of tertiary institutions of learning, needs a constant energy supply to meet their daily work demands. Laboratories, Research centres, hostels, and administrative buildings in our public institutions cannot survive a day without an adequate energy supply. Therefore, it's essential to find a sustainable, clean and cost-effective way to keep our public institutions running without too much cost burden and ensure constant energy supply to critical infrastructures.

Due to the current COVID-19 pandemic, institutions worldwide have switched over to virtual learning platforms. Thereby, constant energy supply for critical infrastructures is in high demand. It will be a total disaster if the ICT unit goes off for hours during this pandemic era; such units need a constant energy supply to keep knowledge and

information dissemination alive in our public institutions. Due to the surge in energy demand during the pandemic, there is also a sharp increase in monthly energy bills, plugging so many public institutions in Africa into a heavy debt burden with energy supplying companies.

Electrical energy is the most sorted after in our public institutions, and it can be produced from both sustainable (justifiable sources) and non-sustainable (non-justifiable sources) (Keerthi Jain et al., 2017; Leung, 2018; Olukaju, 2004). Most African countries have inadequate energy infrastructure, with African electrical energy generation standing partly at four per cent (4%) of the world's electric energy consumption (Leung, 2018). The electrical energy demand in Nigeria cannot be met wholly by the national grid; this is due to insufficient electrical energy generation, resulting from poor infrastructure (Keerthi Jain et al., 2017). Nigeria only generates fifteen per cent (15%) of its 31000MW energy demands as of 2015 (Pickering et al., 2018). This has a severe adverse impact on the social-economic life of the Nigerian populace.

The public institutions, a major consumer of electrical energy, have been forced to rely on diesel generators to meet their demand for electrical energy supply in Nigeria. Most public institutions in Nigeria spend millions of naira monthly to buy fuel (diesel) for their generators (Oseni, 2011). This has a considerable effect on the revenue generation of these institutions. Their ability to invest in research and capital development is seriously hampered. Infrastructure is left to decay because public institutions can't afford to renovate them, as the paucity of funds lingers in our public institutions. Nigeria, for example, has more than eight million of its students studying outside the shores of the country due to the poor nature of our tertiary institution's infrastructure (Zhao et al., 2013). Money that could have been freed to develop the Polytechnics, Universities, and other tertiary institutions are paid to energy companies as monthly utility bills. This is not inclusive of money spent on the daily operation of generators and maintenance activities. The problem of a regular electric power outage and its epileptic nature in Nigeria has made public institutions depend on six to seven hours of their electric energy need squarely on diesel generators (B. B Mohsen, 2011). Thereby adding to the cost burden of providing an uninterrupted power supply in running the daily energy need of our public institutions. Renewable energy systems are cost-efficient, reliable, and free of toxic gas emissions and are therefore regarded as environmentally friendly (B. B Mohsen, 2011). The study focused more on solar energy analysis and cost-effectiveness in supplying alternative and uninterrupted power supply to the Federal Polytechnic Bida, Nigeria.

The wildfire in Siberia, Algeria and some parts of Europe calls for serious concern. Global warming is real, and we can't afford the continuous release of toxic gases in to the atmosphere, time to stop atmospheric pollution is now. The need to shunt diesel generators and all other forms of non-renewable energy is fast approaching if we must reach the United Nations goal of stopping further depletion of the ozone layer by 2030 (Merabtine et al., 2018). There is an urgent need to completely remove diesel generators from our public institutions, and their hazardous effect should not be entertained anywhere near our learning environment.

The study (Rabiu Abbas et al., 2017) proved that efficient use of natural light could drastically lower the cost of energy consumption in office buildings. This is correct if only lighting systems are the only major consumer of energy in office buildings. But given the fact that there are various other energy-consuming devices, such as air conditioners, printers, laptops and many heavy laboratory equipment, a system must be derived to ensure these various energy-consuming devices also have a fair share of their required energy from the natural source of light (Sun). This is where designing a photovoltaic solar system becomes a huge interest since it can trap sunlight and convert it to electrical energy, which is clean and sustainable (Ajayi et al., 2016).

This study focused on the electrical energy demand and alternative sources for meeting the energy requirement of public Institutions in Nigeria. This study was achieved using the Federal Polytechnic Bida, Nigeria, as a case study. A well-designed energy

analysis will be the first option for a cost-effective solution for public institutions. This will serve as an alternative solution to the rapidly growing energy demand of the new era, which will lead to more reliable and cost-effective solutions. The heavy debt burden of supplying energy to our tertiary and public learning institutions will have been significantly reduced. This will, in turn, free more funds for capital, infrastructure and research development. A conducive and environmental friendly scenario can only be achieved if we deal away with all sources of environmental pollution (Adekitan et al., 2018).

Previous research has been put forward to address the problem of an energy audits globally. Still, none has been able to address energy losses during long-distance transmission effectively. While in the research of (Adekitan et al., 2018), this problem was massively dealt with. But another problem of increased labour cost was caused by the share number of people required to carry out the energy audit of massive government infrastructure ("Monitor Reduce save Instruction Manual," 2019). The errors associated with other forms of energy meters are highly dealt with in designing the efergy meter, giving it more durability and compatibility when compared to other forms of energy auditing meters (Efergy, 2021). The research by (Dimnwobi et al., 2022) shows that many energy consumption investigations have been done for residential buildings, but not much attention has been dedicated to public institutions. This is understandable as energy consumption at homes is quite small when compared to a public institution. The individual is also desirous of finding a lasting solution to their daily rise in energy utility bills. This zeal is not forthcoming from the owners of the public institution, majorly the government, as they continue to use taxpayers' monies to fruit the payment of energy bill bills for public institutions. These huge monies could have been invested in other critical sectors that need urgent intervention. In this study, efergy meters were installed at the federal polytechnic Bida to help carry out energy audits of the buildings. A comparative cost analysis was carried out to find alternative sources of supplying energy to the institution that is cost-effective, clean and sustainable.

Efergy Energy Meters show the amount of energy consumed by a household when the display is read (Maduekwe et al., 2020). The display can also give the user a reading showing usage in financial terms (Babajide et al., 2021). You can walk around the home with your monitor device, switching appliances on and off, to see the difference that each one makes. With this use, you will know which house appliance consumes energy the most and the best way to save energy and cost. With a few minor changes in your consumption behaviour, the monitor can help you reduce your energy costs. Efergy Wireless Energy Meters are simple to install and maintain. A CT sensor is clipped onto the live feed cable of your breaker panel. A lead from the sensor is connected to the Efergy Transmitter. This Transmitter wirelessly sends real-time data to the Energy Display. The efergy meter is preferred over other energy auditing devices because of its share advantage of being able to transmit data in real-time, easy installation, cost-friendly and cheap labour. The efergy was first employed by energy companies to help estimate the exact amount of energy consumption by household and have never been used for energy auditing and load analysis (Owebor et al., 2021). Their success in eliminating energy losses due to hysteresis and transmission and determining the exact amount of energy consumption in different households simultaneously makes them ideal for future research in public institutions (Juanpera et al., 2022). This will bring a rare balance between cost billed and energy consumed, as a near-zero energy loss reading will have been achieved through the efergy meter.

2. Materials and Methods

2.1. Research area coverage

Essential data were collected through a site survey of all four vital buildings in the Polytechnic. This includes the admin block, business centre hall, security outpost and

student hostel. An "Efergy Meter" was installed to carry out the energy audit of the buildings, as an accurate energy audit is the first step in a reliable energy design system. In the study (Efergy Pro Installation Guide, 2021), an energy audit can be categorized into three: walk-through, investment grade, and general assessment. They all depend on the holistic nature and purview of the audit. The Efergy Meter has three major components: The Transmitter, router, and meter (Efergy Solar Quick Start Manual, 2021) (Figure 1). The Efergy transmitter consists of three magnetic probes connected to the most central load lines of the transfer switch (Figure 2). The Efergy Meter has an operating range of five seconds (5s), ten seconds (10s) and fifteen seconds (15s) (Agbetuyi et al., 2011). These are the time range in which load and energy data are sent to Efergy Meter.



Figure 1. Pictorial view of the efergy with three Magnetic probes connected to the central load lines of the transfer switch in the admin block



Figure 2. Pictorial view of the efergy Transmitter connected to the transfer switch and the efergy router connected to a meter in the admin block.

The Efergy system can transmit real-time data in a dashboard that can be accessed in (Figure 3); data are then collated to help us understand the energy need of each building. The energy profile of each building is accurately gotten, which will help us with the futuristic design plan. Several other studies have been performed as regards energy

audit and load analysis. Most of the methods did not offer solutions to the energy consumed by transmission lines (Adewale et al., 2018; Oh et al., 2014). Thereby leading to inaccurate design analysis and planning for office buildings located inside public institutions. In most of these studies, a twenty-five per cent (25%) increase is added to the final energy consumption value. This was meant to take care of future increases in energy demand and any inaccuracy that might have been associated with the methodology applied (Moyo, 2009; Moran, 1982). With the help of the Efergy Meter, the inaccuracy of load profiling is reduced to near zero, and a twenty-five per cent increase to the final value of energy data will only help in taking care of future increases in energy requirements for buildings. Time-saving is also of critical importance. The number of days and personnel that will have been required to perform energy audits has also been reduced; as the Efergy Meter has the capacity to perform energy audits faster and accurately with less personnel involved, the cost of labour will have been reduced drastically. The effectiveness of the Efergy Meter in energy audit for energy designing system has never been tested, and the Efergy were only previously used to determine the unit cost of energy consumption for solar companies. Haven knew the peak load at the different intervals; it's easy to then determine the average peak load of energy consumption per. This will be a great help to our study. The accuracy of the Efergy is not in doubt since they have been put to use to a fine unit cost of solar energy consumption; all we need is to track the different peak loads over the six-month duration to be able to decide the maximum amount of energy consumption per day accurately.

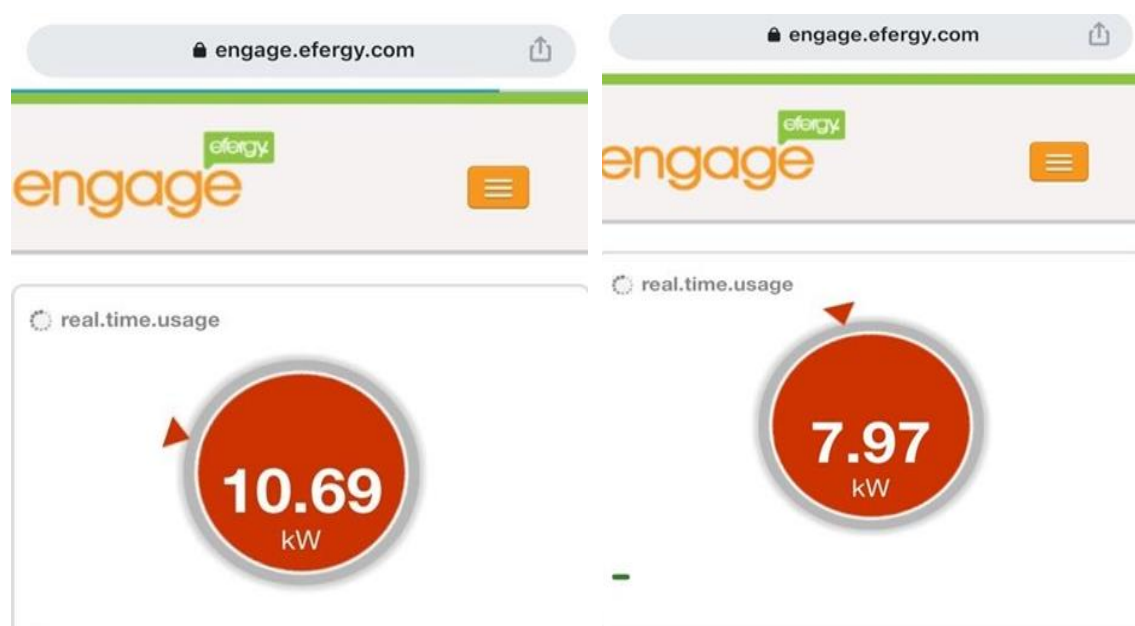


Figure 3. Dashboard real-time reading of the efergy meter (*Efergy Pro Installation Guide*, 2021)

The efergy meter was installed in February 2021 for a period of six months in the four main buildings at the Federal Polytechnic Bida, and they were then uninstalled in August 2021. This was to ensure that the different peak loads were recorded in order to ensure an effective energy design system for the institution. Since the Polytechnic runs two semesters per year, the efergy meter was installed for the whole duration of the first semester. As expected, the energy consumption will be minimal during holidays, so this was captured in the six months duration of the Efergy datasheet.

The flowchart below shows a simple step by step approach employed by the authors in determining the exact amount of energy consumption at the Federal Polytechnic Bida, Nigeria.

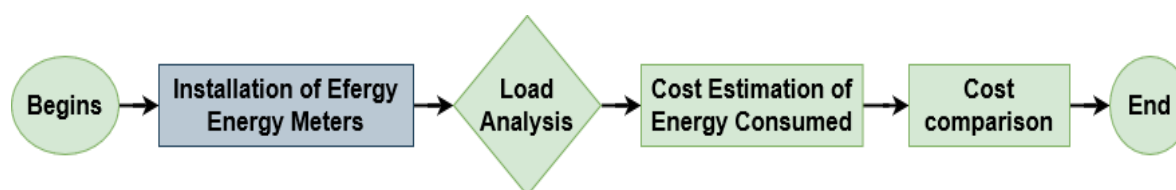


Figure 4. Flowchart illustrating step by step approach of the energy audit

2.2. Load Analysis

Analyzing the result of the energy audit is the first essential step in achieving a comprehensive energy management design (Omeiza, 2020; U. EIA, 2008). This will help in modelling a cost-effective plan for any futuristic energy project. Based on the data obtained from the efergy meter, a cost-effective energy supply system will be built.

Table 1 below illustrates the peak load obtained for the four different buildings at the Federal Polytechnic Bida, Nigeria (Figure 5).

Table 1. Peak load obtained for the four main buildings at the Federal Polytechnic Bida

S/N	Description	Peak Load (KW)
1	Admin block	96.5
2	Business Centre hall	146.8
3	Security outpost	10.9
4	Student hostel	255.6
5	Total	509.8

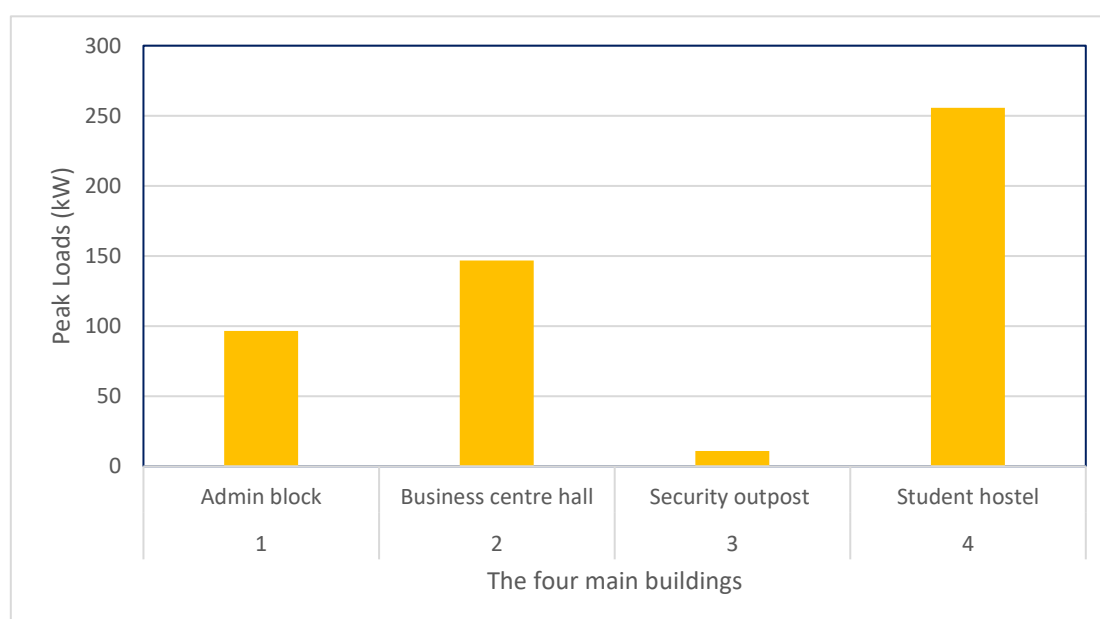


Figure 5. Load analysis of the four main buildings

The official working hours in Nigeria are from 8 AM to 5 PM, making a total of nine hours per day. In this study, we will be making use of ten work hours for each day, covering a period of five working days each week.

This will give us a total of 261 working days per year, and taking a futuristic plan of five years design into consideration, we will have a total of 1,305 working days, with all necessary public holidays in Nigeria taken into account. The table 2 shows the total energy consumption per day in the four main buildings at the Federal Polytechnic Bida, with an average of ten working hours.

Table 2. The total energy consumption in each building

S/N	Description	Peak Load (kW)	Working hours (h)	Energy Consumption (kWh)
1	Admin Block	96.5	10	965
2	Business center hall	146.8	10	1,468
3	Security outpost	10.9	10	109
4	Student hostel	255.6	10	2,556
5	Total	509.8		5,098

2.3. Estimating Unit Cost of Renewable Source Energy

According to the study (Omeiza, 2020; Omeiza et al., n.d.-a), the unit cost of supplying electrical energy through a renewable source can be found using the thermos-economic equation. The cost balancing equation can determine the cost of supplying electrical energy from non-depletable sources (Renewable) and depletable sources (Generators). The exchange rate of the Nigerian currency (NGN) to the United States of America currency (USD) as of 5th June 2021, when this research was being carried out, stands at NGN 414.90 = USD 1.00, this was according to the central bank of Nigeria foreign exchange rate (Isihak et al., 2022).

$$C_f E_z^p + \sum C_1 = C_w E_z^j \quad (1)$$

where, C_f = per unit cost of fuel; E_z^p = consumption rate of fuel energy; C_1 = component of capital cost; E_z^j = electrical energy generation rate.

$$\sum C_1 = C_w T_c E_z^w \quad (2)$$

$$T_c = \frac{\text{Electrical energy generated annually by the energy system}}{\text{Annual capacity of the energy system}} \quad (3)$$

where, T_c (Capacity factor) can then be replaced by a system's energy utilization factor, which is shown in equation (4).

$$U_p = \frac{\text{Annual total hours of operation}}{365 \times 24} \quad (4)$$

2.4. Estimating the Unit Cost of Electric Energy generation by the National Grid

Since the total energy consumed in the four main buildings is 5098kWh/day, the tariff for energy consumed in Nigeria is 35.35NGN/kWh. This is the amount set by the national energy regulation council (NERC) (Omeiza et al., n.d.-b; Oyedepo, 2012).

The estimated average total of daily energy consumption = Daily average total of energy consumed * Tariff (Oyedepo, 2012) (5)

$$= 5098 \times 35.35 = 180,214.3 \text{ NGN/Day}$$

Taking the futuristic plan of five years into consideration, assuming the Nigerian energy tariff for public users remains unchanged, then the energy cost for 1,305 workdays will be;

$$\text{Cost of energy for five years duration} = 180,214.3 \times 1,305 = 235,179,661.5 \text{ NGN.}$$

2.5. Estimating the Unit Cost of Diesel Generator

Since the total load of the four buildings is known to be 509.8KW, we can determine the diesel generator capacity to use (Oyedepo, 2012). With a power factor of 0.8, we can size the generator accordingly.

$$\text{Apparent power (KVA)} \times \text{Power factor (pf)} = \text{actual power (kW)} \quad (6)$$

$$\text{Apparent Power} = \frac{\text{Actual power (KW)}}{\text{Power Factor (pf)}} \quad (7)$$

$$\text{Apparent Power} = \frac{509.8}{0.8} = 637.25 \text{ kVA} \quad (8)$$

With respect to this study and analysis, an Olympian GEP660-1 with a capacity of 660kVA/528kW, 3-phase, 400-V, 50 Hz was chosen, with a maximum capacity of 660kVA and a fuel (diesel) consumption rate of eighty-two litre per hour (82 Litre/hour) and had a lube oil capacity of forty-five litres (Strategic Gas Plan for Nigeria: Joint UNDP/World Bank Management Programme, 2004; IEA, 2006).

Purchase Cost = 60,500,000 NGN

Installation Cost = 500, 000 NGN

Diesel buying price with annual inflation taken into account = 300.5 NGN/Litre

Daily consumption of fuel (diesel) = 820 Litres

Daily cost of fuel (diesel) = $82 \times 10 \times 300.5 = 246,410$ NGN

Total estimated daily energy consumption = 5098 kWh/Day

Hourly energy consumption for a ten-hour work day = $5098/10 = 509.8$ kWh

Yearly maintenance cost = 800,000 NGN

Estimating all cost for a period of 5 years = $60,500,000 + 500,000 + (246,410 \times 1,305) + (800,000 \times 5) = 386,565,050$ NGN

Daily generator usage cost = $\frac{386,565,050}{1,305} = 296,218.8$ NGN

Per Unit Cost = $\frac{\text{Daily Cost of Energy}}{\text{Total daily consumption kWh}} = \frac{296,218.8}{5098} = 58.1$ NGN/kWh

2.6. Estimating the Cost of Setting up a Photovoltaic Solar Energy System

Many studies have been done on Photovoltaic Solar Energy System, which has highlighted them to be more affordable and accessible to the common mass (Dinger and Zamfir, 2011; Adeyemo et al., 2008). The China government has spent billions of dollars on Photovoltaic Energy system design, making it more surplus to the global community. Most neighbourhoods in China will be Solar independent by 2030 (Kadrić et al., 2022). This simply implies that monthly utility bills on electrical energy will end for those communities since they don't rely on the national grid.

A Solar Energy system is a sustainable energy source that uses Solar-Photovoltaic-Cells (PVC) to trap sunlight energy and convert it into electrical energy (Dall'O' et al., 2012; Lucchi, 2018). The electrical energy gotten from it can be put to use immediately or stored in batteries to put to use when the need arises (Dioha et al., 2020). The solar energy system consists of the following major components; P.V. modules, charge controller, inverter, batteries, subsidiary energy sources and load devices (Ascione et al., 2021). For this study, we are going to make use of the following design parameters:

Depth of discharge = 50%

Urated = Rated terminal DC voltage = 48V

Numbers of autonomy days = 1.5 Days

Battery Amperage = 2,490 AH

Hop = Operation hours per day = 10 hours

I. Sizing of the Battery

Estimated Wh capacity of the four buildings = Total energy consumption of the four buildings $\times$ Days of autonomy

= $5098 \times 1.5 = 7,647$ kWh

Depth of discharge allowed = 50% (~ 0.5)

Loss factor of the battery = 0.9

Design kWh capacity = $7,647 / (0.5 \times 0.9) = 16,993$ kWh

Ampere-hour rating = $16,993 / 48 = 354$ kAh or 354000 Ah

Numbers of batteries required = $354000 / 2490 = 142$ (142-wet cells batteries)

II. Sizing of Inverter

The inverter will be required to handle a maximum load capacity of 509.8KW; thus, nine of sixty kilowatts (60KW) inverters will be ideal for this study, which will be equivalent to a total of 540KW, which has a good safety margin.

III. Sizing of Solar P.V.

Estimated total-watt-hours required per day for the four main buildings = 5098 kWh/Day.

Desired watt-hours required from the P.V. system = 5098×1.3

Generation factors for panels in Nigeria = 3.41

Estimated total watt-peak ratings = $5098 \times 1.3 / 3.41 = 1,944 \text{ kWpeak}$

PV power rating per module = 400 Wpeak

The number of Solar Panels required for the design = $1944000 / 400 = 4860$ panels.

Thus, a total of 4860 panels of 400 Wpeak will be needed to supply the required amount of energy to the four main buildings.

IV. Sizing the Charge Controller

The rating of a charge controller is given by the equation (9);

Per string of Solar charge controller = $I_{sc} \times 1.3$ (I_{sc} = all short-circuit current in the PV array) (9)

$P_{max} = 400 \text{ Wpeak}$

$V_{max} = 49.27 \text{ Volts (DC)}$

$I_{max} = 8.12 \text{ Amps}$

$V_{oc} = 61.10 \text{ Volts (Open Circuit)}$

$I_{sc} = 8.62 \text{ Amps (Short-circuit)}$

The minimum rating allowed on a single solar charge controller = $(4860 \times 8.62) \times 1.3 = 0.54, 461 \text{ Amps}$

By using nine strings of PV modules per controller = $(9 \times 8.62) \times 1.3 = 100 \text{ Amps}$.

V. Cost Analysis of acquiring all necessary Components for the P.V. System

Evaluating the cost requirement of setting up a P.V. system requires a thorough knowledge of the life expectancy of the P.V. system. In the study of (Merabtine et al., 2018), a P.V. system has an estimated average life cycle of twenty-five years. They are mostly sold with a limited product guarantee of ten years; this includes workmanship and materials and twenty-five years energy guarantee (Oseni, 2011). The cost requirement for setting-up up a Solar PV-System is tabulated in table 3. below include all necessary components to carry out the P.V. System project.

Table 3. Estimating the cost of setting up P.V. System with all necessary components

S/ N	Components	Design- Type	Quantity	Estimated Rate	Cost(USD)	Cost(NGN)
1	Cables and Accessories			300,000	723.07	300,000
2	Batteries	Deep-Cycle	142	550,000	188,238.13	78,100,000
3	Inverter	60 kW	9	600,000	13,015.18	5,400,000
4	Charge Controller	100 A, 48 V	545	40,000	52,542.78	21,800,000
5	Solar PV Panels	400 W, 48 V	4860	35,000	409,978.31	170,100,000
6	Combiner boxes		545	15,000	19,703.54	8,175,000
7	Battery Rack		1	100,000	241.02	100,000
8	Panel Rack		1	80,000	192.82	80,000

S/N	Components	Design-Type	Quantity	Estimated Rate	Cost(USD)	Cost(NGN)
9	Breaker		1	60,000	144.61	60,000
10	Distribution unit		1	40,000	96.41	40,000
11	Transfer switch		1	50,000	120.51	50,000
12	Total Cost (NGN)				684,996.38	284,205,000

Purchase cost of various components and Installation = 284,205,000 NGN

Yearly maintenance cost = 30,000 Naira

Five years futuristic plan cost = 284,205,000 + (30,000 × 5) = 284,355,000 NGN

PV system daily cost of usage = $\frac{284355000}{1,305} = 217,896.55$ NGN

PV System per unit usage cost = $\frac{\text{Daily cost of energy}}{\text{Total energy consumption}} = \frac{217896.55}{5098} = 42.7$ NGN/kWh

3. Results

With the results of the study, an informed decision can be taken on the best way forward to reduce the total cost of energy consumption for our public institutions in Nigeria. This will help save funds in the long term for the management of the Federal Polytechnic Bida, Nigeria, which can be invested in critical infrastructure development. The result obtained from the study is tabulated in table 4.

Table 4. Shows the estimated cost analysis for the three energy sources

S/N	Description	Daily Cost (NGN)	Unit Cost (NGN)	Total Cost (NGN)	Total Cost (USD)
1	PV-System	217,896.55	42.7	284,355,000	685,357.91
2	Diesel Generator	296,218.80	58.1	386,565,050	931,706.56
3	Nation Grid	180,214.30	35.35	235,179,661.50	566,834.57

The cost trend of energy consumption for the three possible options are then illustrated in the graph below:

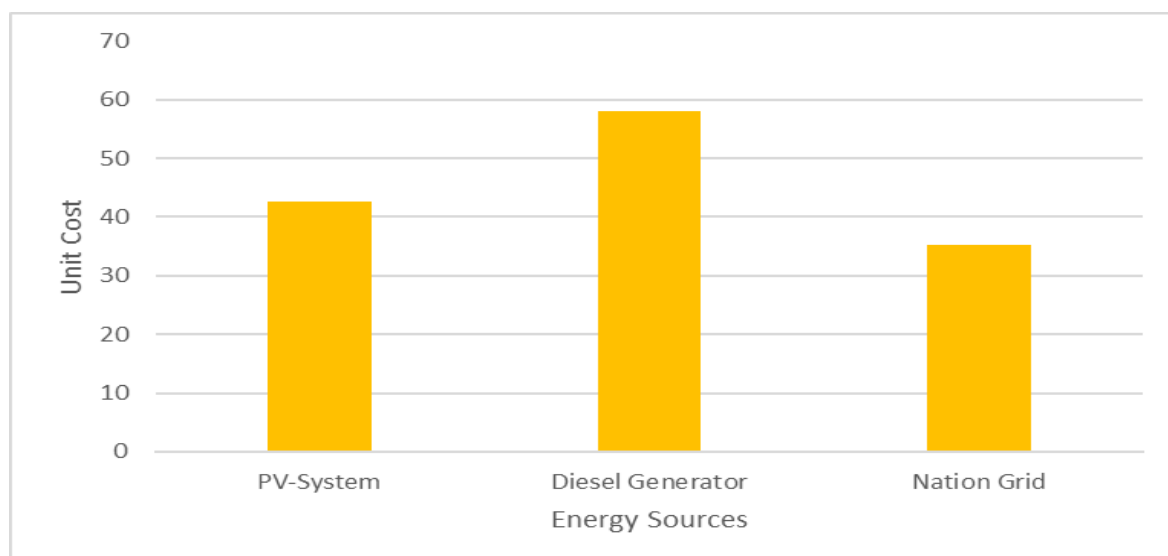


Figure 6. Daily Cost of Energy consumption from three different sources

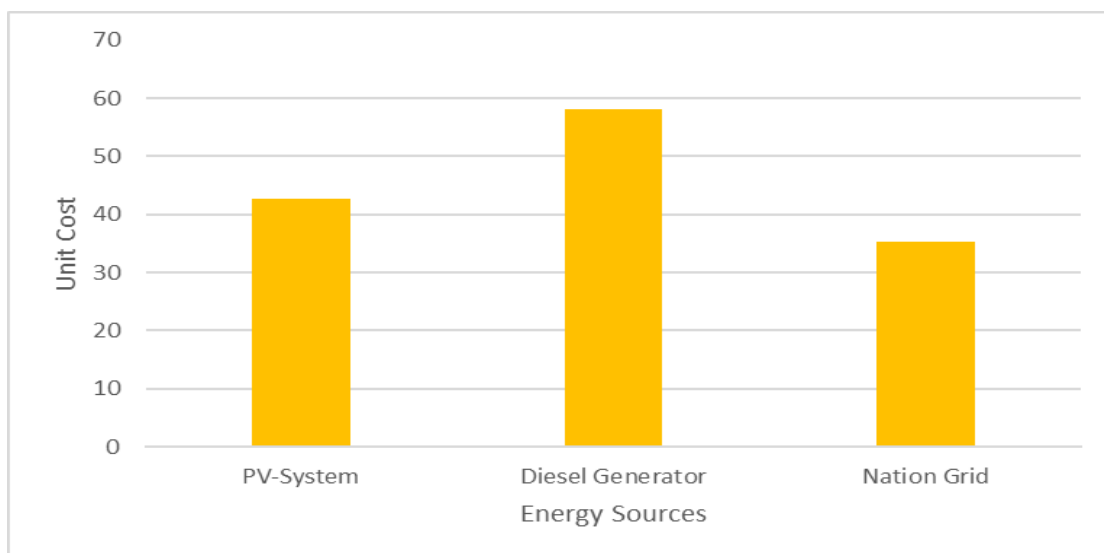


Figure 7. Unit cost of energy consumption from three different sources

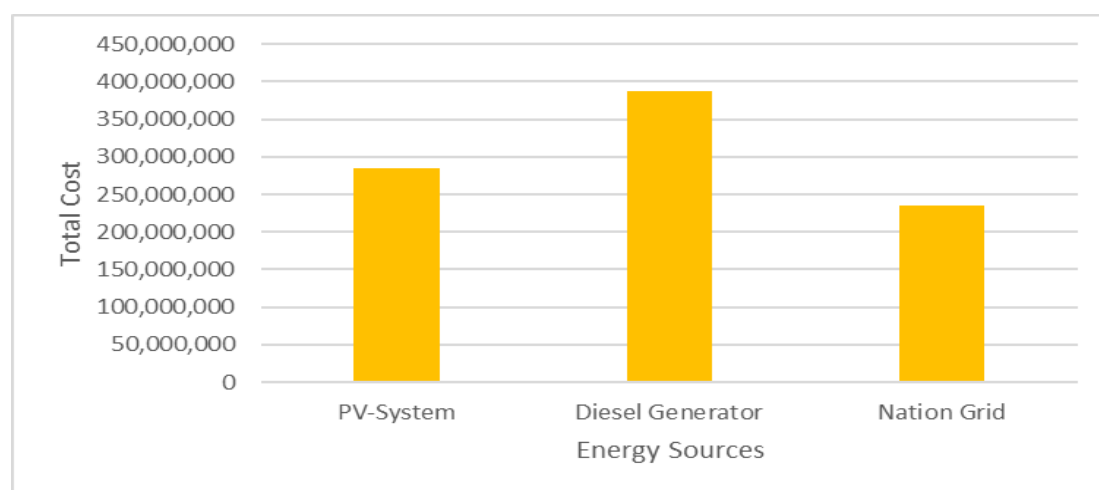


Figure 8. Total energy consumption for three sources over five years period

From the result obtained in this research, there is a clear indication that the national grid supply of energy for five years with a total cost of NGN 235,179,661.50 (USD 685,357.91) is the cheapest. This is actually correct, being that the total amount of energy supplied is less than the required amount needed by the buildings over the stated period. Due to the epileptic nature of the power supply from the national and its unreliable nature (George-Ufot et al., 2017), this cannot be an option for solving the cost burden in our public institutions. Again, if the building were to receive the required amount of energy for the stated period of five years, there would be an astronomical rise in energy bills, bringing us back to the need to reduce the cost burden.

Diesel generators are the highest, with a total cost of NGN 386,565,050 (USD 566,834.57), while they can supply the required amount of energy for the stipulated period, which is not in doubt. Its huge cost burden, unclean nature and environmental unfriendly make it not a suitable option for energy supply in our public institution (Gungah et al., 2019). Environmental experts are also very concerned about global warming, and as such, the emission of toxic gas into the atmosphere needs to be avoided (Afolabi et al., 2021).

The P.V. System, with a total cost of NGN 284,355,000 (USD 685,357.91), are reliable, cheap, clean and sustainable (Ikujenlola et al., 2020). They can also supply the

required amount of energy to the building over the studied period and be cost-effective in the long term. Apart from being affordable in the long term to the public institution, their obvious advantage is their green nature, sustainability, reliability, and being environmentally friendly. The results obtained are in line with previous studies (Orji et al., 2022), but this has significantly addressed the problem of energy loss in the transmission lines, labour cost and complexity associated with other forms of energy auditing devices, practically due to the simplicity with the efergy meters and their accuracy in energy reading which is optimal at all time (Okoro et al., 2021).

4. Discussion

This study was dedicated to finding possible ways of reducing the cost of energy consumption in public institutions here in Nigeria. The rising debt profile of our public institutions has become worrisome, especially to energy companies, so there is an urgent need to find alternative and cost-effective ways of supplying energy to our public institutions. In the study (Al-Saadi, 2021; Ascione et al., 2017), much was dedicated to physical site survey of public offices; inaccurate load profile has become a serious concern to energy auditors. This has an adverse effect on designing an alternative energy source for our public institutions, as much approximation and estimation are made. Time constraint is also a major headache for modern energy auditors (Samira et al., 2018), as plugging each load consumer into a watt-meter in a public office with more than a dozen energy-consuming equipment can be tasking. Energy auditors' first major challenge is knowing the total load profile of our various institutions, which will help them evaluate the energy consumption requirement of each institution.

With the efergy meter, our public institutions' accurate load profiling can easily be found. This ensures that the accurate design of alternative, clean and cost-effective energy sources is fixable. The management of our public institutions will be able to make an informed decision on the long-term approach for ensuring a continuous and uninterrupted supply of energy to their various institutions without running into a serious debt burden. With studies (Adewuyi, 2020) shows a great dealing in designing a sustainable able for public offices, not much was achieved in the area of labour cost reduction, and time-consuming was practically overwhelming. With the use of the efergy meter, much has been achieved with cost reduction and time-saving when compared with the study (Ugwu et al., 2021).

5. Conclusions

The study was able to fashion out ways in which the cost of supplying energy to the Federal Polytechnic Bida, can be reduced, via the installation of efergy meters. Our first approach was to select four main buildings, which are of utmost importance to the institution. An efergy meter was installed in the four main buildings for a period of six months, which covers the entire first semester of the institution and two months of holidays. The load profiles of the four main buildings were found, and the daily energy consumption for a period of ten working hours was calculated; the result was tabulated in table 1.

Based on the result of energy consumption for the four main buildings at the Federal Polytechnic Bida, Nigeria, it was discovered that the Polytechnic would need an estimated NGN386, 565,050 to continue running its diesel generator for five years. This energy source isn't clean and could lead to environmental hazards due to the continuous emission of carbon dioxide. It was advised that the diesel generator source should be replaced with a Solar P.V. system. However, the start-up cost might be a bit worrisome; even at that, the start-up cost and maintenance cost of 284,355,000 NGN for a period of five years are still more economical than that of a diesel generator within the same period study. It is also recommended that the national grid serve as a backup for the Solar P.V. System in case of any emergency maintenance of the P.V. system. Rationing between the national grid and Solar PV-System is also recommended since these two

sources are economical, clean and sustainable. A total sum of NGN 102,210,050 will be saved within five years if the diesel generator source is completely replaced with PV-System, thereby freeing up more funds for the much needed critical sectors within the public institution (Corrado et al., 2017).

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