

# Solar Electricity System Design for Administrative Buildings

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**Abstract-** Regular availability of electricity is fundamentally important for everyday running and productivity of any organisation. In any modern society, stable and reliable electric power is a basic need, without which living condition becomes substandard and smooth business operations become difficult. Unreliability of power services in Nigeria is taking its toll on administrative, academic and research activities at Federal Polytechnic, Ede, just like other institutions in the country. Diesel generator on which the institution depends for alternative power source during outage is not sustainable as outage is too frequent and the duration is usually long, at times for days. This results in a very high running cost if normal activities in the institution are to go unimpeded. This work is on the design of 172.84kW<sub>p</sub> Solar Photovoltaic (PV) System aimed at permanently addressing the electric power challenges at the Administrative Blocks of the Federal Polytechnic, Ede. The proposed project design was simulated and the results show that its real-life performance is highly promising. The least energy yield of the PV system occurs in June with 549.93kWh/day as against the maximum demand of 457.30kWh/day. The system performance is much higher in the months of September to March as solar irradiance is higher in these months. The PV plant has active service life of over 25years without significant change in its efficiency. The benefits of the proposed project are manifold. The project if implemented will solve the electric power problem of the institution at the Administrative Building by providing stable, adequate and reliable 24-hour a day electricity. The estimated cost of the proposed project is N45,000,000 which is much cheaper than diesel generator and interestingly, is appreciably less than the cost of unreliable power supply from the grid.

**Keywords-** Energy yield, off-grid, photovoltaic system, solar electricity, solar photovoltaic

## 1 INTRODUCTION

Electric power availability and reliability is crucially important in any corporate organization. Regular availability of electric power has direct relationship with productivity of staff in any organization. Over the years, the electric power services in Nigeria has been in a very wretched state as most citizens in urban areas covered by the grid go without supply for many hours each day and sometimes zero supply for days (Johnson, 2017). This is particularly the case in Federal Polytechnic, Ede, where regular and stable electricity is needed for administrative and academic activities.

In recent times, students could not perform their laboratory practices due to incessant power failure, lectures theatres become inconvenient and uncomfortable to attend as there is no electric energy to power fans, bulb, and public address systems in lecture halls; printings of official document, photocopying and internet surfing becomes more expensive as academic departments and businesses have to rely on petrol generators on the campus. This, apart from associated costs, has also resulted in all manner of noise and air pollution from use of fuel generator in an environment that is supposed to be serene and conducive for learning and research. This is contributing in no small measure to climate change, degradation of atmospheric oxygen which United Nation and many industrialized countries are aggressively trying to mitigate by decarbonization of power generation through use of renewable energy sources.

Nigeria is abundantly blessed with many sources of renewable energy particularly solar photovoltaic PV energy. Solar photovoltaic, with appropriate policy support and incentive from the government, could provide affordable, stable and reliable supply of electricity. Off-grid solar PV has a great potential in supplying unmet huge electricity demand in Nigeria (ODI, 2015). Unlike petrol generator, solar PV is noiseless, produces no pollution or waste, the system is neat, uses no 'fuel' and has a very minimal running cost. So, a technical exploitation of sunlight to produce electricity is a viable option for Nigeria to overcome the problem of epileptic supply, supplement the grid supply and to also electrify areas the grid could not cover (Johnson and Ogunseye, 2017).

The country enjoys average of nine hours of clear and bright day-light all year round with sufficient amount of radiation ranging from 3.5kWh/m<sup>2</sup> to 7.0 kWh/m<sup>2</sup>. Solar energy resource is more than abundant in Nigeria and offers good opportunity for solar energy conversion to electricity. The technology for this energy conversion is well-established; reliable and very robust. The solar photovoltaic technology is scalable, very suitable for single load, household, community and industrial level operation as well as grid-scale power generation.

This study on the design of 172.84kW<sub>p</sub> solar power system is aimed at meeting the local energy need in Federal Polytechnic, Ede, taking the advantage of available solar energy resource. The objectives of the study are (i) To calculate the buildings' energy demand (ii) To design PV power system capable of meeting the demand efficiently. (iii) To simulate/test run the design and see its possible real-life performance. The project, if executed can work effectively independent of the grid and can also power other parts of the institution particularly during weekends and time when the students are not in session as demand for energy in the school at these times are low.

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Major issues associated with photovoltaic system operation are usually robustness of design and grid integration, fault detection and clearing during operation, energy yield and performance monitoring of the system. Several works have been on all these areas of solar electricity systems. Mairang and Goswami (2019) designed and advocated for DC Microgrid power system fed by solar photovoltaic rather than photovoltaic to AC system. The microgrid is formed by connections of multiples roof-top micro PV generation with Arduino microcontroller-based control features with relay for monitoring and control of the load demand and generated power. The design is simulated and analysed by MATLAB/SIMULINK. Based on the analysis the authors found that PV to DC microgrid has better efficiency, very minimal losses, less costly, improved power quality and reliability than PV to AC system. However, the authors do not factor in the fact that most of the equipment at homes and offices runs on AC system.

Algarín et al (2017) developed a fuzzy logic controller with mathematical model for tracking the maximum power point of PV module so that it can generate maximum energy it is capable of producing irrespective of the day irradiance. The developed Maximum Power Point Tracker MPPT is found to be superior to existing Perturb and Observe (P&O) method in term of power loss, settling time, oscillations and offer excellent performance at the operating point. For effective and safe operations and maintenance of photovoltaic system, there should be provision for efficient and accurate means of detecting fault on the PV array. Ali et al (2017) proposed a method for real time monitoring, fault detection and diagnoses in solar photovoltaic power system. The normal operating threshold of the module's I-V characteristics is compared with the real time operating characteristics of the module, deviation from normal operating characteristics suggest faulty conditions. The electrical signature of the deviation from normal operation provide information on the nature, location on the fault. By this fault such as shading, dust, interconnection resistance etc can be diagnosed. The limitation of this work is that the distinction between different fault can be distorted by noise giving rise to wrong diagnosis.

Similarly, Sarikh et al (2019) presented fault detection and identification method in photovoltaic system by the I-V characteristics of the system's module. The model is based on the fact that different fault has different and unique impact on I-V characteristics of the system. By this approach, faults caused by aging, dust, shading on module, and short circuit fault can be easily diagnosed. Zhao et al (2018) developed a novel method of fault diagnosis on photovoltaic array based on fuzzy C-means (FCM) and fuzzy membership algorithms. The developed method was simulated and test run 9.6kWp. The method is found to be very effective in diagnosing shadow shading, short circuit current, open circuit fault, partial occlusion and a number of other faults.

In order to know possible energy yield for the following two or three of days, Brecl and Topic (2018) developed a forecasting methodology based on local weather forecast, to predict the energy yield of the day and the next two days. The authors work provides root-mean-square error and 65% forecast power data with high correlation of 0.85 in term of R<sup>2</sup>. How an average person who own photovoltaic power system can use it, is however not clear enough.

## 2 LOADS PROFILE OF ADMINISTRATIVE BLOCKS

The Administrative Blocks of Polytechnic consist of two buildings shown in Figure 1. The buildings serve as office complex for the institution's principal officers like Rector, Deputy Rectors, Registrar, Bursar and other highly important units such as Staff Training Unit, Establishment Affairs Offices, Council Affairs Office, Legal Unit of the Polytechnic, Admission Offices, and Academic Planning Unit. It is where decisions for every day running of the polytechnic are made. Important committee meetings as well as management and council' meetings are held in these buildings.

It is therefore very important for electric power to always be available at the buildings as power interruption can lead to disruption of smooth running of activities, make important meetings boring and uncomfortable, delay critical decisions and lead to poor productivity in the institution.

### 2.1 LOAD CALCULATIONS

To design adequate capacity of solar electricity, the load profile in the building need to be calculated, while also taking into consideration the projected load increase to take care of the future demand rise. The loads in the building are aggregated with their diversity factor. Most of the loads are points of light, fans, air conditioning units, printers, photocopiers, electric kettles and refrigerators. Using Locke (2008) and Regulation 433.1.4 of British Standard 7671:2008, the load is calculated as follows

#### *Lighting loads;*

Total numbers of 40-watt lighting load = 236.  
= 40 x 236 = 9,450 W

Using diversity factor of 90% of the total load  
= 0.9 x 9,450 = 8.50 kW

Total numbers of 20-Watt lighting load = 23  
= 20 x 23 = 460 W

Using diversity factor of 90 % of the total load  
= 0.9 x 460 = 0.42 kW

#### *Ceiling Fan*

Total numbers of 75W Ceiling fan load = 175.  
= 75 x 175 = 13,130 W

Using diversity factor of = 90 % of the total load  
= 0.9 x 13,130 = 11.82 kW.



Fig. 1: The Two Administrative Buildings, Federal Polytechnic, Ede, Nigeria

Table 1 Load calculation

S/N	Type of load	Quantity	Load without Diversity (kW)	Load with Diversity (kW)	Hours use/day (Hr)	kWh/day
1.	20-Watt bulb	23	0.46	0.42	8	3.36
2	40-Watt bulb	236	9.45	8.50	7	59.50
3.	Ceiling fans (75W)	175	13.13	11.82	7	70.92
4.	13A Socket	228	115.20	87.84	3	263.52
5.	15A Socket	13	15.60	12.00	5	60.00
	<b>TOTAL</b>		<b>153.84</b>	<b>120.58</b>		<b>457.30</b>

**Socket Outlets**

Total numbers of 13 Amps socket outlet = 228.  
 Total numbers of ring sub circuit = 20 numbers  
 = 30 x 20 x 240 x 0.8 = 115,200 W  
 (Locke, 2008; Regulation 433.1.4 of BS 7671: 2008)  
 Using diversity factor of 100% of the first load  
 + 75% of the remaining load

$$= (30 \times 1 \times 240 \times 0.8) + (0.75 \times 19 \times 30 \times 240 \times 0.8)$$

$$= 5760W + 82,080W = 87.84 \text{ kW}$$

Total numbers of 15 Amps socket outlet = 13.  
 Load ratings of Air-condition = 1500W  
 = 13 x 1500 x 0.8 = 15,600 W  
 Using diversity factor of = 100% of the first load +  
 75% of the remaining load.

$$= (1 \times 1500 \times 0.8) + (0.75 \times 12 \times 1500 \times 0.8)$$

$$= 12.00 \text{ kW}$$

The hours use for each load on Table 1 for calculation of energy (kWh/day), is the expected and reasonable duration the load is estimated to runs on a working day.

**3 DESIGN OF MAJOR COMPONENTS**

This section gives details of the design of major components and how their capacity/rating are arrived at.

**3.1 CONFIGURATION AND CAPACITY OF THE PV ARRAYS**

Table 1 shows the loads and energy calculated values. The total energy required is 457.30kWh per day. The plant capacity should be well above the required energy, so as to cater for the losses. Therefore, the energy requires is multiplied by 1.3 and then divided by generation factor. This 1.3 multiplier makes the plant capacity 30% higher than the energy demand of the buildings to cater for losses along the cable, inverter efficiency, losses due to temperature increase and other losses. The generation factor is location specific and it is taken to be the least irradiance per day of the location. From irradiance data for Ede town the generation factor is 3.68 kWh/m<sup>2</sup>/day in the month of June (PVWatts Calculator, 2019). Therefore,

$$\text{Total PV Capacity} = \frac{1.3 \times \text{Watt-hour}}{\text{Generation factor}}$$

$$= 1.3 \times 457.3 \div 3.68 = 161.55\text{kWh}$$

So, the PV Generator capacity that can power these loads should be at least 161.55kWh and can be increased to cater for future load increase.

A PV array is a series and/or parallel configuration of PV modules to produce desired voltage, current and power output. In this design, the voltage and current rating of each module to be used is 48.35V and 9.93A respectively. Each array consists of string of ten modules to produce 483.50VDC 9.93A and twelve of this string connected are

connected in parallel to produce output of 483.50VDC 119.16A with combined output power of 57.61kWp. Three of these arrays generate 172.84kWp. The arrays are to be mounted on the shed car park and the roof top of the Administrative Buildings and at an angle of tilt of 15° to the horizontal in southern orientation. This is slightly above the latitude angle of the location which is the angle for optimal energy yield of the modules for fix-positioned modules. But for provision of easy wash-off of dirt which causes reduction in energy yield, the module is inclined at angle slightly higher than location's latitude angle. For 480W module, the total number of modules in each array is  $57.61\text{kW} \div 480\text{W} = 120$  modules.

### 3.2 BATTERY SIZING

Almost every activity occurs during the working hours of the day in the building. However, there can be days of cloudy weather and some staff can work till late in the day. So, there is provision for energy storage in form of chemical in deep cycle battery. Deep cycle batteries are capable of discharging to very low level (down to 20%) and rapid recharge to full capacity day in day out for several years. The battery capacity is dependent on number of days the battery is to operate without supply from the module, watt-hour per day of the load, the battery efficiency and the battery depth of discharge.

$$\text{Battery Capacity} = \{W_{hr} \times D_{aut}\} \div \{V_{nb} \times \eta \times D_d\}$$

Where  $W_{hr}$  is watt-hour per day,  $D_{aut}$  is the day of autonomy i.e. the number of days the battery can operate to carry the full load without recharging,  $V_{nb}$  nominal battery voltage,  $\eta$  the battery efficiency and  $D_d$  the depth of battery discharge.

From the design, the watt-hour per day is 457.3kWh, day of autonomy is 2, battery efficiency is 85%, and depth of discharge is 80% i.e. the battery discharge down to 20%

$$\text{Battery Capacity} = \frac{457300 \times 2}{0.85 \times 0.8 \times 420} = 3202.38 \approx 3600\text{Ah}$$

Since there are three arrays of modules, three inverters, the battery bank is split into three, each at a capacity of 420VDC 1200AH. The battery voltage is 420VDC because it has to be less to PV generator voltage (483.5VDC) so that it can charge it efficiently. Seven 60V 150Ah in series gives 420V 150Ah while eight of such in parallel is equivalent to 420VDC 1200Ah. This equals to 56 batteries with each capacity 60V 150Ah.

### 3.3 INVERTER RATING

Inverter is a key device where DC electricity is to be used by AC appliances. Since the solar module produces DC electricity and most appliances are designed to be powered by AC source, an inverter is required to convert the DC to AC electricity. The inverter capacity should at least be (Leonics, 2019):

- i) 25-30% higher than the total wattage to be powered.
- ii) three times the total wattage of loads with high-starting current such as motor, air condition etc.
- iii) never less than the PV capacity.

Whichever is the highest of the three conditions above is the appropriate rating of the inverter. The first condition gives  $1.30 \times 153.84 = 200\text{kW}$ , the second condition is estimated to be 100kW, while the third condition is 172.84kW. So, the first condition is reckoned with in selecting appropriate inverter rating. Since, the PV generator is sectionalized into three different arrays, each for a single phase, the inverter for each of the three arrays should not be less than  $200 \div 3 = 66.666 \approx 70\text{kW}$ . Therefore, three 70kW single phase inverter is selected for this design.

### 3.4. MPPT CHARGE CONTROLLER

This is a charge controller on which maximum power point tracking (MPPT) algorithm is embedded. As it controls the charging and discharging of the battery energy saver, it also operates to make the PV module to produce maximum power it is capable of. The maximum power production occurs at possible peak voltage and current. This is to increase the energy yield from the solar module by making the module to operate at its most efficient or maximum voltage and current irrespective of changing irradiance. MPPT algorithm is most efficient during cold weather, hazy and cloudy weather.

Charge controller rating is given by the product of number of strings in the array and short circuit current of each module and 1.25 at, at least nominal voltage of the PV generator (Sundog Energy, 2006; Microgeneration Certification Scheme, 2012).

Hence,  $1.25 \times 12 \times 10.04 = 150.6$ . So, the charge controller rating is 150A 483.5V or better at 160A 500V

### 3.5 WIRING AND CABLE RATING

Wiring is a very important aspect in power system particularly in PV system for safety of the systems and users. Wrong wiring and inappropriate cable size can result in overheating, fire outbreak, electric shock, high losses and poor performance of the PV system. The cable must be of appropriate rating and must be such that the drop does not exceed 3% of the expected voltage to carry. Each module just needs to be plugged-in to each other to obtain a string. Combiner might be needed to obtain parallel configuration of strings. Voltage and current rating of the cable that feed the inverter from battery bank and array (combiner box) should be  $1.15 \times M \times V_{oc}$  and  $1.25 \times N \times I_{sc}$  respectively (Johnson, 2017; Sundog Energy, 2006; Microgeneration Certification Scheme, 2012). Where M and N are numbers of modules in string and number of strings in parallel respectively). This is the standard for rating of all DC components (cable or device) in PV system.

$$\text{Voltage: } V_{oc} \times 10 \times 1.15 = 677.35\text{V}$$

$$\text{Current: } I_{sc} \times 12 \times 1.25 = 150.60\text{A}$$

The voltage and current rating may be appropriately set to be 700VDC, 160A.

**3.6 GROUNDING AND LIGHTNING PROTECTION**

All exposed, non-current-carrying metal part in the system, majorly the module frame, array mounting structure, inverter casing, are to be connected through high conducting path (cable) to the earth electrode for safety of the system and users from leakage or fault current. The PV array and its mounting structure installations are to be protected against damage from lightning strike by conducting the current of the strike by means of appropriate lightning arrestor away down to the ground.

**4 TECHNICAL COMPOSITION OF PV PLAN DESIGN**

The solar PV system is designed to be three single-phase off-grid arrays with a total capacity of 172.84kWp. The system’s major components are 480W Monocrystalline PV modules, three 70kW single phase Inverters, three set of banks of 56 batteries each with rating of 60V 150Ah with output of 420VDC 3600Ah. Other crucial components include cable of appropriate size and rating, fuse, distribution board, DC disconnectors, AC Switch, gear switch, Maximum Power Point Tracker MPPT and other Balance of System (BOS) like mounting frames, stands etc. Table 2 shows at glance the technical specifications of major sections of the proposed PV project. Figure 2 shows the design’s schematic diagram of the proposed Solar PV system.

Table 2. Technical specification of the PV Power System

PV Generator (Array)		Inverter Specification		Battery Energy Storage	
No of modules in string	10	V <sub>dc</sub> input	300-500V	Nominal voltage	60V
No of strings in parallel	12	I <sub>dc</sub> input	119V	Rating	150Ah
DC current I <sub>dc</sub>	119.16A	V <sub>ac</sub> output	240V	No. in series	7
DC voltage V <sub>dc</sub>	483.50V	Frequency	50Hz	No. in parallel	8
Average sun-hour/day	8hours	Capacity	70kW	Capacity	420V 1200Ah
Generator capacity	3 × 57.61kWp	Quantity	3	Quantity	3

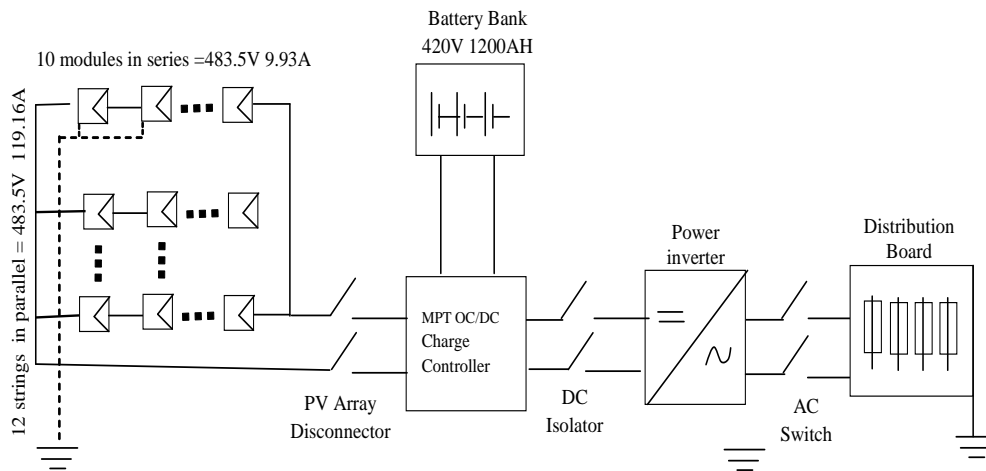


Fig. 2: Schematic diagram of the proposed PV power plant.

**5 SIMULATIONS RESULT OF PV DESIGN**

The design of the proposed PV project was simulated to determine its real-life workability and ascertain the system true life performance if executed. The simulation was done with PVWatt, an online software provided by the American National Renewable Energy Laboratory NREL (PVWatt Calculator 2019). It is simulation software specially designed for solar photovoltaic power analysis. The software is based on 30 years of actual solar resource and weather data of the defined location (Ede town at 7° 44' 0" N / 4° 26' 0" E), as well as inputted data, the software was run and it gave expected amount of electric energy yield of each month in a year.

Table 3 shows the summary of the system energy yield. The highest energy yield of the PV system occurs in January, February and December with daily production average of 1010, 958 and 954kWh respectively. The least energy yield of the PV system occurs in June with 549.93kWh/day as against the maximum demand of 457.30kWh/day. The total yearly production will be 291,380kWh from the installed PV system capacity of 172.84kWp. So, the simulation result shows very bright, promising real life performance. The system design is very good and robust.

Table 3. Expected Energy Yield of Proposed PV System

Months	Irradiance (kWh/m <sup>2</sup> /day)	Energy Yield (kWh/month)	Energy Yield (kWh/day)
Jan	6.97	31,304	1009.81
Febr	6.60	26,816	957.71
March	6.13	27,865	898.87
April	4.97	21,907	730.23
May	4.07	18,730	604.19
June	3.68	16,498	549.93
July	3.94	18,324	591.10
Aug	4.52	21,065	679.52
Sep	5.32	23,838	794.60
Oct	6.14	27,956	901.81
Nov	6.27	27,511	917.03
Dec	6.60	29,566	953.74
<b>Ave.</b>	<b>5.43</b>	<b>24,281.67</b>	<b>798.30</b>

## 6 COST AND FINANCIAL ANALYSIS

Cost is very important in any engineering project. It can determine whether the project will be executed or not most especially when there are alternatives. Cost analysis is given among PV generator, diesel generator and grid electricity bill.

### 6.1 COST OF PROPOSED 172.84KW PV SYSTEM

As at September 2019, the average cost of a large solar power system without battery energy saver is \$1.00 per watt (Solar Electric Supply Inc., 2019; R. Fu et al 2018). However, for medium to large scale PV systems, the more the wattage installed the lesser the cost per watt. Furthermore, from reliable experience in the photovoltaic industry, the cost of each component in PV system is usually at certain percentage of the total cost. For instance, the cost of PV module is around 30% of the cost of the system, inverter is around 10-12% of the total cost depending on the inverter configuration, labour cost is country dependent but usually falls between 5-15%.

Operational, repair and maintenance cost for 25 years of the PV system's service life is usually between 20-25% (EnergySage, 2019; Solar Mango, 2019). Maintenance and operational cost include repairs, change of inverter and batteries after some years. Other components include gear switch, DC disconnect, AC isolator, fuse, meter etc. In this cost analysis, care is taken to ensure that all cost is covered and this is summarised in Table 4. This estimate is based on prevailing official Central Bank of Nigeria CBN exchange rate of ₦307 to \$1 as at September 2019.

Table 4. Cost of PV Power system

172.84kW <sub>p</sub> module at N100 per watt	16,074,120
Three 70kVA inverter cost	4,500,000
MPPT DC/DC converter	1,500,000
Wiring/Cable	500,000
Mounting hardware	626,000
Battery bank	7,890,000
Labour cost	1,300,000
Maintenance and Operational cost	12,000,000
Other components	500,000
Miscellaneous	500,000
<b>GRAND TOTAL</b>	<b>45,000,125</b>

### 6.2 COST OF DIESEL GENERATOR

Diesel generator has been the alternative energy source in the institution as a result of frequent outage. 150kVA generator was dedicated to the two Administrative Blocks. The average cost of 150kVA Perkins or Cummins diesel generator is around 10million naira and unlike PV system it has less than 25years of active service. It consumes 25liters of diesel for an hour. If it were to work for at least 7hours a day like PV generator. The cost of fuel consumption will be:

$$25\text{liters} \times 7\text{hours} \times 5\text{working day a week} \times 52\text{week a year} \\ \times 25 \text{ years} \times \text{₦} 225 = \text{₦} 255, 937,000$$

provided that the pump price of diesel will remain at ₦225 for the next 25 years. Adding the cost of the generator with the running cost gives ₦265,937,000. This is apart from the cost of servicing at least once every three months. Note that fuel efficient 150kVA generator will likely use more than 25litres at full load but the calculation is based on ¾ full load. So the cost of using diesel generator for the same period of using PV generator is around ₦266 million which is more than five times the cost PV generator

### 6.3 COST OF GRID ELECTRICITY

The bill from Ibadan Electricity Distribution Company to the Institution is not constant; it varies every month depending on the power availability during each month and the power consumed. Based on the source from Electrical Maintenance Unit of the institution, it is around ₦957,000 on monthly average if school is in session. It is estimated by the authors and staff in Electrical Maintenance Unit that the load on the two buildings is about one-sixth of the total load in the main campus of the institution  $\frac{1}{6} \times 957,000 = \text{₦} 159,500$  per month. For 25years, if the tariff is to remain constant for the period, the electricity bill for the Admin block is  $159,500 \times 12 \times 25 = \text{₦} 47, 850,000$ . This is significantly higher than PV Power cost. Yet it is still not stable and reliable. It can be safely concluded that cost of solar photovoltaic power system is cheaper and more reliable than grid power in the country.

### 6.4 COST OF GRID AND DIESEL ENGINE ELECTRICITY

The true or real picture is that the Institution like most consumers combines the grid supply and generator to improve reliability of power supply, such that when grid supply goes off, the generator is switched on and when the grid supply is available, the generator is switched off. To calculate the cost of this combination requires knowing the number of hours per day the grid supply is not available. This is not constant as numbers of hours of Availability varies each day and grid supply can be very erratic by going on and off several times within one or few hours. There are days without supply at all and there is rarely a day with supply all through. According to staff in the Electrical Maintenance Unit, generator is put on for the Administrative Buildings on the average of three hours per day. The cost of running generator for three hours alongside with grid supply is:

$$25\text{liters} \times 3\text{hours} \times 5\text{working day a week} \times 52\text{week a year} \\ \times 25 \text{ years} \times \text{₦} 225 = \text{₦} 109,687,500$$

Breaking it down further show that the institution is spending ₦4,387,500 yearly or ₦365,625 monthly on diesel in addition to ₦159,500 for electricity bill from the Utility whereas, if photovoltaic system is installed, the cost will greatly reduce though require high initial cost. Hence, PV system is by far cheaper than generator

## 7 CONCLUSION

The design of 172kW<sub>p</sub> Solar Power System for the proposed solar power project is viable, robust and technically sound. The design implementation is a worthwhile project for the Polytechnic because it is far much cheaper than diesel generator the institution is currently using and cost less than utility bill although the initial cost is very high. The proposed photovoltaic system is capable of providing stable and reliable electric energy to power the institution's Administrative Blocks as confirmed by the simulation result and hopefully will produce the same results when implemented. It can help the Polytechnic to generate electric energy for its use and as well serve as good motivation for other institutions. This will in no small measure contribute to PV renewable energy deployment in the country.

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