Maintenance Cost Comparative Analysis of Generator/Solar Power Systems: A Case Study of FPI, In Ogun State

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Abstract

Electricity supply to the Federal Polytechnic, Ilaro (FPI) communities continues to be major challenge. Many offices, laboratory and security lightning in the polytechnic community still run on generator because of the epileptic power supply from the national grid. The Department of electrical/electronic engineering installed some solar powered security lighting system to provide lighting during generator shutdown, this work presents a brief life-cycle-cost comparison of solar power supply system and petrol generator power supply system for various lighting applications in FPI. In this comparative analysis, conceptual designs were developed for solar power system and premium motor spirit (PMS) powered systems to meet the base-case load requirements. A case study for cost comparison of 1.5kVA, 3kVA and 4kVA solar power system and 1.5kVA, 3kVA and 4kVA equivalent PMS generator was considered. Economic assessment of providing 1.5kVA, 3kVA and 4kVA photovoltaic system in the polytechnic community was carried out and compared with that of 1.5kVA, 3kVA and 4kVA corresponding PMS generator. These two systems were compared for the period of four (4) years taking the cost analysis to obtain the total capital and operating cost. The result show that PV powered system would be more effective and economical in the running of practical's, street lightning and office use. The results show that PV is the cost effective option for low power energy demand for departmental office, laboratory and street lightning in the polytechnic community.

KEY WORDS: life-cycle-cost comparison; Photovoltaic (PV) power System; PMS generator;

INTRODUCTION

Electricity is critical to a country's economic development, and it is the backbone of any sustainable institution's curriculum delivery. Nigeria has been struggling to generate enough power to fulfill demand for decades. Because of the lack of electricity, the majority of higher education institutions are unable to carry out a significant portion of their academic activity.The country's rising unemployment rate can also be linked to the country's erratic electrical supply (Oluwaseun et al., 2018; Duque et al., 2017). Many of the country's higher education institutions have insufficient electricity. Small isolated petrol generators are used to provide the electricity demand in these locations.The operational expenses of these petrol generators may be excessively high due to rising petroleum prices and the noise they produce, as well as challenges in fuel delivery and generator maintenance. Renewable energy sources, such as solar photovoltaic (PV), offer a viable alternative to engine-driven generators for electrical delivery in laboratories and departmental offices, allowing for more efficient and effective learning.This paper present a detailed comparative analysis of using generator and solar photovoltaic systems: a case study of the department of electrical and electronic engineering (FPI).

Sources of Renewable Energy

Renewable energy is based on the principles of sustainability, renewability, and pollution reduction. Renewable energy resource management has gotten a lot of attention in the literature because of the balance sheet and expected energy shortages and environmental challenges. To address this issue, renewable energy sources must be used to replace traditional fuels because they deliver high electrical efficiency while having a low environmental impact (Jürgensen & Technology, 2015).

Related Work

Adejumobi et al., (2014) presented a number of factors that affect solar energy performance in Nigeria some of this factors are; High cost, lack of knowledge, insecurity, poor maintenance and lack of technical manpower

Oluwaseun et al., (2018) compares biogas and solar energy for "Ajaba" near Ila-Orangun in Osun State to know the best renewable energy source for the area. The study considers photovoltaic cells as the device for trapping and converting solar energy to electrical energy while pig dung was used to prepare the digester materials for biogas energy and bio-digesters were used to convert the digester to electrical energy through dual ac generator. The simulation was carried out using MATLAB software to calculate the output energy. The result shows that biogas energy produced more energy and does better as compared to the solar energy for the area. Pradhan et al., (2013)focus on consideration of the economic and simulation for a stand-alone hybrid system having PV, wind and biomass for electrical production in remote areas. The average solar radiation, quantity of biomass, average wind speed for the remote area were taken for predicting the general performance of the generating system. The results obtained enhanced the performance of the model. Pradhan et al., (2013)presented economic consideration of solar PV and biomass for generation of electricity in remote areas. The average solar radiation and quantity of biomass required data that were used to predict the general performance of the generating system. The results and analysis

improved the development of the model.Adejumobi et al., (2014) proposed a development of a grid-based rural electrification design for a rural environment such as Ishashi and Ilogbo communities in Lagos state, Nigeria using grid-based method. A load audit of the two communities was carried out to determine their energy demands. The proposed electrical model design for the two communities was implemented using AutoCAD Software. Furthermore, (Efunbote MI & Adeleke MB, 2015) designed hybrid solar-wind power system for a coaster area in Lagos State, south western Nigeria using HOMER software to simulate a solar and wind hybrid system. The result showed that the energy supplied using solar-wind hybrid power system was reliable and can produce electrical energy to power appliances in the community.

Study Area

Electrical Engineering department is situated in Ilaro town near papalanto in Ogun State, Nigeria. The place has a good potential for solar energy generation because it is easy to get enough amount of sun radiation. The solar irradiation in this area is around 1775 kWh/m2, which is also moderate for solar electricity generation (Wara & Abe, 2013).

3.0. MATERIALS AND METHOD

3.1. Solar power Cost of installation and maintenance

In this work, a detailedrecord of expenditures and maintenance cost of running a generator set were compile and compared with solar power system in department of electrical/electronic engineering FPI.Table 1. Shows the expenses incurred installing a 1.5 kVa solar power system in control laboratory while table 2. Also shows the expenses incurred installing 3 kVa solar power system in electronic laboratory and table 3. Shows the expenses incurred installing 4 kVa solar power system in thedepartmental office of electrical/electronic engineering of FPI.

Table 1: Bill of Engineering Measurement and Evaluation for 1.5 kVa (Control laboratory)

S/No	Item	Quantity	Unit Price (₦)	Cost(₦)
1.	12V, 150W Solar Panel	6	50,000	300,000
2.	220 AH/12V Tubular Battery	2	140,000	280,000
3.	30A 12V/24V Solar Charge Controller	1	45,000	45,000
4.	1 Coil of 6mm^2 Cable for solar power connection	1	20,000	20,000
5.	Battery Rack	1	18,000	18,000
6.	Construction of metal frame for solar panel	1	27,000	27,000
7.	63A Change Over Switch	1	2,000	2,000
8.	Surge Arrestor	1	18,000	18,000
9.	1.5 kW Inverter	1	90,000	90,000
10.	Solar Mount End/Mid Clips	Lots	10,000	10,000
11.	Cable Clips	Lots	3,000	3,000
12.	Tools Kit (Mechanical and Electrical)	1	42,000	42,000
13.	Voltmeter	1	2,500	2,500
14.	Contingency		5% of Total Sum	42,875
			TOTAL	**900,375**

Table 2: Bill of Engineering Measurement and Evaluation for 3kVa (Telecom Lab)

S/No	Item	Quantity	Unit Price (₦)	Cost(₦)
1.	12V, 150W Solar Panel	6	50,000	300,000
2.	220 AH/12V Tubular Battery	2	140,000	280,000
3.	30A 12V/24V Solar Charge Controller	1	45,000	45,000
4.	1 Coil of 6mm^2 Cable for solar power connection	1	20,000	20,000
5.	Battery Rack	1	18,000	18,000
6.	Construction of metal frame for solar panel	1	27,000	27,000

7.	63A Change Over Switch	1	2,000	2,000
8.	Surge Arrestor	1	18,000	18,000
9.	3kW Inverter	1	235,000	235,000
10.	Solar Mount End/Mid Clips	Lots	10,000	10,000
11.	Cable Clips	Lots	3,000	3,000
12.	Tools Kit (Mechanical and Electrical)	1	42,000	42,000
13.	Voltmeter	1	2,500	2,500
14.	Contingency		5% of Total Sum	50,125
			TOTAL	**1,052,625**

Table 3:Bill of Engineering Measurement and Evaluation for 4 kVa (Departmental Office)

S/No	Item	Quantity	Unit Price (₦)	Cost(₦)
1.	12V, 150W Solar Panel	6	50,000	300,000
2.	220 AH/12V Tubular Battery	2	140,000	560,000
3.	30A 12V/24V Solar Charge Controller	1	45,000	45,000
4.	1 Coil of 6mm^2 Cable for solar power connection	1	20,000	20,000
5.	Battery Rack	1	18,000	18,000
6.	Construction of metal frame for solar panel	1	27,000	27,000
7.	63A Change Over Switch	1	2,000	2,000
8.	Surge Arrestor	1	18,000	18,000
9.	4 kW Inverter	1	250,000	250,000
10.	Solar Mount End/Mid Clips	Lots	10,000	10,000
11.	Cable Clips	Lots	3,000	3,000
12.	Tools Kit (Mechanical and Electrical)	1	42,000	42,000
13.	Voltmeter	1	2,500	2,500
14.	Contingency		5% of Total Sum	64,875
			TOTAL	**1,362,375**

3.2. Generator Cost of fueling and maintenance

Data that comprises cost of fuelling, purchase of generators, servicing of generators and maintenance of engine-driven machine over a period of four years in other to ascertain the economic advantages of using solar energy systems over engine-driven machine were gathered.

Cost of Fueling a 1.5 Kva Petrol Generating Sets

Statutorily, the laboratory is used for a period of 8 hours per day on the average
For generating sets 150KVA, it was found that 1/4th of the rating such sets is the amount of fuel
Amount of petrol/ hour for 1.5 KVA, 1/4th of 1.5 KVA = 0.375ltr/hr
In a day, amount of petrol/day for 1.5 KVA = 8 x 0.375 = 3ltr/day
In a week, amount of petrol/week for 1.5 KVA = 7 x 3 = 21ltr/wk
In a year, amount of petrol/year for 1.5 KVA = 52 x 21 = 1,092ltr/year
For 3 years, amount of petrol for 4 years for 1.5 KVA = 4 x 1,092 = 4,368ltr/3 years
If petrol is @#165/ltr, then for 4 years, amount of fuel to be used = 4,368ltrs x #165 = **#720,720**

Cost of Fueling a 3 Kva Petrol Generating Sets

Statutorily, the laboratoryand security lighting is used for a period of 8 hours per day on the average
For generating sets 150KVA, it was found that 1/4th of the rating such sets is the amount of fuel to be used per hour.
Hence, Amount of petrol per hour for 3KVA is 1/4th of 3KVA = 0.75ltr/hr

In a day, amount of petrol/day for 3KVA = 8 x 0.75 = 6ltr/day
In a week, amount of petrol/week for 3KVA = 7 x 6 = 42ltr/wk
In a year, amount of petrol/year for 3KVA = 52 x 42 = 2,104ltr/year
For 4 years, amount of petrol for 4 years for 3KVA = 4 x 2,104 = 8,416ltr/4 years
If petrol is @#165/ltr, then for 4 years, amount of fuel to be used = 8,416ltrs x #165 = **#1,388,640**

Cost of Fueling a 4 Kva Petrol Generating Sets

Amount of petrol/ hour for 4 KVA, 1/4th of 4 KVA = 1ltr/hr
In a day, amount of petrol/day for 4 KVA = 8 x 1 =8ltr/day
In a week, amount of petrol/week for 4 KVA = 7 x 8 = 56ltr/wk
In a month, amount of petrol/month for 4 KVA =4 x 56ltr/wk = 224ltr/month
In a year, amount of petrol/year for 4 KVA = 52 x 56ltr = 2,912ltr/year
For 4 years, amount of petrol for 4years for 4 KVA = 4 x 2912 = 11648ltr/4 years
If petrol is @#165/ltr, then for four years, amount of fuel used = 11,648ltrs x #165 = **#1,921,920**

Table 4: The Total cost of Generator Sets

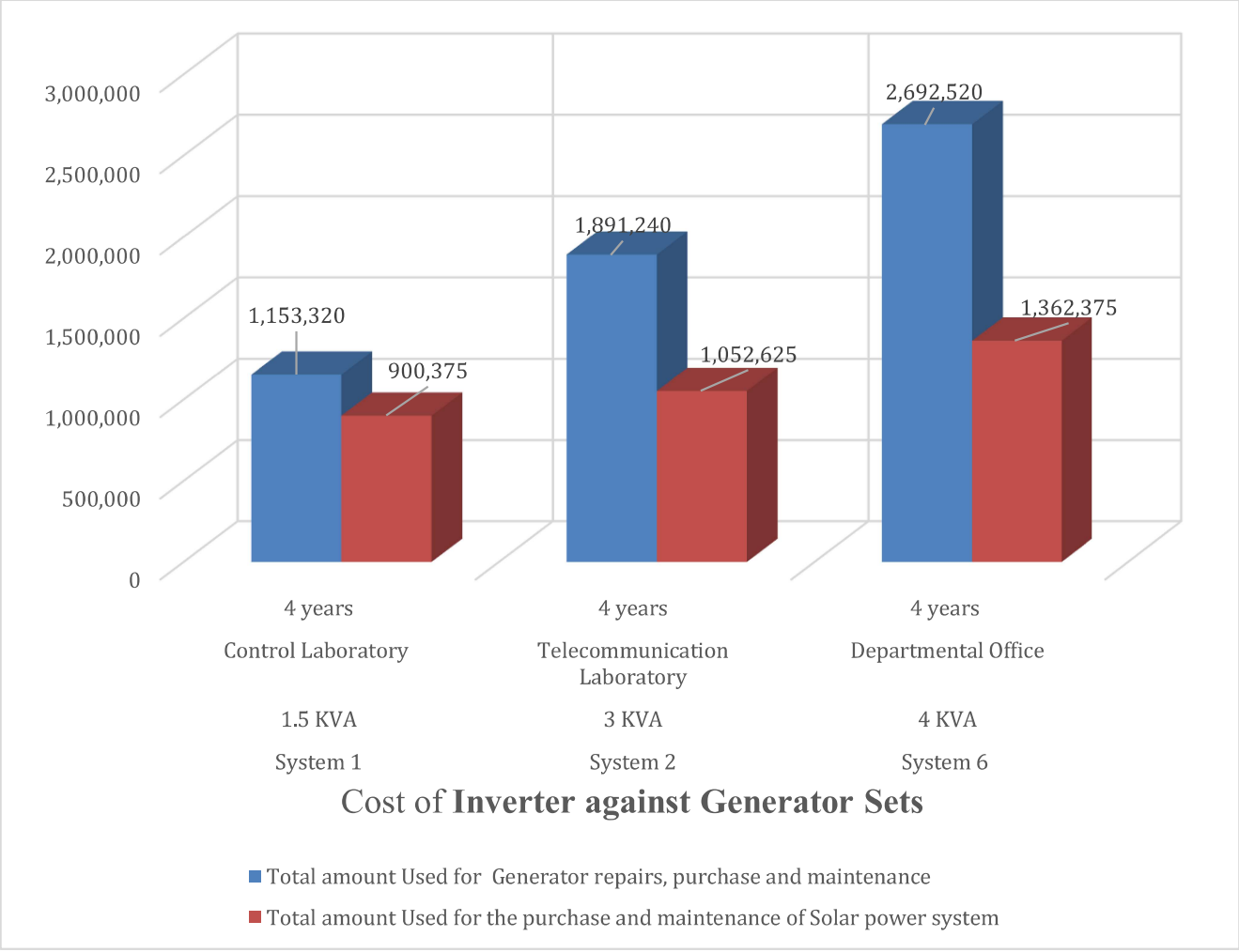
Item	Rating	Location	Age	Amount spent on servicing (#)	Amount spent on repairs(#)	Amount spent on petrol (#)	Amount spend on purchase of generator	Total amount
System 1	1.5 KVA	Control Laboratory	4 years	197,600	150,000	720,720	85,000	1,153,320
System 2	3 KVA	Telecommunication Laboratory	4 years	197,600	160,000	1,388,640	145,000	1,891240
System 3	4 KVA	Departmental Office	4 years	220,600	250,000	1,921,920	300,000	2,692,520
Total								**5,737,080**

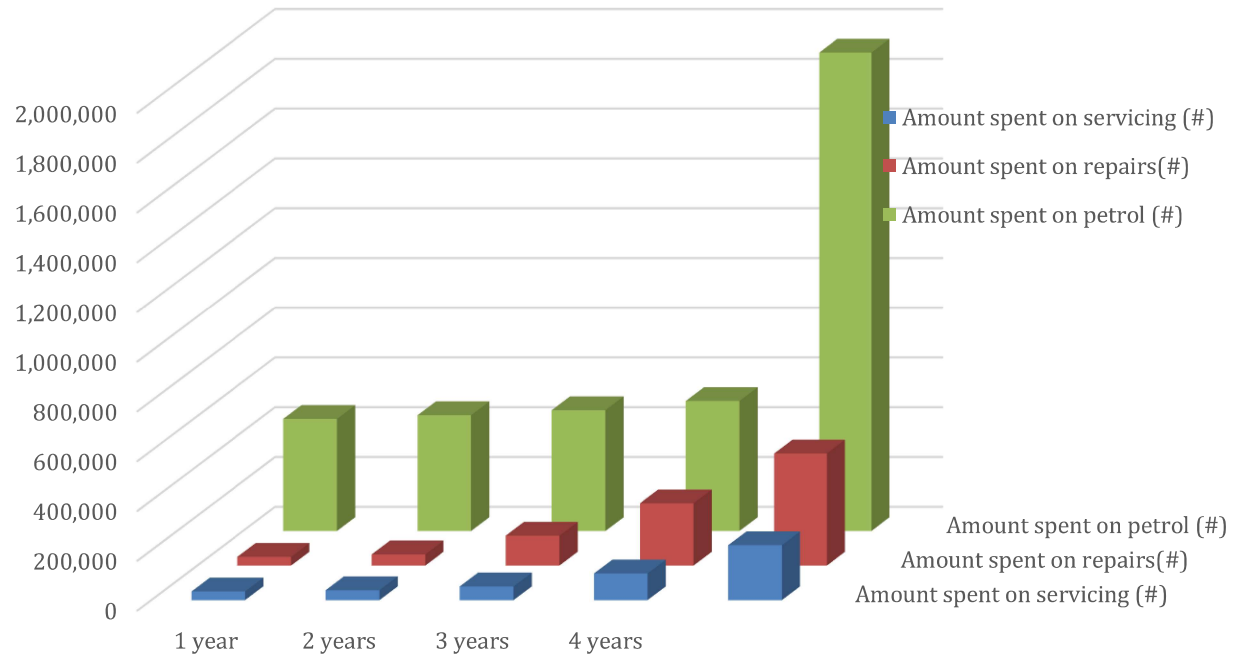
Table 5: Showing the Total breakdown of Inverter against Generator Sets

Item	Rating	Location	Age	Total amount Used for Generator repairs, purchase and maintenance	Total amount Used for the purchase and maintenance of Solar power system
System 1	1.5 KVA	Control Laboratory	4 years	1,153,320	**900,375**
System 2	3 KVA	Telecommunication Laboratory	4 years	1,891240	**1,052,625**
System 6	4 KVA	Departmental Office	4 years	2,692,520	**1,362,375**
Total				**5,737,080**	**3,315,375**

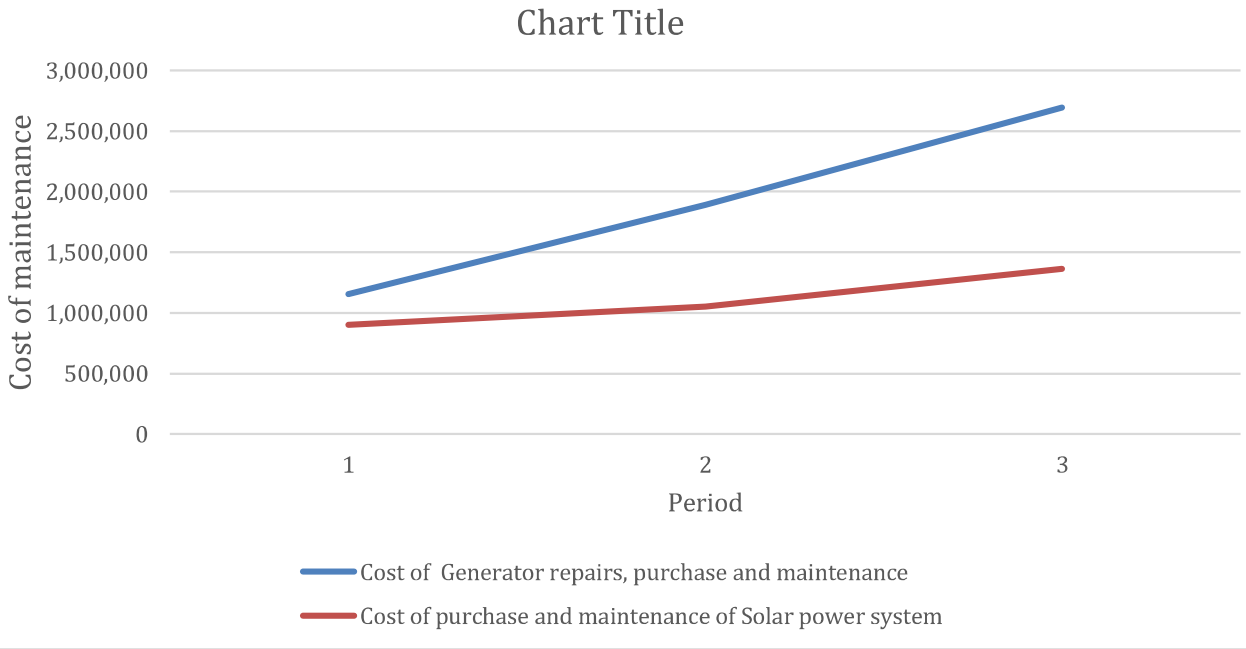
Table 6: The Total cost of Generator Sets

Item	Rating	Location	Age	Amount spent on servicing (#)	Amount spent on repairs(#)	Amount spent on petrol (#)	Amount spend on purchase of generator	Total amount
System 3	4 KVA	Departmental Office	1 year	35,000	35,000	450,000	300,000	820,000
System 3	4 KVA	Departmental Office	2 years	40,000	45,000	465,000	300,000	850,000
System 3	4 KVA	Departmental Office	3 years	55,000	60,000	485,000	300,000	900,000
System 3	4 KVA	Departmental Office	4 years	107,400	110,000	521,920	300,000	1,039320
Total				220,600	250,000	1,921,920	300,000	**2,692,520**





Cost of Generator Sets maintenance for period of 4years



5 CONCLUSION

This study show that petrol generator can be considerably be more expensive than solar power systems in long-term (upto 4years)due to high operating cost of petrol generator. The difficulty of purchasing spare part, servicing and fueling to keep it running make the petrol generator not economical. As we project into years the price of petrol is likely to goes up while the price of PV system is likely to come down. It is also proved that PV system is environment friendly source of energy which should also be consider

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