A Cost Analysis of Renewable Energy as an Alternative Energy Source for Selected Poultry Farms in Ekiti Metropolis, Nigeria

A.E. Adeleke, Ph.D.[1*]; T. Ogudana, M.Sc.[1]; O.A. Sotunde, M.Sc.[2]; S. Oyelami, Ph.D.[3]; and A.E. Ogbebor, B.Sc.[1]

[1]Department of Mechanical Engineering, Federal University of Oye Ekiti, Ekiti State, Nigeria.
[2]Registry, Federal University of Agriculture Abeokuta, Ogun State, Nigeria.
[3]Department of Mechanical Engineering, Osun State University, Osogbo, Nigeria.

E-mail: ademola.adeleke@fuoye.edu.ng*
Telephone: 08054813210

ABSTRACT

Raising of domesticated birds such as chickens, ducks, turkeys, and geese for the purpose of producing eggs or meat for food is referred to as poultry farming. Poultry farm equipment requires an electrical energy supply to function effectively and efficiently. This work studied and analyzed the annual cost of the existing energy source used by some poultry farms in Ekiti metropolis such as the use of diesel generators, connections to the national grid, and use of biomass as an alternative source of energy. The cost analysis of existing and proposed energy sources was carried out based on the capital investment cost, operation, and maintenance cost. The comparative study was carried out to access the economic viability of biomass as alternative energy source. The result of this study shows that the use of biomass as a renewable energy source should be encouraged.

(Keywords: biomass cost analysis, poultry farms, renewable energy).

INTRODUCTION

Energy, which is very important in the economic, political, social, and environmental aspects of any nation has become one of the most discussed issues globally. The industrialization of the world and technological developments have brought a higher energy need for the entire planet. However, the amounts of reserves of traditional energy resources differ from one country to another. Thus, this has resulted in major environmental concerns, serious political conflicts, unavoidable economical dependency, and important social consequences. The existing situation and the future estimations for energy requirements have led people to find alternative energy resources (Hanley and Nevin, 1999).

In Nigeria, located on the west coast of Africa, lack of access to a wide range of modern energy services has remained a major barrier to improving key indicators of human development (Okafor and Uzuegbu, 2010). Electricity, which is the foundation of modern economies, is not readily available, and if available, is of poor quality, or better still unreliable as less than 4,000 MW of the 7,876 MW installed electricity capacity is being generated (Sambo, et al., 2010).

There are two prominent categories of energy; renewable and non-renewable energy. Non-renewable energy comes from sources that will run out or will not be replenished in our lifetimes. Non-renewable energy sources come out of the ground as liquids, gases, and solids. Most of it energy sources that are fossil fuels: coal, petroleum and natural gas. Renewable energy is the energy generated from natural resources. The energy sources can be replenished or recreated when they are used. They are generally less-polluting and cannot be exhausted. This energy comprises a heterogeneous class of technologies. Various types of renewable energy can supply electricity, thermal energy, and mechanical energy, as well as produce fuels that are able to satisfy multiple energy service needs. They include solar energy, hydropower, biomass, wind, water waves, and geothermal.

Electricity generation in Nigeria varies from gas-fired, oil-fired, coal-fired, and hydroelectric power stations. The generating plants consist of 3 hydro-plants and 11 thermal plants (gas/steam). The national grid is made up of 4,889.2 km of 330 KV line and 6,319.33km of 132 KV. Presently, less than 4000 MW of the total

installed capacity of 7,876 MW is actively being utilized due to a number of factors ranging from technological deficiencies, loss through transmission (estimated to be between 30 and 35% of power generated), lack of modern standardization components, and lack of qualified maintenance staff (Ikeme, 2005).

Blankinship (2002) and Amelin and Hersoug (1997) evaluated diesel generator sets as the most common source of electric power in rural areas in developing countries. They observed that the pollution from the combustion of diesel fuel is a major threat to the local environment and contributes to global warming. Amelin and Hersoug (1997) described the investment cost for installing a diesel generator as low. The maintenance costs are also comparatively low, but the operation costs are high. The operation costs mainly consist of costs for diesel and lubricant oil. Thus, the operating costs depend primary on the local diesel price, which in turn depend on taxes, transportation costs, and world market price.

Nigeria has vast renewable energy resources (Islam, et. al., 2004). Renewable-energy technologies that are already or nearly commercialized include solar, small-scale biomass power generation, and small scale off-grid wind power. Renewable energy potential depends on geographic resources such as wind speeds, solar radiation, and biomass residues from agriculture and other industries. If good geographic resources are present, several applications offer plentiful opportunities for cost-competitive commercial or near-commercial renewable energy (Martinot and McDoom, 2000).

Many researchers have carried out different work on the various aspects of renewable energy to ascertain the advantages over the non-renewable sources of energy; including Solar PV Systems (Bates, et al., 2009; Ismail, et al., 2012; Borenstien, 2008; and Lee, et al., 1994), Wind System (Ackermann, et al., 1999; Baigarin, et al., 2001; and Suresh, et al., 2001), and Biomass Systems (Sheikh, 2007; Bhanu, 2010; Rezaur, 2014; Ayalon, et al., 2001; and Fennell and Thompson, 2013).

It is important for poultry farmers to know their current energy usage in order to determine the magnitude of energy being consumed by the farm. The energy consumption varies among different farms, hence the amount of electricity used is converted to per unit weight of broiler produced. Farms raising heavier birds tend to incur higher annual electricity than those raising lighter birds.

This study will give the poultry farmers a new direction to a more sustainable energy source which can reduce the energy crisis of the country significantly. This will help to reduce the dependency on fossil fuel to meet up the energy demand of the country. This study looks into the present status of energy consumption in different poultry farms which will give the people concerned an idea to find a way to reduce the energy consumption in poultry sector. The study also estimates the total annual cost of electricity that could be generated from poultry waste.

Justification for the Study

The research was used to assess the potential for renewable energy applications to the poultry industry by surveying four poultry farms in Ekiti State. During the survey, an interview was conducted to assess the poultry farmer on which of the proposed renewable energy solutions would be best preferred, three out of the four farm selected biomass from their poultry droppings based on different considerations.

Also, site analysis was conducted which includes data collection in the forms of interviews, questionnaires, and energy audits of each of the poultry farms. Using this data, the amount of electrical energy potentially utilized and the existing power source which was mainly diesel generator and grid source electricity from BEDC were cost estimated. Cost analysis was then performed by evaluating the total annual cost of each existing power sources used on the poultry and the proposed biogas energy from poultry droppings. After which a cost comparison of the proposed biogas system with the existing energy source on the poultry farms was used to determine the best energy source solution(s) for the poultry farms (Cunningham, 2007).

Objectives of the Study

The primary aim of this research is to evaluate the economic potential of electricity generation from renewable energy for poultry farms in Ekiti metropolis to help substitute or reduce the use of fossil fuel. The objectives are:

- To carry out energy audit in order to determine the amount of energy been utilized in each of the surveyed poultry farm

- To estimate the cost requirement of the existing energy source used in the surveyed poultry farm.

- To perform cost analysis of establishing a biomass power plant for the poultry farms compared to the operation of the existing diesel generator.

This project addresses the energy been utilized in poultry farms for different operations.

Scope

This work covers the annual cost assessment of energy use in poultry farms in Ekiti metropolis. A survey was carried out on different poultry farms in the region to determine the energy usage of each farm by conducting a load audit by distributing the prepared questionnaire among the farmer to get insight on which renewable energy would be best preferred. Information gather from the farm was analyzed and evaluated to determine which energy source would be suitable for the farms. This provides a basis for poultry farmers to approach the usage of renewable energy and hopefully to invest in this technology with a reasonable expectation.

METHODOLOGY

Study Area

The studied poultry farms were located in Ekiti State, a southwestern part of Nigeria. It was conducted among four different poultry farms which are:

- Afebabalola Livestock Centre.
- Gbobo Farm.
- Federal Polytechnic Ado Ekiti Poultry Farm
- Ekiti State University Poultry Farm (EKSU).

The methodology of this research includes but not limited to the following:

- The four poultry farms located in Ekiti State, Nigeria were visited and the load demand was assessed in a form of load audit.

- A cost analysis using annual cycle cost was carried out to evaluate the economics of the each of the existing energy source system available and the proposed biogas generator energy system.

- Finally cost comparison of diesel generator set, National grid supply and Biogas system was carried out.

Data Collection

Various types of data were collected related to the study from different types of sources. Secondary data was collected from different organizations, relevant literature and internet searching. Primary data was collected by means of a questionnaire survey in different poultry farms.

Secondary Data Collection

Different concerned institutions/organizations were contacted and internet searching conducted to collect necessary information for the study. Poultry related data where gotten from http://www.clemson.edu on 02/07/2016, Biogas related data and information was gotten from BCAS, 2005: “Report on Feasibility Study on Biogas from Poultry Droppings”, Bangladesh Centre for Advance Studies. Diesel and gas generator prices related data where gotten from Mikano International limited Nigeria. National grid energy related data were collected from the Benin Electricity Distribution Company (BEDC) website.

Besides the details mentioned above, information was also ascertained through discussions with local officials and the relevant literatures, documents, publications, and internet searching was done and various relevant files from different web sites were downloaded.

Primary Data Collection

Primary data was collected by means of a questionnaire survey and interview with the poultry farmers. Questions were asked to learn about present energy consumption, deficit of energy supply, size of backup system, running hours of the backup system, the problems facing with the technology, the interest of the farmers in

producing electricity from renewable energy, what type of renewable energy is preferable, and the barriers to disseminate the technology. Data concerning the load demand was also ascertained through an inventory of the different poultry farms.

Electricity Consumption

We found it necessary to gather energy data from the poultry farms in form of a load audit by carrying out an inventory on all the equipment and machines used in the poultry farms and their hourly usage of this equipment, in order to gain a better understanding of what size of the proposed biogas system would be considered for each of the poultry farms. Previous electric bills and meter reading contained the number of kilowatt hours consumed by the various poultry farms, as well as the price paid for these hours. Using this data, we were able to summarize the trend in cost of energy usage over the course of the year, and more importantly, compare the cost of energy from the electricity provider BEDC to the estimated cost of energy that could be produced by a biogas generator system and their current backup system which is diesel generator. The electrical purchasing history of the poultry farms also gave us an initial cost of electricity, which was very useful in our economic analysis.

Cost Analysis

The cost consideration of the following system where considered for analysis over the period of a year.

- National grid electricity energy supply from BEDC
- Existing Backup system a diesel generator.
- Proposed Biogas energy generating system.

A major factor in accessing the overall potential for the application of implementation, and benefits that each alternative energy source offers is their overall cost. In order to estimate the total cost of each of the alternative energy sources, as much information as possible was obtained from different resources regarding the costs of components, installation, site preparation, maintenance and operational fees. A manufacturer such as Mikano International LTD. was contacted to determine capital cost, installation and maintenance, and operation costs of a diesel and gas generator. The costs of maintenance and operation of each system was determined by case studies and factored into an annual cost analysis for each of the poultry farm. An accurate estimate of the actual cost of each option was ascertained to provide the poultry farm's management with a realistic estimate.

Categories of Costs

As far as costs are concerned there are two major categories considered in the analysis:

Operation and Maintenance Costs (running costs): The operation cost of the diesel generator was consider to be the cost of diesel at a fix price of N190/liter and maintenance cost was estimated at 5% of the initial cost of the generator which would be carried out at a working interval of 250 hours. Biogas gas generator operational cost was considered to be zero, because the fuel source which is the biogas would be generated from the poultry farms waste while the annual biogas maintenance cost include the generator, biogas plant and H_2S and moisture removal unit.

Capital Costs: For the biogas generator the capital cost estimate where made on the cost of the whole system which are biogas plant, generator, H_2S and Moisture removal unit, compressor for regeneration process for the different size of the farm, while the cost of diesel generator and installation also consider.

RESULT AND ANALYSIS

Energy Consumption Status in the Poultry Farms

During the research survey of the different poultry farms, information gathered was used to analyze the energy consumption of the four farms visited. The farms surveyed are:

- Afebabalola Livestock Centre.
- Ekiti State University Poultry Farm.
- Federal Polytechnic Ado Ekiti Poultry Farm.
- Gbobo Farm.

These poultry farms in Ekiti State are covered by the national electricity grid. Benin Electricity Distribution Company (BEDC) a rural

electrification company that is responsible for the commercial operation of electricity in the State. Almost all the surveyed poultry farms are grid connected, just a single farm was not connected to the grid (Gbobo farm).

There is a huge power shortage in the study area as well as in the country. For uninterrupted power supply all the poultry farms use backup systems such as a diesel generator. The daily energy consumption pattern in poultry farms varies according to the sizes of the farm, but the electrical consuming appliances are almost similar. Usually, the farms consume less energy in the daytime and consume more in the evening. However, the farms using energy efficient lamps use less electricity in the evening than daytime.

None of the poultry farms in the district have a renewable energy powering system. The details of utilization of different types of energy in the poultry farms are discussed in this chapter.

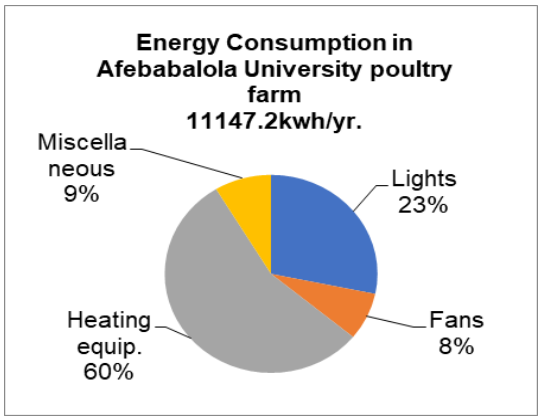
Energy Consumption of Major Electrical Appliances Used

Electricity is used in the surveyed poultry farms mainly by lamps to provide proper lighting in the poultry shed, fans to maintain the required temperature, incubators which are used for maintaining the temperature of the eggs, water pumps to supply water, and other miscellaneous equipment include mixers, grinders, and electric heaters.

The following are the details of the status of electricity use for the main appliances in the poultry farms.

Energy Usage Analysis for Afebabalola Poultry Farm

The farm has a capacity of 5,820 birds and a double poultry house. This facility consists of a number of equipment which consumes energy. The average energy usage per month/year is about 916.2/11,147.2 kilowatt-hour of electricity which are based on the equipment inventory and measurement of electricity consumption on a daily basis.



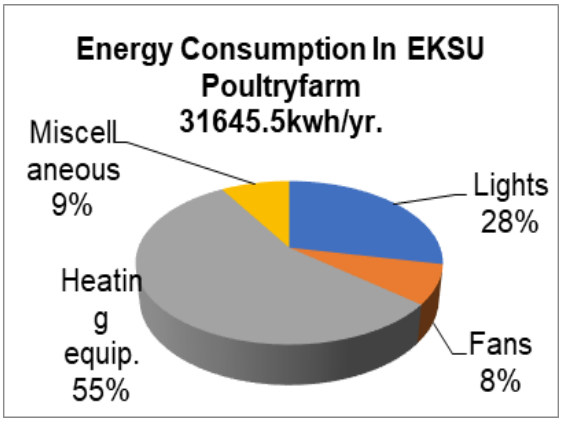
Source: Researchers Survey, 2020

Figure 1: Electric Energy Use in Afebabalola Poultry Farm.

The pie chart above represents the lights, fan, heating equipment and miscellaneous equipment used in the farm. It can be seen that the heating equipment consumes a greater portion of energy and fan consumes lesser energy.

Energy Usage Analysis in Ekiti State University Poultry Farm

The facility consists of an office and 3 poultry houses with a total of 4,500 birds. Due to the poultry farm size and daily activities, it is no surprise that EKSU poultry farm, out of the four farms visited, uses the highest average amount of electricity in a year/month which is about 31,645.5/2601 kilowatt-hour of electricity per year/month.



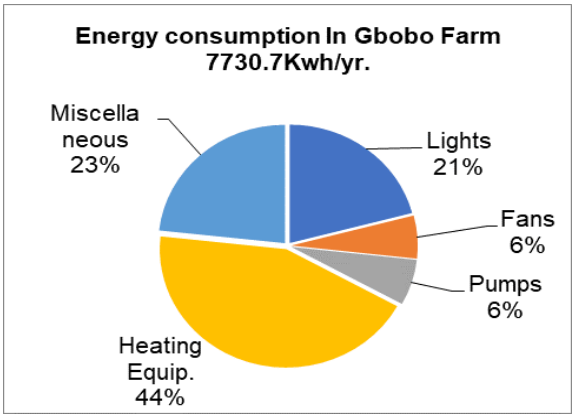
Source: The researchers Survey, 2020

Figure 2: Electric Energy Use in EKSU Poultry Farm.

The Pie Chart represents the light, fan ventilation, Electric Water Heater, Mixer Grinder, and miscellaneous.

Energy Usage Analysis for Gbobo Poultry Farm

The facility holds a capacity of 700 birds. The existing energy usage in Gbobo Poultry Farm is the least out of all the farms visited with an average electricity usage of 635.4/7730.7 kilowatt-hour per month/year. The estimation was ascertained using and inventory of the equipment and the hourly usage of the equipment.



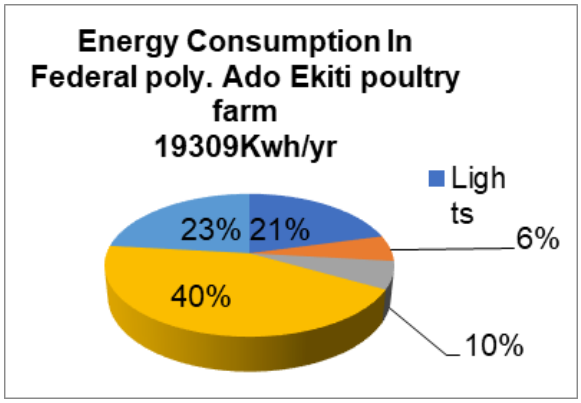
Source: Researchers Survey, 2020

Figure 3: Electric Energy Use in Gbobo Farm.

The pie chart above represents the energy usage of the different farm ranging from the different equipment used.

Energy Usage Analysis for Federal Polytechnic Ado Ekiti Poultry Farm

The facility has a total of 2,250 birds, the estimated average energy consumption of the farm is 19,309/1590 kilowatt-hour per year/month. This farm holds the second highest energy consumption for the surveyed farms.



Source: Researchers Survey, 2020

Figure 4: Electric Energy Use in the Ado Poly Poultry Farm.

The pie chart above represents the energy usage of the different farm ranging from the different equipment used.

Electricity Cost for Poultry Farms Connected to the Grid

From the survey of the poultry farms visited, it shows that majority of the farms are connected to BEDC for electricity supply only just one was not connected. It was also ascertained that power outage is a regular phenomenon in the different poultry farms. The poultry farms face enormous power outage every day, 100% of the poultry farms experience the power outage. However, the duration of power outage varies from fifteen hours to eighteen hours in a day. It can happen any time throughout the day.

Cost Analysis of Grid Supply (BEDC) for Each Poultry Farm

The cost per kWh of electricity from BEDC is ₦24.00 and the VAT rate is 5% of the electricity bill. Considering the cost of electricity for each poultry farm depends on their hourly usage and the total load consumed by each of the farm, this data was available during the survey of the farms.

Table 1: Cost of Electricity for Each Poultry Farm from the Grid Source.

Poultry farm	Average hours of Electricity	Monthly energy use (KWh)	Monthly Cost of electricity from BEDC	Annual Cost of electricity from BEDC
Afebabalola University	6	621	₦15,649	**₦187,788.00**
Federal Polytechnic Ado Ekiti Poultry Farm	6	834	₦21,017	**₦252,204.00**
EKSU	8	1615.2	₦40,703	**₦488,438.00**

Source: Researchers Survey, 2020

During the analysis, Gbobo Farm was not considered this because the poultry farm doesn't make use of the convectional power source from the national grid.

The Cost of Diesel Generator as a Back Up System for the Poultry Farms

All the surveyed farms visited have installed diesel generator as a backup system due to power outage from their electricity provider BEDC, diesel generator was the only backup system recorded during the survey. The sizes of the diesel generator range between 10-35KVA capacity and consume between 6-10litres per hour. The Capital cost of the generator could not be ascertained from the poultry farms during the survey, but an online source was used to determine the Capital and installation cost of the generator.

Table 2: Summary of Cost on Diesel Generator.

Poultry farm	Afebabalola farm	EkSU poultry farm	Gbobo farm	Federal Polytechnic Ado Ekiti Poultry Farm
Diesel generator size	35KVA	30KVA	10KVA	20KVA
Daily Average Usage	9-10hrs	6-8hrs	2-3hrs	5-7hrs
Fuel Consumed	8litre/hr	6litre/hr	2litre/hr	6litre/hr

Source: Researchers Survey, 2020

Annual Cost on Running of Diesel Generator for the Poultry Farms

The following are criteria for the cost analysis of using a diesel generator for the poultry farm as a backup system. This analysis would be considered under annually basis.

1. Capital Generator Cost
2. Operating and Maintenance cost
   - ✓ Fuel cost
   - ✓ Routine Service.
3. Total operating cost

To assess the annual costs of diesel generators, the following assumptions based on estimates provided by Wade and others (2016) are used:

- Capital generator purchase and installation costs: N186, 000/KVA.
- Operation and Maintenance costs: 5% of Capital costs for maintenance at 250hours interval and operational cost is the amount of diesel consumed.
- Price of diesel is taken as N190/liter

1. Afebabola Poultry Farm

Afebabalola Poultry Farm uses a 35KVA generator supplied by Mikano as a backup system during power outage. The generator has an average daily usage of about 9-10hrs on a daily basis and also consumes about 8 liters/hr of diesel when running on full load.

- **Capital Cost of Generator.** The capital cost for the 35KVA generator set include purchasing and installation = ₦6,510,000.00
- **Operating and Maintenance cost**. Based on the operation and maintenance cost, the annual cost of diesel for the generator based on the daily usage would be considered, estimated hour of use is 9-10hrs and also the routine service cost. Taking the current price of diesel at ₦190/liter

Annual Diesel Cost = Generator diesel consumption (liter/hr) X Mean Daily Usage X No. operation Days in year X Cost of diesel per liter

ADC = 8.00Lt/hr x 9.5hr x 365 x ₦190/liter

ADC= ₦5, 270,600.00 per/year

Routine Service Cost: The routine service cost involves the maintenance operation performed on the generator to increase it life span.

Annual routine service cost which is 5% if generator set price = ₦325, 500.00

Routine is to takes place every 250 hours of operation according to standard generator manual. We have 14 times of routine service per year, which was calculated through the daily average usage.

Annual Service cost ASC = 325500 x 14 = ₦4, 557,000:00

ASC = ₦4, 557,000:00

Total Annual Maintenance & Operating Cost:

Annual Service Cost + Annual Diesel Cost = 4,557,000+5,270,600

TACM&O = **₦9, 827, 600**

Table 3: Annual Cost of Power for a 35KVA Diesel used in Afe-Babalola P. Farm.

Total Cost per year	Total per year (₦)
Capital Generator Cost	₦6,510,000.00
Annual Service Cost	₦4, 557,000:00
Diesel Cost	₦5, 270,600.00
Total Cost	**₦16,337,600.00**

Source: Researchers Computation, 2020

2. EKSU Poultry Farm

EKSU poultry farm uses a 30KVA generator as backup system during power outage. The generator has an average daily usage of about 6-8 hours on a daily basis and also consumes about 6 liters/hr of diesel when running on full load. Considering the listed factor above we can get the total cost per year.

Annual Cost of Power For A 30KVA Diesel Generator in EKSU.

- **Capital Generator Cost.** The capital cost for the 30KVA generator set include purchasing and installation = ₦5,580,000.00

- **Operating and Maintenance Cost**. Based on the operation and maintenance cost, the annual cost of diesel for the generator based on the daily usage would be considered, when ascertained the generator runs about 6-8 hrs per day and also the routine service cost. Taking the current price of diesel at ₦190/liter.

ADC = 6.00Lt/hr x 7hr x 365 x ₦190/litre

ADC= ₦2, 912,700.00 per/year

Routine Service Cost: The routine service cost involves the maintenance operation performed on the generator to increase it life span. The Annual routine service cost which is 5% if generator set price = ₦279, 000.00

Routine is to takes place every 250 hours of operation according to standard generator manual. We have 10times of routine service per year, which was calculated through the daily average usage.

Annual Service cost ASC = 279000 x 10 = ₦2, 790,000:00

ASC = ₦2, 790,000:00

Total Annual Maintenance & Operating Cost:

Annual Service Cost + Annual Diesel Cost = 2,790,000+2,912,700

TACM&O **= ₦5, 702,700**

Table 4: Annual Cost of Power for a 30KVA Diesel used in EKSU P. Farm.

Total Cost per year	Total per year (Naira)
Capital Generator Cost	N5,580,000.00
Annual Service Cost	N2, 790,000:00
Annual Diesel Cost	N2, 912,700.00
Total Cost	**N11,282,700.00**

Source: Researchers Computation, 2020

3. Federal Polytechnic Ado Ekiti Poultry Farm.

Table 5: Annual Cost of Power using 20KVA Diesel Generator in Ado Polytechnic Poultry Farm.

S/N	DESCRIPTION	VALUES
1	Capacity Of Generator.	20KVA
2	Fuel Consumption Per Hour	5 liters/hr
3	Daily Usage Per Day	5-7hr

Source: Researchers Computation, 2020

- **Capital Generator Cost.** The capital cost for the 30KVA generator set include purchasing and installation = ₦3, 720,000.00.

- **Operating and Maintenance Cost.** Based on the operation and maintenance cost, the annual cost of diesel for the generator based on the daily usage would be considered, when ascertained the generator runs about 5-7 hrs per day and also the routine service cost. Taking the current price of diesel at N190/liter.

ADC = 6.00Lt/hr x 6hr x 365 x N190/liter

ADC= N2, 496,600.00 per/year

Routine Service Cost: The routine service cost involves the maintenance operation performed on the generator to increase it life span.

Annual routine service cost which is 5% if generator set price = N279, 000.00

Routine is to takes place every 250 hours of operation according to standard generator manual. We have 9times of routine service per year, which was calculated through the daily average usage.

Annual Service cost ASC = 279000 x 9 = N2, 511,000:00

ASC = N2, 511,000:00

Total Annual Maintenance & Operating Cost:

Annual Service Cost + Annual Diesel Cost = 2,511,000+2,496,600

TACM&O **= N5, 007,600**

Table 6: Annual Cost of Power for a 20KVA Diesel used in Ado-polytechnic P. Farm.

Total Cost per year	Total per year (Naira)
Capital Generator Cost	N3,720,000.00
Annual Service Cost	N2, 511,000:00
Annual Diesel Cost	N2, 496,600.00
Total Cost	**N8,727,600.00**

4. GBOBO FARM

Table 7: Description of the Diesel Generator at Gbobo Poultry Farm.

DESCRIPTION	VALUES
Capacity Of Generator.	10kva
Fuel Consumption Per Hour	2 liters/Hr
Daily Usage Per Day	2-3hr

- **Capital Cost of Generator.** The Capital cost of the generator and installation = ₦1, 860,000.00

- **Operation and Maintenance Costs:** The O&M cost for the generator includes:

ADC = 2.00Lt/hr x 3hr x 365 x N190/liter

ADC= N 416,100.00 per/year

Annual Routine Service Cost: Annual routine service cost which is 5% if generator set price = N93, 000.00

Routine is to takes place every 250 hours of operation according to standard generator manual. We have 4times of routine service per year, which was calculated through the daily average usage.

Annual Service cost ASC = 93,000 x 4 = N372, 000:00

ASC = N372, 000:00

Total Annual O&M Cost:

Annual diesel cost + Annual routine service cost**=** 372,000+416,000

TAO&M Cost**=788,000.00**

Table 8: Annual Cost of Power for a 10KVA Diesel used in Gbobo P. Farm.

Total Cost per year	Total per year (Naira)
Capital Generator Cost	N1,860,000.00
Annual Service Cost	N372,000.00
Annual Diesel Cost	N416,100.00
Total Cost	**N2,648,100.00**

Summary of Case Maintenance and Capital Cost of Generator

The cost of acquiring the generator is a fixed cost which must be consider and also the maintenance cost after installation are considered fixed costs because they are generally incurred over fixed time intervals with consideration to annual operating hours.

The standard operating hours for which maintenance are carried out is 250 hours which was used in the analysis above. The energy price [₦] includes the one-time Capital investment [₦/KVA] for the generator, routine service cost and the running cost of fuel [liter/hr] on hourly usage. The running cost is evenly divided across the time duration of power production. Operating cost are driven by the diesel costs, efficiency of the machines and the numbers of hours of operation, there is a range of fuel consumption rate of the various generators which was stated in the table above. In this analysis, the price of the burned fuel (diesel) is based on the market price which is ₦190/liter.

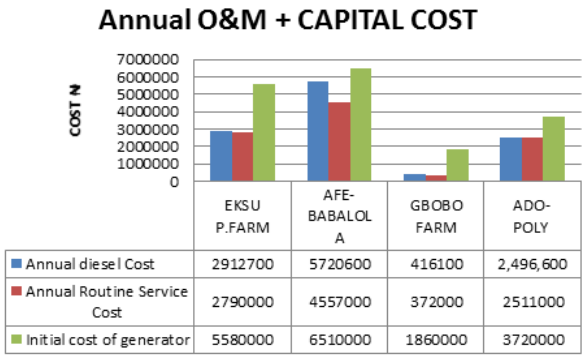


Figure 5: Annual Cost of O&M and Capital Cost of the Generator.

The graph above shows the annual maintenance and capital costs for the various poultry farms varies because of the different size of generators utilized. The capital investment cost for the generator is smaller compared to the O&M cost for utilizing a generator over the running years. The case studies report shows that the operation and maintenance cost ranges between ₦788,100- ₦10,277,600. This range of cost is significant, and it is driven by the extent of hourly usage over the years for each poultry farm.

Biomass Analysis

At present there is no poultry farm that uses a biogas energy for generating electricity or thermal energy during the survey of the farms. Biomass power is of different types, this analysis would consider biogas energy from poultry waste.

Technological Consideration

In this system the biogas from the digester passes through a H_2S removal unit where the H_2S content in the biogas is reduced to an acceptable limit (250 ppm). After the H_2S removal unit, the gas passes through a moisture removal unit where the gas is freed from moisture. Then the gas enters into the generator. It also considered a regeneration system to regenerate the material used in the H_2S removal unit and moisture removal unit. For regeneration the system uses the exhaust gas of the generator.

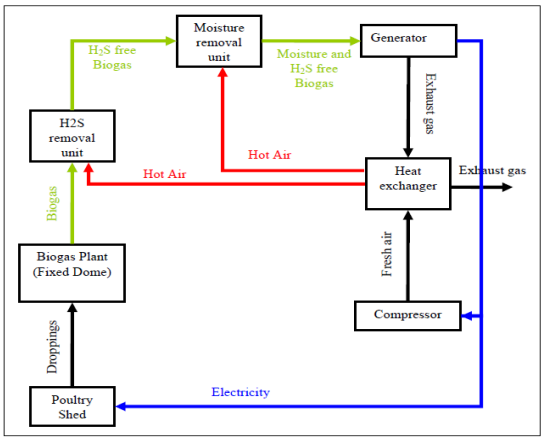


Figure 6: The Flow Diagram Considered to Produce Electricity from Poultry Waste.

ANALYSIS FOR BIO-GAS GENERATION FOR THE POULTRY FARMS

From the survey of the different poultry farms, information on the number of the poultry birds

raised in each farm was ascertained which would be used to estimate the potential generation of biogas from poultry waste.

Table 9: Parameters Consider for Energy Generation.

Litter/ droppings production	0.1 kg/ day per bird
Biogas production per kg of droppings	0.063 m3/day at 30° C
Amount of bio gas required to produce electricity	0.75 m3/ kWh
Cost of acquiring poultry waste	3.5/kg

Estimates for the amount of waste gotten from the different poultry farms varies base on the number of birds raised in the farm. The amount of litter/droppings production per day excreted by a bird per day is 0.1kg for a layer and broiler birds, this standard would be used to evaluate the amount of dropping from the surveyed farms.

Table 10: Estimate of Bio-gas and Electricity Production from the Surveyed Farms.

Poultry farm	Afebabalola	Gbobo	Ado-poly	EKSU
No. of birds	5820	700	2250	4450
Litter/dropping production (kg /day per bird)	0.1	0.1	0.1	0.1
Amount of dropping per day (kg)	582	70	225	445
Bio-gas production per day	36.7m^3	4.4 m^3	14.2m^3	28m^3
Biogas to electricity evaluation per day (kWh)	27.5 kWh	3.3 kWh	11 kWh	21 kWh
Biogas to electricity evaluation per year	100378 kWh	1205 kWh	4015 kWh	7665 kWh

On the basis of different parameter considered, the Table 10 above estimated the following: Amount of droppings (kg), Biogas production per day, Biogas to Electricity evaluation per day were calculated for different sizes of poultry farms.

From the table, the range of electricity that could be generated per day from the bird droppings is (3.3kWh-27.5kWh) for the different population of birds of the different farms.

Cost of Small Scale Biogas Plant

The construction costs of different sizes of biogas plant are shown in Figure 7 below.

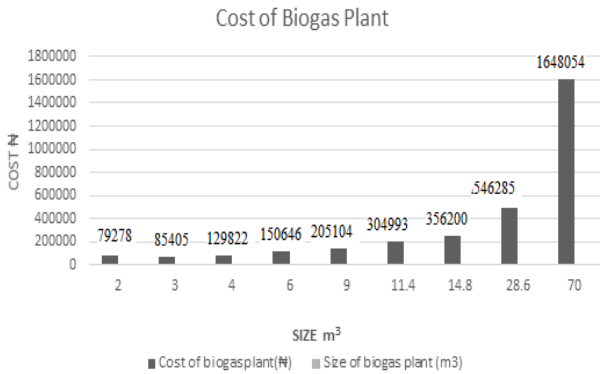


Figure 7: Cost of Different Sizes of Biogas Plant.

The cost of the biogas plant depends on the size, the different poultry farms visited has different size estimate of biogas produce per day as calculated above. Hence the construction of biogas plant varies for each farm.

Table 11: Cost of Biogas Plant for the Poultry Farms.

Name of poultry farm	**Estimated Biogas plant size**	**Cost of biogas plant (₦)**
Afebabalola Poultry Farm	40m^3	₦764,034.00
Gbobo Farm	8m^3	₦200,861.00
Ado-poly Poultry Farm	20m^3	₦483,888.00
EKSU Poultry Farm	32m^3	₦753,405.00

Source: Compiled and translated by author based on BCSIR, 2008 as quoted in BCAS, 2014.

Table 11 shows the cost of the biogas plant for the different poultry farms. The estimated plant size varies from the one calculated above because of the added 4m^3 for each farm, which might be useful if any change arises in the number of bird raised in the farm.

Operation and Maintenance (O & M) Cost of Biogas Plant

Operation cost consists of Labor cost and cost of poultry litter and maintenance cost is considered as the cost of changing valves, gas pipe, etc.

I. **Operation Costs**: The labor cost for charging the droppings into the biogas plant is considered zero in the analysis as the poultry farm would construct a drainage system around the poultry shed which is connected to the inlet chamber of biogas plant and the charge can flow into the inlet chamber due to gravity.

II. **Maintenance Cost of Biogas Plant:** Maintenance cost of biogas plant is considered as the placement cost for valves, socket, gas pipe etc. It was considered that valves, gas pipe, etc., must be replaced every year due to leakage. For a 6 m^3 biogas plant the cost is considered as **₦8,800** (Grameen Shakti, 2006). For a larger size of biogas plant the replacement cost of valves, gas pipe, etc., would not vary too much. Therefore, the cost of maintenance for all the biogas plant that would be used in all the poultry farms is considered the same at **₦8,800.**

Cost of Biogas Generator

The sizes of the gas generator to be used for the different poultry farms vary depending on the load consumption of each farm. Information regarding the cost of the gas generator can be found below. Capital generator purchase and installation costs is considered at ₦195,000/KW

Table 12: Cost of Biogas Generators.

Poultry Farm	Required Size (kW)	Cost (₦)
Afebabalola Poultry Farm	30	₦5,850,000.00
Ado-poly Poultry Farm	20	₦3,900,000.00
Gbobo Poultry Farm	5	₦975,000.00
Eksu Poultry Farm	20	₦3,900.000.00

Source: Compiled by author based on interview with Mr Mohammed Katee 20.08.2016 at Mikano International Limited.

I. **Maintenance Costs of Generator:** The annual maintenance cost generator was considered as 10% of its investment cost.

II. **Operation Costs of Generator:** The operation cost of generator was considered zero as biogas is free of cost for the generator.

Cost H_2S and Moisture Removal Unit: For each size of plant the cost would be different. For the simplicity, the cost for H2S and Moisture removal unit was considered as per kW which is drawn from a GTZ flagship project at a rate of 1 kW plant the cost ₦7000.

Table 13: Cost for H_2S and Moisture Removal Unit for Each Farm.

Poultry Farm	Size of plant(kW)	Cost of H2S (₦)
Afebabalola Poultry Farm	30	₦210,000
Fed. Poly. Ado Poultry Farm	20	₦140,000
Gbobo Poultry Farm	5	₦35,000
Eksu Poultry Farm	20	₦140,000

Maintenance/Operation Cost of Moisture Removal Unit: Maintenance cost for moisture removal unit was also derived from GTZ flagship project. The cost is considered for 1 kW plant at ₦1500 per year.

Table 14: Maintenance/Operation Cost of Moisture Removal Unit for Each Farm per Year.

Poultry Farm	Size of plant(kW)	Cost of O&M for moisture removal unit (₦) per year
Afebabalola Poultry Farm	30	₦45,000
Ado-Poly Poultry Farm	20	₦30,000
Gbobo Poultry Farm	5	₦7,500
Eksu Poultry Farm	20	₦30,000

Cost of Compressor for Regeneration Process: Estimate for a 10 kW plant the cost of compressor was ₦25,300 .For other sizes of power plant it was considered proportionally. Similarly, the cost of a 30 kW plant compressor would be considered as the summation of three 10 kW plant compressor.

Table 15: Cost of Compressor for Regeneration Process for Each Poultry Farm.

Poultry Farm	Size of plant(kW)	Cost of Compressor for regeneration process (₦)
Afebabalola Poultry Farm	30	**₦75,900**
Ado-Poly Poultry Farm	20	**₦50,600**
Gbobo Poultry Farm	5	**₦12,650**
Eksu Poultry Farm	20	**₦50,600**

OVERVIEW OF THE COST ANALYSIS RESULT FOR BIOGAS USE IN EACH OF THE POULTRY FARM.

On the basis of the different estimation made above, the different parameters considered were used to calculate for the cost of different sizes of biogas for electricity purpose in the poultry farms. The following would be considered for analyzing the cost of using biogas as a source of electricity.

I. Capital cost of biogas systems: The Capital cost of the biogas system include the overall cost which are cost of biogas plant, generator, H_2S and Moisture removal unit, compressor for regeneration process.

II. Cost of O&M of the Systems: The cost of poultry droppings is considered zero as the electricity will be generated in individual poultry farms from their own poultry droppings, maintenance cost is provided for the generator, biogas plant and H_2S and moisture removal unit. Below is the estimate made for each of the poultry farm considered in this study.

Table 16: Biogas Cost Consideration for Each Poultry Farm.

Poultry farm	Capital cost	Annual Maintenance Cost	Total Cost (Maintenance + Capital cost)
Afebabalola	₦6,899,934	₦638,800	₦7,538,734
Eksu	₦4,844,005	₦428,800	₦5,272,805
Gbobo	₦1,223,511	₦113,800	₦1,337,311
Ado-Poly technic	₦4,574,488	₦428,800	₦5,003,288

RESULTS AND DISCUSSION

From the result in audit analysis chat above for the different poultry farms it was observed that the annual power consumption for Afebabalola, EKSU, Ado Polytechnic and Gbobo are 11147.2kWh, 31645.5kWh, 19309kWh and 7730.7kWh per year, respectively.

Also, the economic viability of the existing power technology system was done carefully using Annual Cycle Cost analysis calculation of diesel generator set for 35KVA, 30KVA, 20KVA, and 10KVA and National Grid System. The cost of both nonrecurring (first cost) and recurring costs that occur over the annual cycle of the system, with future sum converted to their present worth values.

Table 17 shows that the capital cost of generator set for Afebabalola, EKSU, Ado Polytechnic and Gbobo are ₦6,510,000, ₦4,580,000, ₦3,720,000 and ₦1, 860,000.00, respectively. The cost of fuel for running generator set is ₦5, 270,600, ₦2, 912,700, ₦2, 496,600 and ₦416,100, respectively which is depend majorly on the hourly usage of the generator in the poultry farms. The price of fuel may even go higher in the scarcity and pilfering of product. The gaseous emission arising from the combustion of the fuel in the generator affects the environment adversely.

Estimate made for the proposed biomass power from poultry waste shows that the different poultry farms Afebabalola, EKSU, Ado polytechnic and Gbobo can generate biogas of about 36.7m^3, 28m^3, 14.2m^3, and 4.4m^3 respectively for powering the different capacity of the biogas generator, the operation cost of the biogas generator is consider zero as the biogas would be generated from the poultry dropping in the different farm. A biogas system would require maintenance, the maintenance cost which was also calculated for Afebabalola, EKSU, Ado Polytechnic, and Gbobo are ₦638,800, ₦428,800, ₦428,800 and ₦113,800, respectively.

Finally, of the three power sources analyzed, biomass was found to be more economically and environmentally feasible than diesel generator and more reliable and available than convectional grid power for BEDC for poultry farms in the Ekiti.

Comparison of The Existing Power Sources vs Proposed Biomass Power

Table 17: Comparison of Energy Source.

	AFEBABALOLA POULTRY FARM			EKSU POULTRY FARM			ADOPOLY POULTRY FARM		
Technology Parameter	Grid	Biomass (Proposed) 30KW	Diesel Gen (Existing) 35KW	Grid	Biomass (Proposed) 20KW	Diesel Gen (Existing) 30KW	Grid	Biomass (Proposed) 20KW	Diesel Gen (Existing) 20KW
Reliability	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Availability	20~25%	<95%	<80%	30~35%	<95%	<80%	30~35%	<95%	<80%
Capital cost (₦)	-	6,899,934	6,510,000		4,844,005	4,580,000		4,574,488	3,720,000
Annual Operation Cost (₦)	187,788	Nil	5,270,600	488,438	Nil	2,912,700	252,204	Nil	2,496,600
Annual Maintenance Cost (₦)	Nil	638,800	4,557,000	Nil	428,800	2,790,000	Nil	428,800	2,511,000

In the Comparison of the final results, Gbobo Poultry Farm was excluded reason because the farm does not have an electricity sources from the national grid.

A biomass system would reduce annual energy costs per year from the national grid if incorporated. This is direct cost saving from mitigated diesel and propane fuel consumption annually and also greenhouse gas emissions will be mitigated.

CONCLUSION

Demand for electrical energy continues to grow each year and current power stations available in the country are unable to keep up with the demand, therefore causing load shedding, so there needs to be investigation into new energy supplies. For the environment and the future, looking into renewable energy sources to meet this demand is the best possible solution for the poultry farms. Renewable energies, however, have a high capital cost and many have fluctuations in the supply.

Biomass energy as it is readily available can be integrated easily with the electricity from the national grid during the load shedding period. The four poultry farms have the resource of biomass energy that can be harnessed from their poultry drooping and waste to provide energy for their daily consumption.

The study has revealed the cost estimate to produce electricity from poultry waste and shows that there is high interest from the poultry farms to produce this type of electricity. This interest has come about because all of the poultry farms experience load shedding throughout the day which hampers the production of the farms.

Also, the benefits of biogas electricity installations are numerous, ranging from green stewardship to reducing the poultry farm's carbon footprint, and from building a strong public image for the farms, to reducing the poultry farm's monthly electricity bills. The potential application of the biogas system is determined by a financial analysis alone. Based on current prices, a biogas generator system installed at the different poultry farms would have a greater year payback period, than the existing backup diesel generator system been utilized.

RECOMMENDATIONS

On the basis of our findings and the analysis of this study the authors recommend the followings:

- Installation of biogas plant in the poultry farms should be made mandatory to avoid the environmental hazards and should be integrated in the national policy document.
- Awareness development program is required to build up the knowledge about the benefit of using renewable energy source as a source of electricity in poultry farms and the world at large.
- Awareness development program is required to make the poultry farmers aware about the use of energy efficient appliances which can reduce the electricity consumption of the farm.
- After installation of the system in poultry farms, the farmers should be properly trained for regular maintenance of the system otherwise it will incur additional cost to hire a technician.
- Some enterprises can be established to serve the poultry farmer in case of necessity regarding the technology used for electricity production.
- Further study is required for the dissemination of the technology at mass level.
- Further study can be done to find out the potential of producing electricity from poultry waste through a centralized system to feed on to the grid.

REFERENCES

1. Ackermann, T., K. Garner, and A. Gardiner. 1999. "Embedded Wind Generation in Weak Grids - Economic Optimization and Power Quality Simulation". *Renewable Energy*. 18(2): 205-221.
2. Ayalon, O., et al. 2001. "Solid Waste Treatment as a High-Priority and Low-Cost Alternative for Greenhouse Gas Mitigationǁ". *Environmental Management*. 27(5): 697–704.
3. BCAS. 2005. "Report on Feasibility Study on Biogas from Poultry Droppings". *Bangladesh Centre for Advance Studies*. 27(6): 521-530.
4. Bates, B., D. Buchanan, S. Mueller, and T. Parenteau. 2009. "Solar Panel Feasibility Study at Wesley United Methodist Church, Worcester." *Qualifying Project Report, Worcester Polytechnic Institute*. 1-126,
5. Blankinship, S. 2002. "Conversion Package Aims at Cleaning Up Stationary Diesel Gen-Sets". *Power Eng*. 1(2): 106, 52.
6. Bhanu. D. 2010. "Analyzing Biomass Energy Opportunities for a Small Scale Off-Grid Facility: A Case Study at Experimental Lakes Area (ELA)". *Ontario*. 18(2): 205-221.
7. Borenstien, S. 2008. "The Market Value and Cost of Solar Photovoltaic Electricity Production." Center for the Study of Energy Markets (CSEM). University of California Energy Institute. WP 176.
8. Cunningham, D. 2007. "Broiler Production Systems in Georgia (2007) Costs and Returns Analysis" Department of Poultry Science. http://pubs.caes.uga.edu/caespubs/pubs/PDF/B1240-3.pdf. Accessed 9/8/08.
9. Fennell, K. and S. Thompson. 2013. "Cost Analysis of Harvesting and Transporting Wood Biomass to a Northern Off-Grid Community: A Case Study of Barren Lands First Nation at Brochet, Manitoba, Canada". 1(6), 493-519.
10. Hanley, N. and C. Nevin. 1999. "Appraising Renewable Energy Developments in Remote Communities: Advantages and Disadvantages of Power Technology". *Energy Policy*. 27(9): 527 547.
11. Ismail, O.S., O.O. Ajide, and F. Akingbesote. 2012. "Performance Assessment of Installed Solar PV System: A Case Study of Oke-Agunla in Nigeria". *Engineering*. 4: 453-458.
12. Ikeme, J. 2005. "Nigeria's Electric Power Sector Reform: What Should form the Key Objectives". *Energy Policy*. 33:1213-1221.
13. Islam, M., A. Fartaj, and D.S. Wale. 2004. "Current Utilization and Future Prospects of Emerging Renewable Energy applications in Nigeria". *Renewable and Sustainable Energy Reviews*, 8(6): 493-519.
14. Lee, A.F. R.E.H. Sims, H. Rogner, and K. Gregory. 1997. "Design and Implementation of Hybrid Air-Electricity Storage System for A PV System".
15. Amelin, M. and E. Hersoug. 1997. "Options for Rural Electrification in Developing Countries. A Case Study in Kasulu, Tanzania". Diploma Thesis, B-EES-9705, Department of Electric Power

Engineering, Royal Institute of Technology: Stockholm, Sweden.

16. Martinot, E. and O. McDoom. 2000. “Promoting Energy Efficiency and Renewable Energy: GEF Climate Change Projects and Impacts”. Retrieved 6/2/2008. http://66.102.1.104/scholar?hl=en&lr=&q=cache:7DAQ1yGYfelJ:www.martinot.info/Martinot_McDoom_GEF.pdf

17. Okafor, E.N.C. and J. Uzuegbu. 2010. “Challenges to Development of Renewable Energy for Electricity Power Sector in Nigeria”. *International Journal of Academic Research*. 2(2): 211- 216.

18. Rezaur, R. 2014. *Feasibility Analysis of Wood-Biomass Energy Generation for the Off-Grid Community of Brochet in North-west Manitoba, Canada*. Chapter 4 (83-102). CRC Press: Boca Raton, FL. Retrived online 20/6/2013 from http://www.nariphaltan.org/gasbook.pdf

SUGGESTED CITATION

Adeleke, A.E., T. Ogudana, O.A. Sotunde, S. Oyelami, and A.E. Ogbebor. 2020. “A Cost Analysis of Renewable Energy as an Alternative Energy Source for Selected Poultry Farms in Ekiti Metropolis, Nigeria”. *Pacific Journal of Science and Technology*. 21(2):112-127.

Pacific Journal of Science and Technology