# Economics of Methane Production from Animal Dung Using 681.3 $M^3$ Fixed-Domes Digester for Farm Application

**Mtamabari, S. T.[1], and Ebigenibo, G.S.[2]**

[1]Department of Mechatronic Engineering, University of Port Harcourt, Choba, Port Harcourt, Rivers State

[2]Department of Mechanical Engineering, University of Port Harcourt. Choba, Port Harcourt, Rivers State

**Corresponding email:** tamsimeonis@yahoo.com



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Mtamabari Simeon Torbira

Department of Mechatronic Engineering, University of Port Harcourt,

B.Eng., M.Eng. (Mechanical Engineering) University of Nigeria, Nsukka, 2004 & 2010 respectively. M.Eng.(Sc) Mechatronic and Robotics Engineering, University of Leeds, England, 2019.

Tamsimeonis@yahoo.com, Mtamabari.torbira@uniport.edu.ng

Engr. Prof. Enibe Samuel Ogbonna

Department: Mechanical Engineering

Faculty: Engineering

Designation: Professor

Email: samuel.enibe@unn.edu.ng

B.Eng. Honours (Mechanical Engineering) University of Nigeria, Nsukka, 1982., M.Sc. (Alternative Energy) University of Reading, Reading, England, 1986 and Ph.D. (Mechanical Engineering) University of Nigeria, Nsukka, 1995.

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[2]Department of Mechanical Engineering, University of Port Harcourt. Choba, Port Harcourt, Rivers State

**Corresponding email:** tamsimeonis@yahoo.com

## Abstract

*Renewable energy is one of the vital sources to meet partially the global energy demand of developed as well as developing countries. Biogas plant can be one of the major sources of renewable energy in farms and rural Nigeria as huge amount of animal dung and poultry waste is available. Biogas plant can be of different types of which fixed dome and floating cover is in use in many countries for many years. The bag design is becoming popular in many countries. The generated gas can be used for cooking, lighting, power generation and the sludge can be used as fertilizer for land. Animal waste is easily available and inexpensive; the major share of cost is incurred at the initial stage. The operating and the maintenance costs are quite low. In the present work, an attempt has been taken to study the economics of a 681.3$m^3$ fixed dome digester for methane gas production. Costs related to the fabrication of plant are collected from various sources and the other items were estimated based on available information. Net present worth, internal rate of return, benefit-cost ratio and payback period were calculated. Based on calculated values, it was found that the biogas plant is economically viable, and viability increased with the increase of plant size, availability of waste and increased cost of fossil fuel. The technological suitability in the context of prevailing situation, economic viability and future scope of biogas plants has been evaluated. The findings of this study would give some directions and guidelines for future planning and implementation of biogas plants in Nigeria.*

***Key Words:*** *Biogas, Digester, Slurry, Life-Cycle Costing, Annualized Life-Cycle Cost, Cost of Biogas, fossil fuel*

## 1. Introduction

Huge quantities of organic waste running into several hundreds of tons are generated in each year in both rural and urban areas. At the same time, inhabitants of these areas spent huge sums of money on electricity bills, operating private power generating plants, fuel wood, kerosene, etc. to meet their energy needs. The national targets concerning energy generation from renewable energy sources are consistent with the global target of 22 % of total community gross energy consumption by 2010 (Walla & Schneeberger, 2005). Agriculture can contribute to the Kyoto targets by preventing uncontrolled emission of methane gas and Nitrous oxide gas during manure storage by the sealed process of fermentation in biogas plants and using the CH4 for generating electricity and heat. The reduction of emissions and the substitution of fossil energy sources by biogas are considered as a very cost-efficient possibility of achieving the targets (Neubarth and Kaltschmitt, 2000). Investment in biogas generation has become a safe, cost saving, green and economic alternative. Most investments involve an initial payment in return for future income. This is especially true of investments in energy efficiency and renewable energy systems such as biogas production, both of which typically require an up-front investment in equipment to derive future savings or future income. Financial analysis is the most commonly used tool that helps to decide whether a farm benefits by installing a biogas plant and if so, by how much. The basic underlying assumption for financial analysis is that the farm will adopt a new technology only if the farm expects it to have a positive impact in the farm's financial situation. In this analysis, all costs and benefits are valued from the point of view of the farms for which this is being done. Since this analysis is undertaken before deciding to install the plants, it is important to ensure that all costs and benefits are estimated as they are most likely to be realized by the user (farm) of the plant installation. Benefits and costs of a biogas plant will vary depending upon the use of inputs and outputs, by the farms. For example, if additional cost is incurred in the use of inputs, such as the need to buy cattle dung or use additional labour for feeding the plant, such cost, though it does not exist in this work, should also be included in the financial analysis, (Torbira, 2009). The financial analysis shows when the cost and benefit accrue or how they are distributed over the project period. To make the analysis more comprehensive costs and benefits are reflected for each year of project life. It includes all those costs and benefits that are changed or influenced using the technology. Any change in the cost and benefits that are not related to the use of biogas is not included in assessing the financial viability of the biogas plant. (Torbira, 2009) carried out a research on techno-economic analysis of a model biogas plant for agricultural applications, a case study of Concordia farms, the total cost avoided by owning a biogas was well over N17, 000, 000.

## 2. Objective of the study

- To provide an alternative source of energy to the farm hence reduce its over dependency on fossil fuels.
- To produce a cheap, environmentally friendly energy for the farm use.
- To convert the huge organic waste generated on the farm into useful energy hence enhancing good farm hygiene and reducing expenses on fossil fuels.
- To increase farm outputs and reduce inputs.
- To integrate biogas technology

- To replace fossil fuel with renewable energy.

## 3. Methodology

Economic and cash flow analysis and literature were used to determine the viability of this biogas digester plant. The economic analysis of the biogas plant, Project or Digester life, priced and unpriced Benefits, Costs were used to determine the profitability of investment for the entire period of production and to draw the most realistic picture of its economic performance. In the Cash flow analysis, the net present value, Benefit-cost ratio, Internal rate of returns, annuities were calculated using MATLAB. These calculations were made based on well-defined input parameters from the literature and analytical data.

## 4. Economic Analysis

Some benefits and cost of biogas plant are not restricted to the users and savings in cost alone. For instance, if a large biogas plant is installed in a farm, the farm and community will also benefit due to a cleaner community and conservation of forest in the area. Such benefits and costs that accrue even outside of the user environment is a subject matter of economic analysis and not of financial analysis. Here, the digester life span, the various benefits and costs associated with owning this digester plant is analysed. They include,

### Digester Life Span

The life span of a fixed dome digester could be more than 40 years depending on the quality of construction and the materials used. Yet, the economic life of a plant is taken as 20 years largely because any cost or benefits accrued after 20 years will have insignificant value when discounted to the present worth. Hence in the calculations in this work, (for 681.3 m3 plant), it is assumed that the plant will become non-functional by the end of the 20th year from its first day of commissioning.

### A) Benefits

The benefits of owning a biogas plant can be categorized into priced and unpriced benefits. while priced benefits can be quantified in monetary values, unpriced benefits cannot be accurately valued in terms of naira and kobo. In doing the economic analysis of this digester plant, its priced and unpriced benefits were examined as follows;

### I) Unpriced Benefits

**Some of the un-priced benefits includes;**

- **Benefits as Feeds** - With the availability of slurry, a farmer may decide to profit from raising pig or fish as the slurry could supplement as much as 30% of their feed leading to substantial decrease in the cost of production.
- **Benefits as Fertilizer** - Biogas technology will improve the quality of soil and serve as improved biological fertilizer. Several researches on the value of effluent as a soil conditioner have revealed or concluded that the effluent is a good fertilizer, (Jo Lawbuary, 2007).
- **Benefits on human Health** - One of the most severe health problems in rural Nigeria is air pollution from the domestic burning of firewood. Health damaging pollutants in

the smoke are associated with Acute respiratory infections (ARI) in children, Chronic lung diseases and associated heart diseases in adults.

Therefore, one of the benefits of this research will be to reduce spending on health care on the national level and lead to improved health and lower susceptibility to disease on individual level.

- Sanitation/ Environment - Decrease in the population of harmful pathogens and parasites in the slurry. Also, the stabilization of the organic compounds through the fermentation process attracts fewer flies to the dung heaps, hence less fly population. The environment is free of waste heaps.
- Tourism – This new business opportunities are created
- Development – Related Benefits: - Improve situation on the farm. Provide employment for masons and extension workers.

## II) Indirectly Priced Benefits

There are some forms of benefits from this biogas plant which can be priced by using indirect methods:

- **Valuation of Lighting Benefits** - Biogas will be used for lighting along with its use for cooking. The benefit of lighting/cooking could be quantified in terms of cost saved by reducing the use of kerosene, charcoal, fuel wood, diesel and PMS.
- **Salvage Value** - The salvage value of biogas plant is not included in the benefit stream of financial analysis because after 20 years of operation, the plant or its parts will not be re-saleable.
- **Value of Cooking fuel Saved** - It is the quantity and value (price) of the fuel wood and kerosene and charcoal saved that becomes the benefits of the biogas plant. Problems associated with the collection, storage and use of fuel wood, kerosene, diesel, and PMS etc. are avoided by availability of this gas.
- **Valuation of time Saved** - Working on the farms either spent 15 minutes or gain up to 4.5 hours per day depending on access to forest and water. Another study with 100-biogas household in 16 districts has reported an average net labour saving of 3.10 hours, (FAO/TCP/NEP/4415-T, 1996)

According to (East Consult, 1994) in all these studies, the availability of firewood and water were the critical factors to determine the extent of labour saved. Existing rate of employment and market wage rate for the unskilled labour, as shown below assuming 3.09 hours are saved from installation of biogas plant.

$$Y = \frac{3.09hrs * 365\ days}{8} * P \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.1.0$$

Where;

Y = value of saving time

3.09 = gross saving in time for fuel wood. Collection, cooking and cleaning of utensils

8 = working hour per day of labour

P = current market wage rate for labour (₦300/day)

The money valuations of the above calculation come to be N42, 294.375 i.e.

$$Y = \frac{3.09hrs * 365days}{8} * 300 = N42{,}294.375.$$

If average employment in agricultural activities for men and women is about 200 days a year, then the value for 200 days, which, in this case, should be N23, 175.00, should be used for financial analysis.

- **Valuation of Slurry -** Slurry from a biogas plant is known to have better influence on soil and its productivity compared to the use of fresh or composted dung.
- **Economic Valuation of Labour -** The use of biogas results in the saving of unskilled labour time. A wage rate for unskilled labour must be reduced by a factor that would reflect the cost of large-scale farming. Gautam used a factor of 0.65 to arrive at the economic wage rate of an unskilled labour (Gautam, 1988).

**A) Costs or Out-Flow**

**i) Investment cost:** The cost of a digester differs with time, space, location and so many other factors as will be shown in this work. The investment cost includes;

- Cost of unskilled labour
- All over-head costs borne by biogas builders
- Provision for penalty on constructive defaults
- 1-year guarantee on pipes and appliance
- 6 years guarantee on inlet, digester, dome and outlet
- 6 years after-sales-services (including yearly visit)
- Participation fees.

However, transport cost of building materials, pipes and appliances are excluded.

**ii) Operations and Maintenance (O & M) Cost**

In addition to operational time spent on O & M, additional cost may accrue in changing gas values, mantle, and glass of lamps and procuring technical support service from biogas companies. In this work it is estimated that about N100, 000 is spent to meet other expenses such as changing of mantel and traveling cost to nearby biogas firm for technical help.

## 5. Cash Flow Analysis

The basic procedure of the cash flow analysis of this gas plant is to enter all the yearly income to be received over the estimated life of the project as inflows. similarly, yearly expenditures are entered in the analysis as outflow. Finally, expenditure is deducted from income. The result thus arrived at is the net cash flow or net benefit.

Generally, in the initial year(s) of the project, the net cash flow or benefit tend to be negative, because of the expenditures incurred to meet establishment costs (Gittinger. 1982)

**A) Time Value of Money and Discount Rate**

The real value of money changes over time. The reasons for such changes are;

- Money can be invested to earn a return in the future
- People or investors have time preferences, i.e. they prefer now to future.

For example, if N100, 000 is invested today at an interest rate of 20% per annum, this will be worth N120, 000 in a year's time, N144, 000 after two years etc.

**B) Net Present Value (NPV) -** The Net Present Value, NPV techniques measure the worthiness of this biogas project by converting the annual cash flow to a single present value. A positive NPV indicates that the benefits are higher than the costs that accrue over this project life. The process of relating future amount to the present value is known as discounting and expressed by the following equation

$$P = F(1+i)^{-N} \quad or \; P = \frac{F}{(1+i)^N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.0$$

$$P = A * \frac{(1+i)^N - 1}{i(1+i)^N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.0$$

Where;

P = present worth of cost (money)

F = Future sum of money

A = End of year payments or savings

i = Rate of interest

N = Number of years

C) **Choice of Discounting Rate** - The commonly used discount rate is the rate of interest that a bank charges on loans and the opportunity cost of capital in situation where private capital is being committed. The on-going investment on biogas loan is 20%

Therefore, the NPV and benefit cost ratio (BCR) calculated in this work is at the rate of 20%.

D) **Internal Rate of Return (IRR**) - IRR, a most widely used measure of project profitability, determines the rate (in %), which makes the NPV of this project zero. In other words, IRR is that discount rate which makes the discounted benefits of this project equal to its discounted costs. IRR can also be viewed as the interest rate that the investment pays to the farm. Calculation of IRR requires trial and error methods. The NPV needs to be calculated assuming several discount rates until the value is zero. The following equation (based on interpolation) can be used to derive an approximate value of IRR.

The IRR is the i*% at which

$$\sum_{k=0}^{N} Rk(\frac{P}{F}, i\%, K) = \sum_{k=0}^{N} Dk(\frac{P}{F}, i\%, K) \ldots\ldots\ldots 4.0$$

Where;

RK = net receipt for k-year

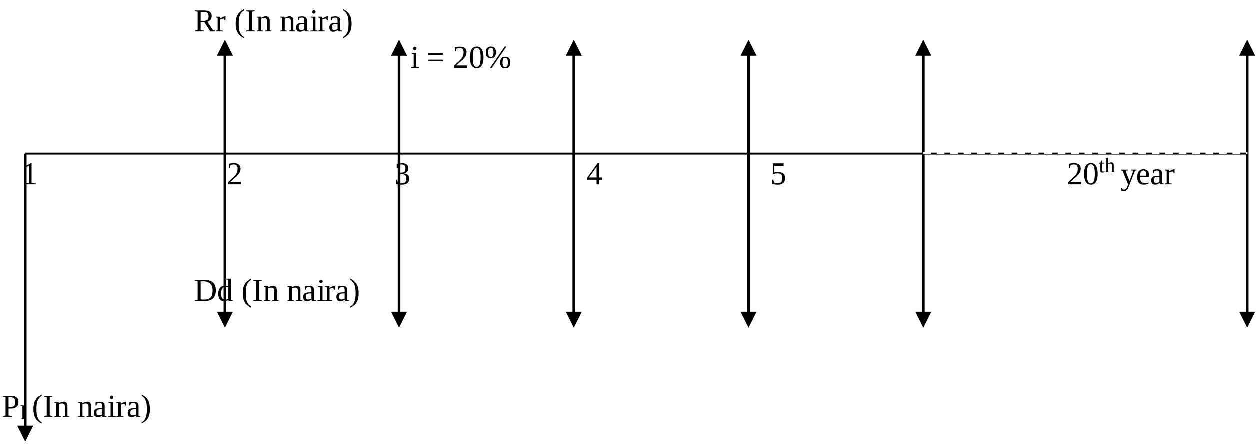
DK = net disbursement for k-year and

N = project life.

E) **Benefit-Cost Ratio** - The benefit-cost ratio (BCR) is another tool for assessing the profitability of a project. If the ratio is greater than unity (i.e. B/C > 1.0), the rule of thumb is to accept the project. In this work, the B/C ratio is more than 1.0, so the project is viable.

**F) Calculations**

**(i) Net Present Value (NPV)**




$$P_{Rr} = R_r \times \frac{[(1+i)^N - 1]}{[i(1+i)^N]}, Present\ value\ of\ savings \ldots\ldots 5.0$$

$$P_I = Present\ value\ of\ Investment \ldots\ldots 6.0$$

$$P_{Dd} = D_d \times \frac{[(1+i)^N - 1]}{[i(1+i)^N]} \ldots\ldots 7.0$$

$$Total\ expenses = P_T = (P_I + P_{Dd}) \ldots\ldots 8.0$$

$$Net\ Present\ Value\ NPV = [P_{Rr} - (P_I + P_{Dd})] \ldots\ldots 9.0$$

**(ii) Internal Rate of Returns (IRR)**

$$-PI + [R_r - D_d] \times \frac{[(1+i)^N - 1]}{[i(1+i)^N]} = 0 \ldots \ldots \ldots \ldots \ldots 10.0a$$

$$-P + [R_r - D_d] \times \left(\frac{P}{A}, i\%, N^{th}\right) = 0 \ldots \ldots \ldots \ldots \ldots 10.0b$$

$$\left(\frac{P}{A}, i\%, N^{th}\right) = \frac{[R_r - D_d]}{P} \ldots \ldots \ldots \ldots \ldots 10.0c$$

**(iii) Benefit-Cost Ratio**

$$Net\ revenue = P_{Rr} \ldots \ldots \ldots \ldots \ldots 11.0$$

$$Net\ Expenses = (P_I + P_{Dd}) \ldots \ldots \ldots \ldots \ldots 12.0$$

$$\frac{B}{C} ratio = \frac{P_{Rr}}{P_I + P_{Dd}} \ldots \ldots \ldots \ldots \ldots 13.0$$

## 6. Result and Discussions

| Parameter | Description | Unit | Value |
|---|---|---|---|
| $C_C$ | Cost of charcoal | ₦ | 8,750.00 |
| $C_d$ | Cost of diesel | ₦ | 542,750.00 |
| $C_k$ | Cost of kerosene | ₦ | 330,750.00 |
| $C_p$ | Cost Petrol | ₦ | 514,500.00 |
| **$C_{Total}$** | **Total Cost** | **₦** | **1,524,250.00** |
| $E_c$ | Energy from charcoal | MJ | 31,500.00 |
| $E_d$ | Energy from diesel | MJ | 384,100.00 |
| $E_f$ | Energy from fuel wood | MJ | 240,000.00 |
| $E_k$ | Energy from kerosene | MJ | 218,531.00 |
| $E_p$ | Energy from petrol | MJ | 343,980.00 |
| **$E_{Total}$** | **Total Energy of fuels** | **MJ** | **1,218,111.25** |
| $U_{cc}$ | Unit cost of charcoal | ₦ | 0.2778 |
| $U_{cd}$ | Unit cost of diesel | ₦ | 1.413 |

| | | | |
|---|---|---|---|
| $U_{cf}$ | Unit cost of fuel wood | ₦ | 0.5333 |
| $U_{ck}$ | Unit cost of kerosene | ₦ | 1.514 |
| $U_{cp}$ | Unit cost of petrol | ₦ | 1.496 |

**Table 1: Results of energy audit of the farm**

**(i)** Energy Audit of the farm - From the energy audit results obtained in table 1.0, the farm utilizes a total of 1,218,111.25 MJ of energy in a month at a huge cost of N1, 524,250. The monthly energy values, cost, and unit cost of each source of energy used are shown below. As earlier mention the farm sources of energy does not include electricity, as there is no such power supply to this farm. The energy audit reveals that the farm needs a more economical, cheap and environmentally friendly source(s) of energy such as Biogas. It is evident from both the total and unit cost that too much money is expended on the current sources of energy used by the farm.

**(ii)** Comparism of biogas generation prospects of the farm with its energy requirements

The biogas generation prospects depend on the common raw materials used for biogas generation and are often defined as "organic waste materials", e.g. human excreta, animal manure, sewage sludge and vegetable crop residues. With 6,050Kg of organic waste, 1,713.92 $m^3$ of biogas will be yielded per day. This indicates that in one month, a total of 1,713.92 x 30 = 51,417.6 $m^3$ of biogas will be generated in the farms. Since 1$m^3$ of biogas is equivalent to 0.4Kg of diesel, 0.6Kg of petrol, 1.3Kg of fuel wood, and 0.8Kg of charcoal and 0.5Kg of kerosene **(FAO/TCP/NEP/4415-T, 1996).**

**Table 2: Biogas Yield**

| Parameter | Description | Units | Values |
|---|---|---|---|
| $E_b$ | Energy value of biogas produced | MJ | 1.337E+06 |
| $Y_T$ | Total volume of biogas yield per day | $M^3$ | 1,714 |
| $Y_{tb}$ | Volume of biogas yield from birds | $M^3$ | 3.92 |
| $Y_{tc}$ | Volume of biogas yield from cow | $M^3$ | 1,080 |
| $Y_{tp}$ | Volume of biogas yield from pigs | $M^3$ | 600 |
| $Y_{ts}$ | Volume of biogas yield from sheep | $M^3$ | 30 |

One can say generating 51,420 $m^3$ of biogas in a month is equivalent to buying the fuel quantities in column three at the prices in column seven of table 3.0.

**Table 3.0: Equivalent Value of Biogas Consumption per Month**

| **Fuel type** | **Units** | **Quantity** | **Unit price** | **Heating values (MJ)** | **Energy/month (MJ)** | **Cost/month (N)** |
|---|---|---|---|---|---|---|
| Biogas | $M^3$ | 51,420 | 0.00 | 20-26 | 1,336,920 | 0.00 |
| Diesel | Kg | 20,568 | 65.00 | 46.00 | 946,128 | 1,336,920.00 |
| Petrol | Kg | 30,852 | 70.00 | 46.80 | 1,443,873 | 2,159,640.00 |
| Wood | Kg | 66,846 | 6.40 | 18.40 | 1,229,966 | 427,814.00 |
| Charcoal | Kg | 41,136 | 2.50 | 30.00 | 1,234,080 | 102,840.00 |
| Kerosene | Kg | 25,710 | 70.00 | 46.26 | 1,189,344.6 | 1,799,700.00 |

Which is far more than the quantities and costs the farms purchase and pay-out per month as reflected in the energy analysis. Also, a total of 1,336,920 MJ of energy will be available to the farm in a month. This amount of energy is more than the estimated 1,218,111.25 MJ of energy consumed on the farm per month as reflected in energy audit of the farm. So, the biogas generation prospects of the farm can meet the energy needs of this farm. This amount of energy can be utilized in cooking, lightning, heating, warming etc. on the farm

### (iii) Financial Analysis of the Biogas plant

The financial analysis takes into account capital and maitenance cost, and life of the system, and cost avoided in purchasing woods ,kerosene, PMS, diesel , labour etc.From calculations, total cost avoided or savings ($R_r$) stand at N18,314,175, investment cost $P_I$ is N5,954,100, maintenance cost $D_d$ =N100,000, total expences is N6,441,060 and net present value NPV becomes N82,741,646.58, total present worth of savings is N89,128,706.58. Interest rate is taken to be 20 %, life of project is 20 years. No salvage value. The economic life of the plant is taken as 20 years mainly because any cost accrued after 20 years will have insignificance when discounted to the present worth. Table 4.0 show the annual cost (amount spent per year) of fuel consumption (which becomes the cost saved or avoided by owning a biogas plant) by a farm.

**Table 3: Annual Cost of Fuel Consumption of the Farm**

| Fuel Type | Quantity/Month | Cost/Month (N) | Cost/Year (N) |
|---|---|---|---|
| Fuel wood | 20,000Kg | 128, 000.00 | 1,536,000.00 |
| Kerosene | 7000 liters | 330, 750.00 | 3,969,000.00 |
| Diesel | 10,000 liters | 542, 750.00 | 105,000.00 |
| P.M. S | 10,000 liters | 514, 000.00 | 6,168,000.00 |
| Charcoal | 3,500Kg | 8, 750.00 | 23,175.00 |

Therefore, by owning a biogas plant, the farm will save or avoid the cost of N3,969,000.00 on buying Kerosene (see table 3) each year throughout the 20 years life of the biogas plant. In table 4, the life span (in years) of the biogas plant run from 1-20 years but because of space, the table is truncated in column six and the values of annual savings continues from the fifth – tweentieth year_representing the indicated data per annum. The annuities (in form of savings or revenue) can run in thesame amount throughout the project life. The inflation accounted for will have significance when discounting the net savings or benefits to the present worth or value as was computed. See cash flow digram below.

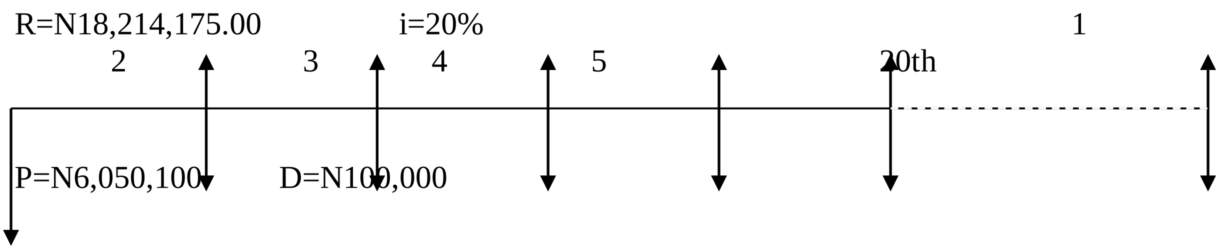


**Table 4: Financial Analysis of a 681.3m3 Active Biogas Plant [Without Loan & Subsidy]**

| YEAR | 1 | 2 | 3 | 4 | 5……20 |
|---|---|---|---|---|---|
| **Benefits**<br>To non-users<br>- Forest conservation<br>Unpriced<br>- Feeds<br>- Fertilizer related<br>- Health<br>- Sanitation/environment<br>- Tourism<br>- Development related | | | | | |
| **Directly priced** | 1,5 36,000 | 1,536,000 | 15,36,000 | 1,536,000 | 1,536,000 |
| - Savings in wood | 3,969,000 | 3,969,000 | 3,969,000 | 3,969,000 | 3,969,000 |
| - Kerosene | 105, 000 | 105,000 | 105,000 | 105,000 | 105,000 |
| - Charcoal | 6,168,000 | 6,165,000 | 6,165,000 | 6,165,000 | 6,165,000 |
| - Petrol [P.M.S] | 6,513,000 | 6,513,000 | 6,513,000 | 6,513,000 | 6,513,000 |
| - Diesel | 23,175 | 23,175 | 23,175 | 23,175 | 23,175 |
| - Labour | | | | | |
| **Salvage value** | | | | | |
| **Increased crop yield** | | | | | |
| **Loan** | | | | | |
| **Subtotal** | **18,314,175** | **18,314,175** | **18,314,175** | **18,314,175** | **18,314,175** |
| **Cost**<br>- Investment<br>- Operation | 5,954,100 | | | | |
| - Maintenance | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| - Loan Repayment<br>- Others | | | | | |
| **Subtotal** | **6, 054,100** | **100,000** | **100,000** | **100,000** | **100,000** |
| **Net Benefit** | **12, 260,075** | **18,214,175** | **18,214,175** | **18,214,175** | **18,214,175** |

**Cost Distribution of the Biogas Plant**

The cost distributions (in %) of the active bio-digester plant have been calculated as a percentage of the total cost of the plant. The result is shown in the pie chart below.

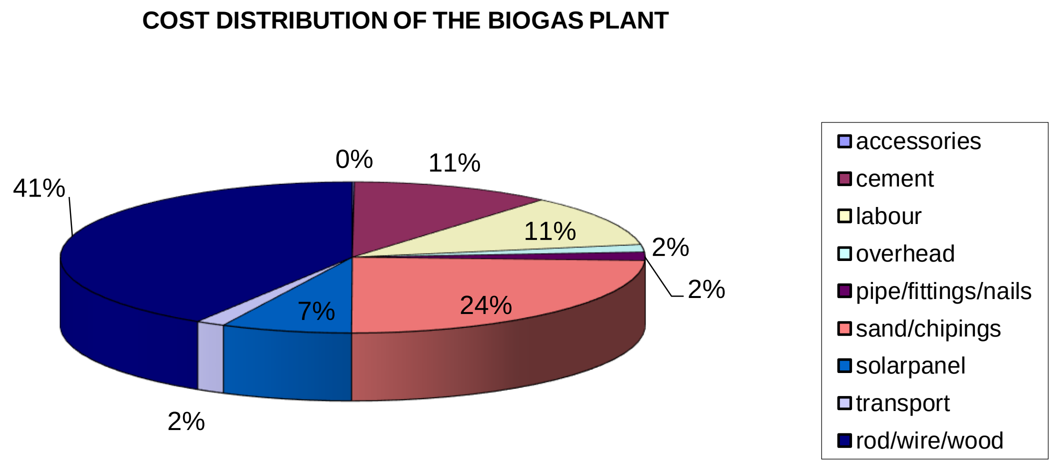



**Figure 1: Cost Distribution of 681.3 $m^3$ Biogas Digester**

## 7. Conclusion

As seen from result above, iron rod, iron wire and wood consume the highest amount of construction cost of the digester plant representing 41.14%. Other major costs are; sand & chippings, cement, and labour while digester accessories gulp the least cost.

From the economic point of view, the net cash flow of a 681.25m3 biogas plant without subsidy is positive in the first year. This indicates that without subsidy, a user can still invest to get a positive return on investment. This is not beyond the investment capacity for a commercial or large-scale or mechanized farmer. Though there is still need for subsidy to encourage this technology. Another factor observed in the economic feasibility is the higher benefit of biogas plant use in terms of petrol, diesel and kerosene saved. This suggests that the biogas plant may not be viewed as profitable if these savings is not used for generating more income by ploughing back these savings into the farming business.

Furthermore, the profitability of investment in biogas will increase with the increase in the price of firewood, kerosene, diesel, etc. in the future.

So far, we have analysed the organic waste generation of a farm, its energy requirements, and we have compared its biogas generation prospects with energy requirement. The economic studies also reveal the viability of this project.

Biogas is a potential renewable energy source for rural Nigeria. Taking biogas generation as a farm base activity, the energy requirements of these farms can be meet.

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