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POTENTIAL CAPABILITY OF CORN COB RESIDUE FOR SMALL POWER GENERATION IN RURAL NIGERIA

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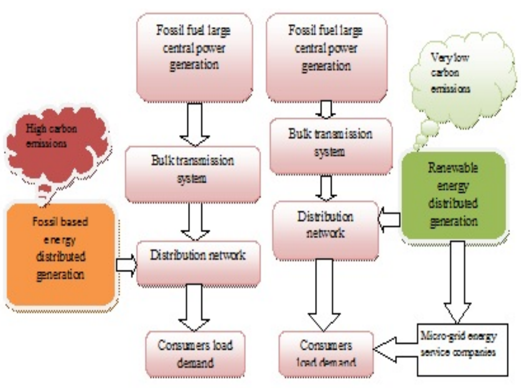
ABSTRACT

The ongoing global decarbonization strategies has paved ways for mixed power generation options involving both conventional and non-conventional sources of energy which is aiming at the simultaneous interest of lowering the price per unit of energy produced and sustaining healthy environmental requirements. However, future energy supply structures is expected to be dominated by renewable energy systems distributed generation while the reserves of fossil-based energy resources continue to decline on daily basis. Possible conversion technologies for electrical power generation utilizing the corn cob bio-residue were outlined in this framework. The article also seeks to investigate the potential opportunity of small power generation from biomass corn cob residue in Nigeria. A mathematically modified method was employed for evaluating the potential of the residue for power generation. Data from the United Nations Food and Agricultural Organization (FAO) statistics was used for the analysis and concentrated body of literature back-up was also exploited for the analysis. The observation of data was carried-out from 1996 to 2010, though, the general result signifies a fluctuating potential. Summarily, the outcome of the study indicated that close to 3000MW electrical power is possible with availability of 70% of the residue in 2010. The study was concluded with brief description on prospect for implementation strategies of rural bioelectricity project.

Keywords: corn cob, power generation, bio-energy, rural Nigeria.

1. INTRODUCTION

Power generation from renewable energy resource has occupied a front burner issue in global energy scenarios. The apparent reason behind this notable development is the current growing efforts to thwart unhealthy environmental activities orchestrating from energy consumption. More to this development is that the future of power supply structure which is also expected to change regarding the inevitable incursion of renewable energy structures (Figure-1).



Present system Future structure

Figure-1. Comparative structural system between the present and future electricity supply.

Corn cob is one of the many bio-energy resources in Nigeria. More than 10% of global primary energy consumption is being derived from biomass resource [1]. Meanwhile, the global available potential of biomass for energy is yet to be exploited for constructive socio-economic development and atmospheric sanitation. Kyoto Protocol and other summits on global warming fervently supported application of biomass resource for power generation. In line with this advantageous call, intensive research efforts now focus on different bio-energy resources potential exploitation in the world today.

The existing potential of terrestrial biomass is high and promising such that if well exploited for energy purpose it may eventually displace large amount of fossil based fuels and thereby reduce the level of greenhouse gases (GHGs) emissions. Biogenic carbon dioxide emitted from biomass during combustion process for energy enters the atmosphere for reuse in the growing process of living plants. This process can be referred to as inert carbon emissions as it constitutes no harm to biodiversity. The entire process of carbon release from biomass and reused by plant is illustrated in Figure-2 [2].

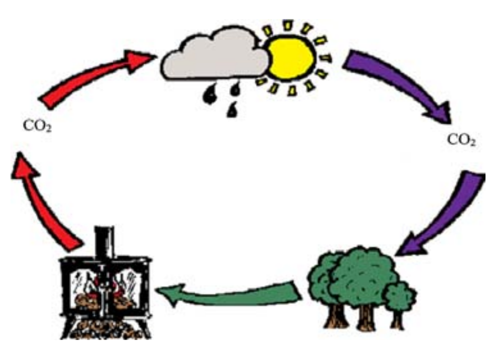


Figure-2. Carbon Cycle.

In developed and some developing countries, the demand for socio-economic development has encouraged

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electricity generation from some locally available bio-energy resources due to their fuel diversification tendency and mitigation potential against global warming. In the case of Nigeria like other Sub-Sahara Africa countries with so many rural settlements associated with serious energy poverty, there is a crucial need to explore the country's bio-energy resource potential to augment for the national energy crisis. On a global scale, there is a need to increase efforts towards exploitation of renewable energy resource for power application not only in rural areas because the atmosphere is common to all. The world is vulnerable to serious environmental pollution constraint if the current trend from fossil fuels consumption is allowed to persist for a longer duration in the history of mankind [3]. Since bio-energy resources are readily available within the vicinity of rural communities; therefore, tremendous hopes exist for any rural energy support programme in the near future in Nigeria.

In attempt to present an understandable overview of an opportunity for small power generation in the country especially in rural communities, this study explores the potential sustainability of bio-power using residue from corn cob. An estimated potential of corn cob residue for power generation in the case study country (Nigeria) was investigated.

2. ENERGY SITUATION AND CEREAL CROP PRODUCTION IN NIGERIA

2.1 Energy situation in Nigeria

2.1.1 Overview of energy supply situation

Power supply condition of the country has been in a state of retrogression when compared to the productive efforts being channeled in developed and some fast developing countries towards rural and urban electricity provisioning. Just about 40% of household in the country have access connection to the national electricity grid system [4] and the general access to electricity is 46% [5]. This negative incidence is due to some complex and interacting features which are summarize in Table-1.

With exploding population of over 160 million, the current national total power generating capacity is fluctuating between 3000-4000MW out of over 8000MW installed capacity. Based on the national energy demand portfolio, about 10, 000MW is required to foster the present socio-economic needs of the country. A national effort by Energy Commission of Nigeria (ECN) towards renewable energy development and application has only been directed towards micro-solar and establishment of very few biogas digesters for cooking in some institutional places such as schools and prison yards. These poor performance indexes of the nation's power sector have conspicuous effects on agricultural production, institutional performances and generally on the economic growth.

Table-1. Electrical energy situation in Nigeria.

Attribute	Summary of the insight
General situation of the nation's energy sector	Recurrent system breakdown, unpredictable power outage situation and frequent voltage surge resulting from poor power system protection
Access to electricity	The general rating of electricity access in the country is below 50% with wide range of disparity in the electrification level between rural and urban settlements
State of power supply facilities	Supply equipment is dominated with out-dated system generators and under-rated equipment with easy tendency to be technically constrainted
Maintenance strategies	Poor operational and maintenance schedule, retrogressing system organizational rigidity and inadequate reliability and maintainability management strategies.
Conventional fuel application for power generation	Fuel application is predominantly fossil-based but about one-fifth of the power supply is hydro-based power.
Funding and investment planning	Under-funding, inadequate investment, mismanagement of fund and revenue generated
Public energy consumers' behaviours	High unwilling tendency of consumers towards settlement of electricity bill, high incidence of illegal connections leading to frequent asymmetrical faults and broken mutual trust between consumers and the nation's power supply authority
Research and sector reform efforts	Absolutely, no research work in the sector and efforts towards reforms is infrequently implemented

2.1.2 Rural energy demand in Nigeria

Modern rural energy application has well identifiable with simplified nature due to their structure in respect to capital investment, power plant construction, system management, generation and distribution scheduling. The demand for energy in rural villages of Nigeria is mainly for household consumption which usually involve simple load such as lighting, cooking, heating and operation of domestic appliances. Figure-3 outlines typical energy demand purposes in rural villages of the country. Generally, there are two basic classifications of rural energy application which are domestic use and rural service operations. Rural service operations include activities like farm irrigation, pumping of drinking water, small-scale processing and storage facilities. Rural schools, worshiping centres and cottage

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healthcare service centres are also among the consumers of rural energy supply.

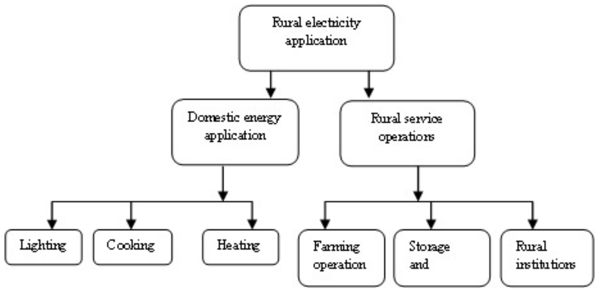

Figure-3. Structure of rural energy application in Nigeria.

In most developing countries with large number of rural villages, cases of energy crisis are long-established phenomenon due to insufficient planning and ineffective diversification of energy resources. This kind of predicament has forced rural inhabitants of many of such countries to concentrate more on the traditional fuel wood for their primary energy consumption. Direct burning of biomass in open space especially in indoor cooking is also not far from contributing to negative environmental practices as smoke and char particle release can obstruct human respiratory system in form of cardiovascular infectivity. Biomass burning in open places can be environmentally hazardous as has been the case for its use as direct fuel in household cooking in South Asia [6]. On a decisive explanation, this also has negative impact on human health in developing countries where eyes irritation is common due to frequent contact with smoke particles.

2.2 Corn production and residue availability in Nigeria

Nigeria is one of the main producers of corn in Africa as indicated in Figure-4 [7].

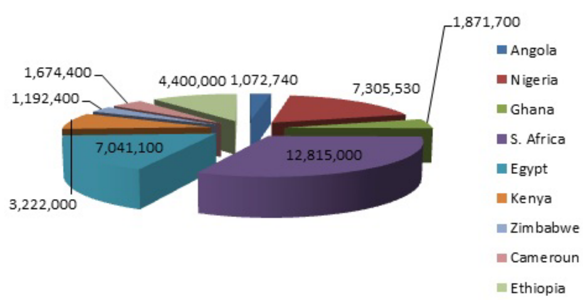

Figure-4. Corn production in some selected countries in Africa.

The countries selected in this study are the major producers of corn in the region of Africa. South Africa, Nigeria and Egypt are the three most leading countries in corn production quantity in the region. Generally, cereal crop production in these three countries has well meaningful potential quantity which signifies sustainable availability of corn residues. Though, availability of different biomass residues in Nigeria can be a strategic opportunity to tackle the nation's energy deficiency especially in rural areas of the country where access to electricity is critically difficult by grid expansion.

Corn cob is one of the three main residues from corn which is obtained after manual or mechanical milling process of corn. Availability of corn cob residues in Nigeria is dictated by annual production quantity of corn (Maize) and some other competing domestic applications such as its relevance for cooking in a popular African open air three-stone stove. In Nigeria (Northern part) especially where the forest structure is predominantly open type due to desert encroachment, corn cob is used mainly to supplement the insufficient forest firewood. In the middle belt region downwards to the southern axis of the country where vegetation is enough to support domestic firewood demand, there is availability of sufficient quantity of the residue for power generation purpose. Figure-5 shows the total annual production of corn and their corresponding harvested area. In many developing countries, especially Nigeria biomass residues are usually available in abundant quantity but energy generation facilities are lacking. This problem usually result to a situation where large quantity of residues are burnt in the field, form mountain of waste deposits in most waste dumping sites and could remain in the fields after extracting the consumable portion of the crops.

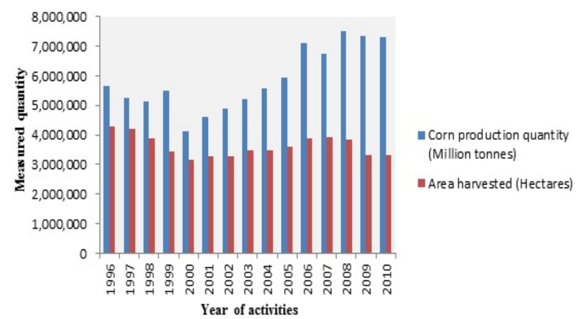

Figure-5. Corn production and area harvested from 1996-2010. [7].

3. BIOMASS APPLICATION FOR POWER GENERATION

Biomass for energy is recognized among renewable energy as the most important energy resource and it has attracted high global policies [8-9]. Utilization of biomass for power generation depend upon some connected criteria such as land availability, feedstock availability and sustainability issues involving techno-economic factors, socio-political decisions and environmental drivers. Coal and other fossil fuel consumptions have accounted for prominent negative environmental consequences and application of biomass including other renewable sources like solar, hydro and wind power is fundamentally the main alternative phenomenon for cleaner environment in the circumstances of power generation. Hence, advantages of biomass for power generation are:

- Promotes socio-economic development of rural communities.
- It has unlimited potential.
- It promotes cleaner environment base on its carbon free tendency.
- Affordability of the energy resources.
- It has the ability to be used for electrical power co-generation process with conventional energy resources such as coal.
- It is a strategic means of waste management.

3.1 Biomass residue from corn cob to electricity generation

Biomass for electricity generation is best accomplished through distributed generation Technology. Large-scale commercial bio-energy application is quite rare due to low bulk density of the energy resources and their corresponding low energy contents. By distributed generation, power is generated and supply to consumers close to their neighborhood. In conventional power system structure where bulk power is produced, construction of bulk transmission network is considered inevitable. Other associated shortcomings of this traditional power system are huge financial expenses, difficulties in power loss management, maintenance of transmission line security and stability, and construction time. These few limitations and others not mentioned here are turns into advantages in the case of biomass for electricity generation through distributed generation. Figure-6 represents a general network of bio-energy conversion technologies to electricity by distributed generation. Gasification and combustion are the two prominent conversion technologies mainly used to generate electricity from dry bio-energy residues in rural areas of most developing countries.

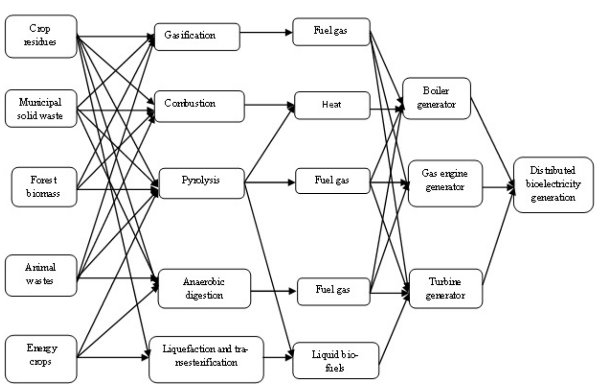

Figure-6. An integrated network of technologies for biomass exploitation for electricity.

Bio-power electricity engine generators are mostly selected based on factors like purchasing cost, electrical efficiency, technological robustness, reliability and possibly easiness to be maintained. It clear from the network presented that a class of feedstock can be converted to electricity through more than one conversion technology. However, considering the feedstock in this study (corn cob), it belongs to crop residues. Corn cob is used for electricity generation in countries like Thailand, Indonesia and China where they are either gasified or combusted for energy. Crop residues are generally treated as dry biomass and which are used for electricity generation purpose mainly through gasification and combustion. Other conversion technologies such as pyrolysis, anaerobic digestion and liquefaction have also been used for corn residues but not as extensively reported compare to that of gasification and combustion. The state of matter of the final energy carrier produce from any conversion technology determines the type of engine generator to be selected for use.

3.1.1 Gasification

The two principal categories of biomass feedstock are dry and wet type. Whereas biochemical treatment is preferred for wet biomass, dry biomass is process into energy by thermo-chemical conversion [10]. Gasification is a biomass thermo-chemical conversion process to obtain energy from solid matter in gaseous form [11] though under the condition of limited supply of oxygen. Gasification process usually begins with pyrolysis which is a thermal decomposition reaction in absence of oxygen. The fundamental similarity between gasification and pyrolysis is that both require heat for operation. Gasification requires oxygen or air to convert organic matter into combustible gas while translating calorific value of the energy feedstock to an energy carrier [12-14]. Effectiveness of gasification for power generation has been proved in both developed and developing countries [15]. A complete schematic set-up of electricity generation through gasification involves series of integrated stages [Figure-7].

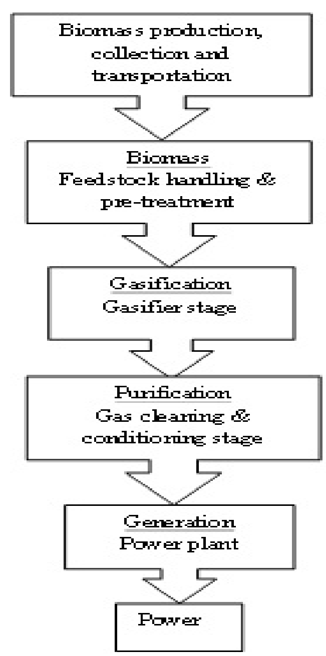

Figure-7. Block diagram of gasification of biomass for electric power generation.

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3.1.2 Combustion

Combustion is the most prominent biomass conversion technology in the world today. This process make use of air to breakdown biogenic material and release thermal gases which is used to run boilers for the production of superheated steam capable of driving turbine generator for electricity production. The most important advantage of this technology is that exhausted process steam generated in the can be utilized for other applications. This makes the bio-energy conversion technology suitable for the operation of combined heat and power (CHP) facilities [Figure-8] which is common in developed countries. Heat and power generation close to the consumers is considered as a strategic way for optimizing energy resource application. It is a technology that ensures the capturing of much of the heat generated for customers demand application while minimizing loss of heat to the environment. By this tradition, global environmental temperature is prevented from rising. Combined heat and power (CHP) is also known as cogeneration.

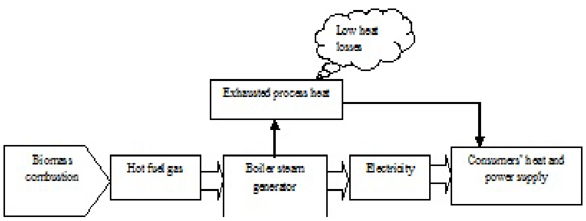

Figure-8. Block diagram of a combined heat and power through biomass combustion.

3.1.3 Engine generators for corn cob bioelectricity

Energy carrier (intermediate fuel) from either combustion or gasification process require an engine generator to produce electricity for the end users. Gasification of corn cob produce energy carrier known as 'producer gas' while combustion of the same residue produces thermal gases for steam generation. Selection of biomass conversion technology between gasifier and combustion systems can be based on efficiency of conversion. Conversion efficiency of the system tends to impact on the overall efficiency of the system.

Literature survey revealed that different values for both gasifiers and combustion systems efficiencies have been reported. Study conducted by [16] reported 35.4-40.3%, 28% [17], 16-30% [18] and 35% [19] for gasifiers. For combustion systems: 26% [17], 30% [20], 20-25% [21] and 19-26% [18]. Making engine choice for generator engine based on the efficiencies presented so far, gasifier has relatively better advantage. According to [22] 'gasifier engine generator' is more appropriate for small-scale electricity production. It was stated by [10] that treatment of dry biomass predominantly employed gasification-based power plant. In reality, heat lost in combustion process tend to reduce the efficiency of the system unless there is facility to make feasible the consumption of heat generated for constructive development as discussed earlier. Nigeria being a developing country where rural demand for heating applications is very limited to cooking and boiling of water. To this reason, gasifier should be given more preference to combustion system to avoid heat waste.

As for the generator engines which must be connected to the system to utilize the energy carrier produced for electricity, micro turbine engines (MTE), internal combustion engines (ICE), stirling engines (SE) and externally fired gas turbines (EFGT) can be used. In isolated areas especially rural communities where there is need for onsite generator, ICE is favorably disposed due to their high nominal electrical efficiency which lies between 30-40% [23-25]. In most cases, ICE is used for gasifiers [26-27], while limited number of gasifiers uses SE [26, 28] and MTE [26, 29]. Generator engine for onsite power generation can either be fabricated on induction or synchronous operation mode. By stringent analysis of performance and operation easiness, synchronous generators are most suitable for standby electricity supply. In biomass grid connected situation, synchronous generator is preferably the better option. This is due to the fact that induction generator operation requires reactive power which can easily be drawn from the grid system whereas in synchronous machine does not.

4. DERIVATION OF THE POTENTIAL OF POWER GENERATION EVALUATING FUNCTION FOR THE CORN RESIDUE

In previous research efforts, evaluation of energy potential of crop residues was easily carried out by simple multiplication of two variables (quantity of the residue and calorific value). However, the issue of diverted quantity of residues was not considered as a potential factor. If ith number of activities have direct effects on the availability of residue for power generation and c biomass residue is obtained from j crop, and the multiple linear equation (1) defines the relationship between all these parameter as:

$$P = a + D_1 t_1 + D_2 t_2 + D_3 t_3 + ... + D_n t_n \qquad (1)$$

Where $P_j =$ production quantity of a j crop, $a =$ intercept component of the linear function which represents the available crop production quantity for power generation purpose and depicts the value of p_j when $t_i = 0$ (time trend) and $D_i =$ coefficients (diverted quantity of the crop produced) which express linear relationship between P_j and t_i.

To obtain an equation connecting P and D such that the sum of the squared deviation of both variables can be minimized, then the equation becomes:

$$\min \sum \left(P = a + D_1 t_1 + D_2 t_2 + D_3 t_3 ... + D_n t_n \right) \qquad (2)$$

If ψ denotes the sum of squared deviation, then

$$\psi(a, D) = \sum \left[P - a - \left(D_1 t_1 + D_2 t_2 + D_3 t_3 + ... + D_n t_n \right) \right]^2 \qquad (3)$$

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If $\frac{\partial \psi}{\partial a} = 0$ for the minimum value,

Then it implies that

$$P - a - \left(D_1 t_1 + D_2 t_2 + D_3 t_3 + ... + D_n t_n\right) = 0$$

If $t_1 = t_2 = t_3 = t_n = 1$

Therefore,

$$a = P - \sum_{i=1}^{n} D_i \quad (4)$$

Then, available biomass residue for power generation can be evaluated as follows:

$$AV_{c,j} = \tau_c \; P_j \text{ - } \tau_c \left[D_1 + D_2 + D_3 + \cdots + D_n\right] \quad (5)$$

Where $a = AV_{c,j}$ = available c residue from j crop for power generation, $P = P_j$ is the j crop production quantity, τ_c denotes a conversion factor for c residue known as crop to residue ratio, $\tau_c \; P_j$ is the total quantity of residue produced from j crop and $\tau_c \sum_{i=1}^{n} D_i$ is the total quantity of residue lost or diverted for ith activities.

Available energy potential, $AE_P = CV_c \times AV_{c,j}$ (6)

$$AE_P = CV_c \left[\tau_c P_j - \tau_c \sum_{i=1}^{n} D_i\right] \quad (7)$$

Where CV_c is calorific value of c residue?

Annual average energy,

$$AAE_P = CV_c \left[\tau_c P_j - \tau_c \sum_{i=1}^{n} D_i\right] \times 1/24 \quad (8)$$

Nominal plant capacity,

$$NPC = CV_c \tau_c \left[P_j - \sum_{i=1}^{n} D_i\right] \times 1/8760 \quad (9)$$

For the sake of this work CV_c = 16.63MJkg^{-1} [5] for corn cob, = 0.3 [30] and it was assumed in the calculation that 30% [31] of the total crop production is either lost or diverted for other activities which is expressed as follows:

$$\sum_{i=1}^{n} D_i = 0.3 \, P_j \quad (10)$$

The 0.3 used here is called loss factor. The result of the estimated power generation potential is shown in Figure-9 and Table-2.

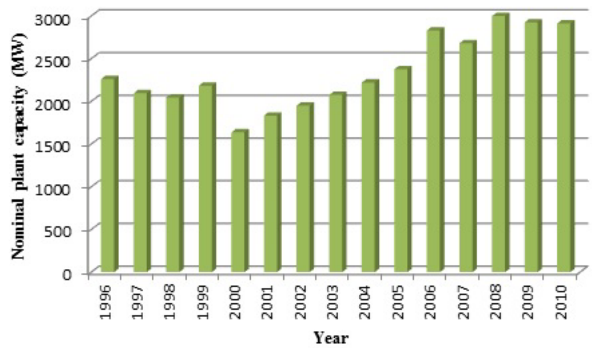

Figure-9. Estimated potential of power generation from 1996-2010.

Geographical factor due to the dispersed nature of rural settlements is one of the main reasons why biomass residues cannot be collected at 100% for energy use in any part of the world. This accounted for the basic rationale why bioelectricity power plants across the world have limited potential of less than 200MW. Biomass for electricity can only be applied for small power generation due to economic reason. To operate a biomass large-scale central power plant very large quantity of the resource will be needed to sustain the power plant. This also means that feedstock logistic planning will cost more. In a country like Nigeria where biomass feedstock cost nothing at present, the major disadvantage on continuous supply of bio-feedstock for power plant lies on the poor road network and inadequate transportation facilities in rural areas. Furthermore, implementation of bio-power project in rural Nigeria can also be influenced by socio-political decision of stakeholders in government, energy investment and rural communities.

Table-2. Annual corn production quantity, residue and estimated power.

Year	**Corn production quantity** (Million tonnes) [7]	**Corn cob residues by 70 % used** (Million tonnes)	**Nominal plant capacity** (MW)
1996	5, 667, 000	1, 190, 070	2, 259
1997	5, 254, 000	1, 103, 340	2, 094
1998	5, 127, 000	1, 076, 670	2, 043
1999	5, 476, 000	1, 149, 960	2, 183
2000	4, 107, 000	862, 470	1, 637
2001	4, 596, 000	965, 160	1, 832
2002	4, 890, 000	1, 026, 900	1, 949
2003	5, 203, 000	1, 092, 630	2, 074
2004	5, 567, 000	1, 169, 070	2, 219
2005	5, 957, 000	1, 250, 970	2, 374
2006	7, 100, 000	1, 491, 000	2, 830
2007	6, 724, 000	1, 412, 040	2, 680
2008	7, 525, 000	1, 580, 250	2, 999
2009	7, 338, 840	1, 541, 156	2, 925
2010	7, 305, 530	1, 534, 231	2,912

5. PROSPECT FOR IMPLEMENTATION OF CORN COB BIOELECTRICITY IN RURAL NIGERIA

This section deals with a proposed framework on bio-electricity prospect for implementation. It was accomplished through interview with some selected focus group in the country. The respondents selected are five each from bio-energy experts and renewable energy developers. Empirical result from the interview is summarized in a flowchart shown in Figure-10.

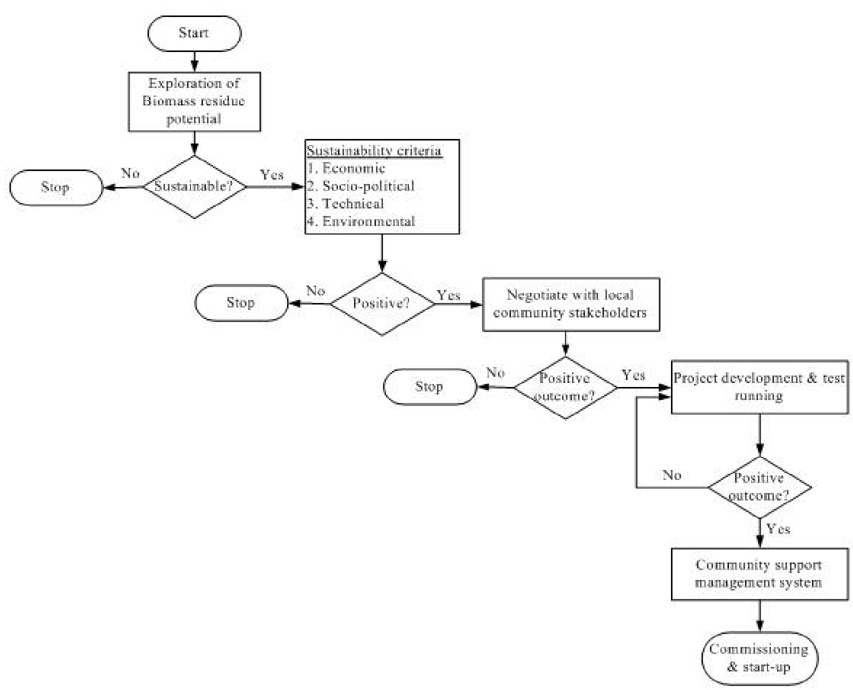

Figure-10. Bioelectricity project prospect for implementation flowchart.

Prospect for biomass power implementation project involve four principal cascaded stages of feedstock potential exploration, sustainability criteria assessment, consultation with local rural community stakeholders and project development.

The first approaching stage is the exploration of feedstock potential capability to technically ascertain the potential of electricity to be generated. This will help in the power plant sizing and contract billing. The second stage is the assessment of the sustainability criteria which is presented in Table-3. Consultation for possible negotiation is the third important stage. It is an inevitable success factor for bioelectricity project implementation. In rural areas, local community stakeholders are key actors that can influence effective feedstock flow from farm centres to power plant. They can also mobilize for the local management team after successful implementation of the project. Some locally existing rural policy may be such that hinder implementation of bioelectricity project but through negotiation, such policies can be amended.

The project developmental stage involves appropriate engineering project design to specifications, selection of the most suitable biomass conversion technology, and provision of adequate technical guide to the construction team. At this stage of implementation, competency of project personnel is paramount to ensure reliability and successful uptake of the final project. On the safer side, project developer may hire the service of expert consultant. At the point of project completion, then test-running of the power plant and further consultation of the host community is required for management team selection before commissioning and start-up.

Table-3. Bioelectricity implementation sustainability criteria.

Sustainability criteria	Focal point for consideration
Economic sustainability	▪ Transport and logistics management ▪ Market policies ▪ Money capital investment ▪ Procedures of financial approval from funding organization ▪ Cost of labour ▪ Contract prize ▪ Licensing ▪ Subsidy ▪ Taxation
Socio-political decision	▪ Local community interest ▪ Government support ▪ Stakeholders investment decisions ▪ Legislative enactment ▪ Government energy development policy
Technical factors	▪ Effective technology selection for better energy conversion efficiency ▪ Rural load demand survey ▪ Site location ▪ Size of power plant ▪ Overall engineering design and construction ▪ Operation schedule
Environmental issues	▪ Environmental impact assessment (EIA) ▪ Environmental regulation

6. DISCUSSION OF RESULTS

The national potential of corn cob for small power generation in Nigeria has been investigated and discussed in this study.

Corn production quantity in the country which is one of the greatest prerequisite for the residue availability was observed to be relatively varying from time to time. The variation is due to some collective factors like climate condition, farm inputs, area under cultivation and economic challenges. From the result presented in Figure-5 and Table-2, between 1996 and 2000, the area harvested for corn production decrease continuously from 4, 273, 400 hectares to 3, 159, 000 hectares. It however increased from 3, 283, 000 hectares in 2001 to 3, 944, 000 hectares in 2007 which corresponded to an estimated power potential of 1, 832MW and 2, 680MW respectively. The highest estimated power potential was observed in 2008 which is 2, 999MW but the harvested area was just 3, 845, 000 hectares. In 2010 also, 7, 305, 000 tonnes of corn was produced from a harvested area of 3, 335, 860 hectares of land compare to 1996 when harvested area was 4, 273, 400 hectares with production quantity of 5, 667, 000 tonnes. This analysis adjudges the fact that area of land under cultivation cannot solely determine the potential of the residue for power generation. Before year 2000, Nigeria was under military rule such that agricultural production was not accord better priority. Going by the trend of the potential power generation from the residue presented in Figure-9, it is clear that a steady increase was observed between 2000 and 2006. The political transition of 2007 resulted into a lot of economic challenges which affected many institutions especially the agricultural sector.

7. CONCLUSIONS

With a potential of over 2900MW of power estimated in 2010 which is about 29% of power demanded in the country, this shows that corn cob residue has good potential for electricity in Nigeria. There are many other biomass residues available in Nigeria that can be exploited for power generation purpose. The ability of government and stakeholders in energy sector to channel efforts towards utilization of these resources could help reduce the current epidemic rate in deforestation and energy crisis long experience in the country especially among rural communities. Illegal cutting of wood fire is persistently on the rise in the country due to widespread of energy shortage. In mean time, this hideous trend in deforestation will cause serious effects on the survival of the country's biodiversity. Conclusively, a pilot power project utilizing the residue can be initiated for demonstration in any of the rural community of the country where the residue is available under the supervision of Energy Commission of Nigeria (ECN) working side-by-side with Rural Electrification Agency of Nigeria (REAN).

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