World Journal of Innovative Research (WJIR)
ISSN: 2454-8236, Volume-8, Issue-3, March 2020 Pages 17-22

Renewable Energy: A Case for AFE Babalola University (Abuad)

OYELEKE AMINAT B.

***Abstract*— Over the years, most institutions and industries in Nigeria are connected to the electrical grid but due to the inconsistent power supply of electricity in the country, most of these communities meet their electricity demand through diesel generators and in rare cases, gas generators. The major purpose of this study is to propose the best hybrid technology combinations for electricity generation from a mix of renewable energy resources to satisfy the electrical needs of Afe Babalola University, Ado Ekiti, Ekiti state, Nigeria. The hybrid systems will be chosen to the requirements of approximately 15MWh/day with a peak load of 1.285MW. Two renewable resources namely, wind system, and solar photovoltaic systems and bio-diesel generators are considered. The software that will be employed for the analysis of generation mix is HOMER because it performs hundreds or thousands of hourly simulations over and over in order to design the optimum system. It offers a powerful user interface and accurate sizing with detailed analysis of the system. The analysis drawn from this is that, it is more cost effective, reliable and environmentally friendly to use the optimal hybrid option than the conventional method used by the school as the 10 biodiesel generators have a total capital cost of approximately $534,426 and cost of operation and maintenance is approximately $780,360 per year and BEDC charges the university approximately $497,679 per yea, therefore the university spends a total cost of about $32,075,619 for 25 years. On the other side, running a hybrid renewable energy generation including grid cost a total of about $8,000,000 for 25 years. That is the hybrid system is more viable than the current system of operation of the university with relatively reduced carbon dioxide.**

***Index Terms*— Nigeria, hybrid systems.**

I. Introduction

To maintain the life of the human community, and in order to facilitate the life, many important inventions were discovered. There is no doubt that the most important of these inventions is electricity, which we depend on in the current modern time. The people's social life almost stops in power outages. This is an indicator of how much electricity is important in our lives. Being a universal energy resource, electricity is obtained from methods such as solar power, hydropower, wind power, natural gas, fossil fuel and the likes. All devices which facilitate our life and impact a big portion of our life require electricity.

Moreover the importance of electricity in schools cannot be over emphasized as work is almost impossible especially in higher institutions. Slides on power point, equipment and machines in laboratories, computer laboratories, e-library, necessities in the hostels and other miscellaneous activities that require almost constant if not totally constant power supply all contribute to why regular power supply is necessary.

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves, and geothermal heat. They replace conventional fuels in four distinct areas: electricity generation, air and water heating/cooling, motor fuels, and rural (off-grid) energy services. Renewable energy are energy sources that are not exhaustible within human time scales. Many countries have initiated programs of development of Renewable Energy sources to enable them reduce their fossil fuel consumption and its attendant problems (Andreas Sofroniou, 2013). They have even gone far, not only in utilizing them but commercializing them. Some of these sources whose utilization may be feasible and practicable in institutions of higher including Afe Babalola University.

II. STATEMENT OF THE PROBLEM

Existing literature on renewable energy indicate that so much has been done in the area of sources of renewable energy for nations and state, methods of distribution and comparison of different sources of energy. Some of the studies include: Asiegbu and G. Iwuoha (2007), Barsoum, N.N., Vacent, P. (2007), Bekele, G. and B. Palm, (2010). Such existing studies have not paid adequate attention to renewable energy as it relates to institutions of learning. This study thus investigates renewable energy sources with particular reference to Afe Babalola University in order to determine the available sources of renewable sources to the University and how it can ease the electricity challenge of the institution.

III. AIM AND OBJECTIVE OF THE STUDY

The aim of this study is to determine the cost effectiveness of incorporating Renewable Energy Resources (RES) into ABUAD generation mix. The specific objectives are:

i. To carry out the analysis of the cost of electricity generation of ABUAD

ii. To access the viability and degree of the RES available in ABUAD

iii. Simulate the generation mix using HOMER software

iv. Evaluate the economic benefit of in the generation mix of ABUAD

IV. LITERATURE REVIEW

Hybrid wind/photovoltaic (PV) power generation systems have been studied extensively. Energy storage is needed in these systems due to the intermittent nature of wind and solar energy.

OYELEKE AMINAT B., graduate of Electrical Electronic and Computer Engineering with Afe Babalola University, Ado-Ekiti, Ekiti State, Nigeria

The hybrid systems considered in this analysis comprise of different combinations of PV modules/arrays supplemented by battery storage. Specifically, the merit of hybrid PV–battery system has been evaluated with regards to its size, operational requirements, cost, etc. National Renewable Energy Laboratory's (NREL) Hybrid Optimization Model for Electric Renewable (HOMER) software has been used to carry out the techno-economic feasibility (analysis and dimensioning) of hybrid power systems.

Solar energy which is gotten from the sun is a resource, a free gift from God, devoid from politics, abundant in nature, even in Nigeria which receives over 2000 sunshine hours per year. Photovoltaic (PV) Systems can be designed for a large category of applications and operational requirements, and can be used for either centralized or distributed power generation. PV systems have no moving parts and are prefabricated and easily expandable. Wind is defined as air mass in motion which is caused by pressure differences across the earth's surface due to the uneven heating of the earth by solar radiation and is another renewable energy resource with huge potential and a power supply option for remote areas in Nigeria. Batteries are usually incorporated into hybrid systems so as to maximize the available renewable resource as well as minimize the use of a generator in meeting load demand. Inverters generally supply loads up to their kilowatt rating, although all inverters have a surge rating for electrical peaks. This allows for motor starting, or other brief overloads. The output power (wattage) of an inverter indicates how much power the inverter can supply during standard operation.

Hybrid Systems

Hybrid systems are combinations of different power systems with different prime movers (conventional and renewable) that are uniquely interwoven, with each constituent system strengths complementing each another to efficiently meet load demand at relatively cheaper cost. Hybrid energy systems with or without renewables, are classified according to their configurations series, switched hybrid, or parallel hybrid.

Hybrid energy systems with or without renewables, are classified according to their configuration as series, switched hybrid, or parallel hybrid According to Wichert *et al*, a key feature of hybrid systems is the fact that their constituent system strengths complement one another. This provides a number of advantages, which are also determined in part by the system type: significantly greater reliability in power supply due to the use of two or more energy sources.

This study is aimed at bridging the knowledge gap in current literature. The design of a hybrid system is very much location specific which depends on the solar irradiation, diesel price and wind intensity. To make investment decisions by the policy makers and stockholders, it is necessary to conduct a comprehensive and independent study on hybrid renewable energy systems. The purpose of this study is to find the best combination of renewable energy systems from the available resources for a particular location in Nigeria.

V. METHODOLOGY

The energy sources are the PV system, Wind turbine system, diesel generators and the battery storage. The system controller is the brain of the hybrid system, it monitors and controls the entire operation of hybrid system ensuring balance in energy distribution to the battery storage system. The inverters convert the DC power from the batteries to AC to meet the load requirements. Since the output power of the PV module and the wind turbine is intermittent due to the climatic conditions and the necessity to provide the constant power supply to the load side, a group of battery banks is required as an energy storage system. The excess power generated by the PV module and the wind turbine is stored in the battery bank until full capacity of the storage system is reached. Once the power is deficit, the battery bank will discharge to supply the shortfall in load demand. The dump load was included for consuming the surplus power generated by the hybrid system.

Mathematical Model of the Wind Turbine

The recorded anemometer data at a reference height (hr.) should be adjusted to the desired hub center (h) using the wind power law. This can be done through the following expression: $(t)=vr(t)*\ (hhr)y$

where v(t) is the hourly wind speed at the desired height h, vr(t) is the hourly wind speed at the reference height hr. and γ is the power law exponent ranging from 1/7 to 1/4. The hourly wind speed was taken at a reference height of 15 meters, the desired tower height specification is 100m. The tower height of the wind turbine is an important factor which significantly influences the operating performance of the wind turbine. It can also be well over half the cost of the wind turbine system overall.

Mathematical Model of the PV Module

A Photovoltaic (PV) array is a device that produces DC electricity in direct proportion to the global solar radiation incident upon it. The power output of the PV array depends strongly on the amount of solar radiation striking the surface of the PV array and also on the PV cell temperature. The power output of the PV array at any given time is simulated by using the expression:

$PPV=PR*fpv(GGSTC)$

Where, PR is the rated capacity of the PV array, (i.e. its power output under standard test condition) fpv is the PV derating factor (%); G is the solar radiation incident on the PV array in the current time step (kW/m2); GSTC is the incident radiation at STC (1kW/m2).

Mathematical Model of Battery Bank System

The battery banks are connected in series to give the desired nominal DC operating voltage (Vbus) and are connected in parallel to yield a desired system storage capacity. Thus, the number of battery banks connected in series (NBAT,s) depends on the DC bus voltage (Vbus) and the nominal voltage of each individual battery (VBAT,nom). It is given by:

$Nbats = Vbus\ Nominal\ battery\ voltage$

The number of the battery banks for parallel connection (NBAT,p) which determines the capacity of the battery bank is the design variable of the system in this study.

Load Profile Assessment

The load profile may vary by the hour, day, week, month, season, or year. The peak demand spikes can be met from the batteries and the engine generator started and operated at a steady load when the battery state-of charge drops below a pre-set level. The most convenient method of determining the load profile of a system is by measuring electricity demand using an energy (kilowatt / kilowatt-hour) meter, and logging the output hourly, or more often, for at least a week, preferably a month or year (seasonal variations).

VI. DATA ANALYSIS

Solar resource assessment

The collected data of the solar was analyzed in order to plan for the structure of the hybrid system. The figure below shows the hourly solar irradiation over a period of time

ABUAD is endowed with high solar per day insolation of over 3500 Whr/$m2$/day, with the highest recorded average of hourly irradiance of over 900W/$m2$. The month of July, and August (the months associated with high rainfall) recorded the lowest solar insolation.

Wind resource assessment

A wind resource assessment involves measuring and analyzing the wind speed and other meteorological data at a site. This is necessary in order to estimate the annual energy production of proposed wind turbine installations, which will determine the economic feasibility of the project. The figure below shows the average wind speed of Nigeria for a period of 1 year.

Load profile assessment

From data analysis, ABUAD has an average peak load of about 0.8MW, at 5pm, and a recorded maximum load of 1.285MW during the month of May. The hybrid system to be analyzed is a 1MW solar system, and a 1MW wind system, with battery storage and 2*500KVA and 1*110KVA diesel generator as back up. The solar resource is more abundant in ABUAD than the wind. The average daily load demand of the university for 6 months is 15MWh/day (approx.). The generators will be used as backup or supplement in cases where the load demand is greater than what the hybrid system can handle or in cloudy seasons.

PV modules energy requirement

PV modules energy requirement is calculated by multiplying peak energy requirement in MWh/day times 1.3 (the energy lost in the system i.e. 10% loss due wiring and connection, 20% losses in the battery) to get the total MW h/day which must be provided by the panels. Based on the load sharing, the peak energy requirement =15MWh/day (approx.) PV modules energy requirement for the entire load was calculated as 18∗1.3=19.5MWh

Estimating the Energy Demand

Table 1: The estimated average daily energy demand for 6months (January-June 2019) in Mwh/day

January	February	march	**April**	**may**	**June**
13.8	13.7	15	15.5	15.8	14.8

The panel generating factor (PGF)

The peak watt (Wp) produced by the PV module depends on the size and climate of site hence the need to find PGF.

The PGF was determined by obtaining the lowest month kWh/$m2$/day value which was 5.5kwh/$m2$/day (approx.), Since the Wp (peak watt) of the panel is rated using a value of 1000 W/m2, hence Each Wp of the panel would therefore deliver 5.5 Wh/day if the conditions were perfect

The conditions are not perfect so we have to correct for the variations from standard conditions, Corrections include:

a) 15% for temperature above 25 C

b) 5% for losses due to sunlight not striking the panel straight on (caused by glass having increasing reflectance at lower angles of incidence)

c) 5% allowance for dirt

d) 10% allowance for the panel being below specification and for ageing

Total power = 0.85 *0 .95 *0.95*0 .90 = 0.69 of the original Wp rating.

The PGF was calculated to be >> 5.5wh/m3 *0.69 =3.8wh/Wp/day

The total watt-peak rating needed by the PV module was calculated by >>

(Wh/dayTOTAL)/PGF

(19.5*106)/3.8 =5.1MW panel

The number of 300W panel required to generate 6.2MW >>

(5.1*106)/300 =17,105.3

17,105 panels will be required.

Sizing the battery

A 4500Ah, 48 v lithium-ion battery was used in this analysis because lithium-ion batteries typically have better lifetime cycling properties, potentially reducing the number of battery replacements over a system lifetime. Batteries with capital cost of $950 for each and the cost of O&M is $80/yr, were used in this analysis, the batteries are connected in series to give the desired dc bus voltage (Vbus) which should match with the inverter for efficiency,

Vbus = 600V,

Nominal battery voltage = 48 V

Number of batteries in series is given by:

Bs = $VbusNominal\ battery\ voltage$

BS = 600/48 = 12.5 i.e. 13 batteries in series

The parallel connection of the batteries provide the Ah/day needed by the load which will determine the battery capacity that has to be available each day and is calculated as>> Bp = $LOADVbus$

(14.8MWh/day)/600V =0.025MAh/day

Factoring in

a. Battery loss =15%

b. Depth of discharge for battery= 40%

c. Bus voltage (Vbus) = 600V

The battery capacity (Ah) = $total\ Watt\ hour\ per\ day*days\ of\ autonomy 0.85*0.6*Vbus$ (3.17)

{14.8*106 * 1}/ {0.85*0.6*600} =0.048MAh.

Hence the number of batteries in parallel can be given as 0.048MAh/4500 = 10.6 i.e. 11 batteries in parallel

The total number of batteries = BS * BP = 13*11= 143 Batteries.

In this analysis, the cost of purchasing generators is neglected based on the assumption that the university already has working generators which will serve as back to the pv/wind hybrid system with battery storage. NREL estimated the cost of batteries to be $300/KWh for lithium ion and $255/kwh for lead acid. This cost assumes that installation and permitting are included.

Note: the balance of system (BOS) for the battery storage system was omitted from the battery cost because it was assumed that the cost is covered by that of the PV and Wind system.

Sizing the inverter

Size of the inverter used in PV power plant depends on the maximum power (peak watts) requirement. The inverter must be large enough to handle the maximum power (peak watt) of the university at any time. The inverter size should be 25–30% bigger than the maximum power (peak watt) required by the university at any time. The peak watt power at ABUAD university was found to be 1.5Mw, hence inverter size = 1.5 x 1.3 = 1.95MW

The PV module circuit

Maximum open circuit voltage =750 Vdc

Open circuit voltage (VOC) of each PV module at NOTC = 41.3 Vdc

Number of modules to be connected in series at 750v = 750/41.3 = 19 modules (Approx.)

Maximum power voltage (Vmp) of each PV module at NOTC =33.3 Vdc

Maximum power voltage (Vmp) at inverter input = 19 x 33.3 =632.7Vdc

Total number of PV arrays to be used for producing 632.7 Vdc = 20667/19 =1088 arrays

The inverter used cost $150 each with the cost of O&M given as $5/yr.

Sizing the wind turbine

A Fuhrlander 100 (FL100) with rated power 100kW AC was used for the analysis costing $100,000 each with a cost of O&M given as $800/yr. The desired daily load is 1MWh, factoring losses in the system, 1 x 1.2 = 1.2MWh/day. The average energy (Wh) per day for 6 months was calculated to be 113.58KWh at a tower height 0f 100m. The number of turbines to meet this load can be calculated as (1.2x 103 KWh)/ (113.58KWh) = approximately 10 wind turbines.

The three major component cost categories are:

i. Wind turbine (e.g., wind turbine components),

ii. Balance of system (e.g., development, electrical infrastructure, assembly, and installation),

iii. Financial costs (e.g., insurance and construction financing) (NREL)

The Cost of Electric Power Network in ABUAD

ABUAD uses two sources of electric power which includes the off- grid and the diesel generators. The off grid produces electricity to the university for approximately 10 hours a day and the generators serve as back up.

Bio- diesel generators

ABUAD has ten (10) diesel generators with an installed capacity of 4915KVA, sourced from two different manufacturers: Caterpillar (1), Perkins (2). When power supply from the public utility fails, the first generator will have to run to produce power. The capital and installation costs of these generators was put as $600,000. The generators have an average lifespan of 35,000 hours and they operate everyday throughout the year (i.e. approx. 7000 hours). Hence, they are replaced every 5 years. The cost of replacement is assumed to be equal to the cost of purchase. Studies show that the total fuel consumed by these generators annually is approximately 2,000,000 liters hence the annual cost of these consumption at diesel cost of $0.72/ltr (N220/ltr) is $9,440,000. The cost of maintenance of these 10 generators is $625,308.

BEDC (Benin Electricity Distribution Company)

BEDC supplies the off- grid electricity to ABUAD charging about $0.1129/kW (N34.42/kW), maximum capacity storage is set at 5% (by HOMER). Since BEDC power supply per day on average is 10 hours, Monthly tariff = (average daily power consumed in KVA)*30 days*cost ($/kW)* 0.7

Where 0.7 is the campus supply factor (supply from national grid)

Monthly tariff = (17708337.5* 30* 0.1129* 0.7) = $42,000

Therefore ABUAD spends approximately $511,475 yearly. The total cost charged by BEDC for 25 years will be $12,786,875.

Technical Specifications

Solar panels

Table 2: TSM-300PA 14 300W panel specification

Electrical data	**(STC)**
Peak Power Watts-*Pmax* (Wp)	300
Power Output Tolerance-Pmax(%)	0/+3
Maximum Power Voltage-Vmp (V)	36.9
Maximum Power Current-Impp (A)	8.13
Open Circuit Voltage-Voc (V)	45.3
Short Circuit current-Isc (A)	8.6
Module Efficiency ή(%)	15.5

Inverter

Table 3: 1MW ABB pvs800-is inverter station

Input (DC)	
Maximum input power	2 x 1200kw
DC voltage range, mpp	600v-850v
Maximum DC current	2 x 1710A
Number of mpp trackers	2
Output (AC)	
Nominal AC output power	2 x 1000kw
Power at cos ϕ = 0.95	2 x 950kw
Maximum AC output power	2 x 1200
Nominal AC current	2 x 1445 A
Nominal output voltage	400V
Output frequency	50/60 Hz
Power factor compensation	Yes

Wind turbine

Table 4: The 60Kw Aeolos wind turbine specification

Rated power	100kw
Max power	65kw
Start wind speed	2.5m/s
Rated Wind speed	9m/s
Survival wind speed	59.5m/s
Rotor diameter	22.3m
Swept area	390.4$m2$
Efficiency	90%

VII. RESULT AND DISCUSSION

The analysis for this study was done for both the hybrid system and the already existing system so as to be able to compare the results. The longitude and latitude of ABUAD was included into the HOMER software that downloaded the solar and wind resources.

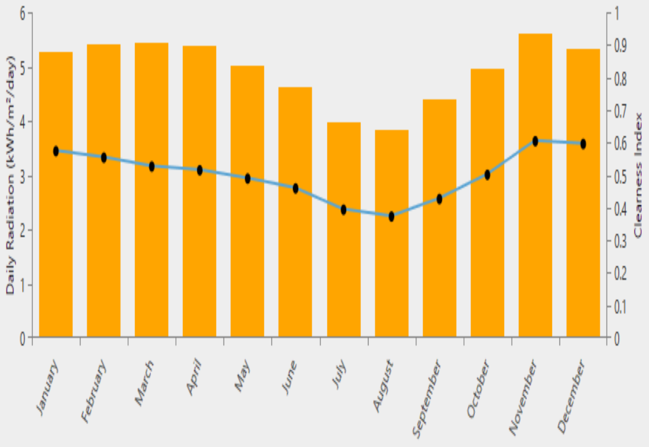
Figure 1: Solar Resource at ABUAD (NASA meteorology database)

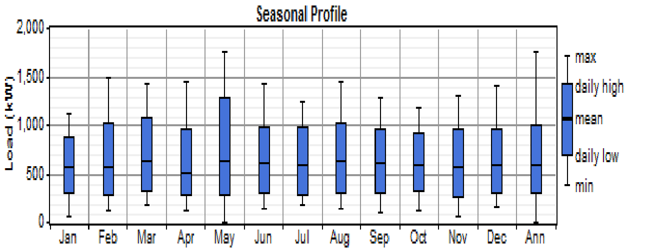

Figure 2: Yearly Load Profile of ABUAD (Works Department ABUAD)

It can be deduced from both the fig 4.2 above that in as much as the hybrid (that is wind and PV system) have relatively expensive total initial cost of $3,352,000, the operation and maintenance cost of the wind and PV is much reduced by about $10,000,000 than the generators in this hybrid system. However, the total cost of the hybrid system for the period of 25 years is $17,796,018. And Fig 4.4 below shows the flow of cash of each of the hybrid system's components over the course of 25 years.

It can be deduced that in as much as the hybrid (that is wind and PV system) have relatively expensive total initial cost of $3,352,000, the operation and maintenance cost of the wind and PV is much reduced by about $10,000,000 than the generators in this hybrid system. However, the total cost of the hybrid system for the period of 25 years is $17,796,018. The average electricity produced by each components per month shows the contribution of each components to the production of electricity to the school for each month in a year and the percentage of each of this component.

The System Adopted by the School

HOMER was also used here to generate a load sharing system for the generators currently used by the university.

The cash summary of the generators in ABUAD show that the cost of operation and maintenance of the generators were high all year round.

The total cost of the system for a period of 25 years= total cost of generating system + total cost of off-grid system = $19,288,744 + $12,786,875 = $32,075,619

Economic Assessment Results

The cost saved by operating on hybrid system is approximately $14,279,601 within a quick payback period of 4 years, a positive NPV of $17.4 million and a 31% return on investment. The reason for the large gap in operation cost between the hybrid system and the generators is mainly the high cost of fuel that accompanies long operational hours of the ABUAD generator system.

Load Profile

The month of May have the highest energy requirement of over 15Mwh. The highest recorded load was 1.285MW in the month of May. The hours of 9pm-6am have the peak load less than 0.6MW which rises gradually towards the afternoon. The hours of 7pm-11pm have the highest average peak load ranging from 0.6MW-0.8MW.

Wind Resource

The university has an average wind speed of about 3m/s occurring most frequently from the SW-SSW direction i.e. from the Atlantic ocean, with the highest recorded wind speed of 9m/s. using high rated turbines does not necessarily mean more power generated as they usually have high cut in speed as well as high rated speed, (designed from high wind speeds) hence at wind speed below the turbine cut in speed no power will be generated and the turbines will only attain its rated power at the rated wind speed.

Solar Resource

ABUAD has an average of 10 hours of sunshine and high solar irradiation of over 1000W/$m2$. Its high probability of occurrence, coupled with its abundance is the reason why it was sized to supply minimum of 27% of the load requirement. The number of solar panels required to meet the average load requirement was found to be 17,105 x 300W panels. The SIEC was estimated to be $2,363,505.

Battery Storage System

The battery storage system consists of about 2.6% of the total capital cost of the renewable part of the hybrid system. It is the system that stores the excess energy from the renewables for further use. The SIEC was estimated to be $449,267. It is the only portion of the renewable system that is most frequently replaced.

Hybrid System

The hybrid system consisting of the PV system, the Wind power system, the Battery storage system and all balance of system to function together efficiently. The SIEC was estimated to be $3.71 million with a levelised cost (COE) of about $0.263kWh. The total pollutant quantity for the hybrid system is 1473600kg/yr less than the current system.

VIII. Conclusion

This study compared the cost of running the PV/wind/biogas generator hybrid system to the ABUAD generator system on ground over a period of 25years. Based on this assessment it can be concluded that the hybrid system project is a viable one with cost saving potential. Also the amount of pollutant emitted in the hybrid ystem is relatively lower than the currently adopted system making the hybrid system relatively more environmentally friendly.

References

[1] G ABB.com, "ABB inverter station PVS800-IS 1.75 to 2 MW," 2014. [Online]. Available: www.ABB.com/solar inverters. [Accessed december 2016].

[2] Accounting Explained. (2013). (Accounting Explained.com) Retrieved december 25, 2016, from accounting explained.com/managerial/capital-budgeting/irr

[3] Asiegbu and G. Iwuoha, "Studies of wind resources in Umudike, South East Nigeria – An assessment of economic viability," Journal of Engineering and Applied sciences2, pp. 1539-1541, 2007

[4] Barsoum, N.N., Vacent, P. (2007) 'Balancing cost, operation and performance in integrated hydrogen hybrid energy system', in

Proceedings of the first Asia International Conference on modelling and simulation (AMS'07), IEEE.
[5] Bekele, G. and B. Palm, 2010, Feasibility study for a sustainable solar-wind-based hybrid energy system for application in Ethiopia, Applied Energy, 87(2), pp. 487-495.
[6] Benjamin O. Agajelu; Onyeka G. Ekwueme; Nnaemeka S. P. Obuka and Gracefield O.R. Ikwu. (2013). Life Cycle Cost Analysis of a Diesel/Photovoltaic Hybrid Power Generating System . Industrial Engineering Letters, III(1), 19-30.
[7] Bhattacharyya, SC, 2012, Energy access programmes and sustainable development: a critical review and analysis, Energy for Sustainable Development, 16(3): 260-71.
[8] Borowy, B., & Salameh, Z. (1996). Methodology for optimally sizing the combination of a battery bank and PV array in a wind/PV hybrid system. IEEE Trans Energy Convers (11), 367–375 .
[9] Borowy and Z. Salameh, "Methodology for optimally sizing the combination of a battery bank and PV array in a wind/PV hybrid system," IEEE Trans Energy Convers , no. 11, p. 367–375 , 1996.
[10] Carpentiero, V., Langella, R., Manco, T., & Testa, A. (2008). A Markovian approach to size a hybrid wind-diesel stand alone system. 10th international conference on probabilistic methods applied to power systems PMAPS'08, (pp. 1-8).
[11] Christopher, M., Tyler, S., Ben, M., & Edward, S. (2015). 2014 Cost of Wind Energy Review. National Renewable Energy Laboratory (NREL).
[12] D.M. Eggleston and R.S. Stoddard. (1987). Wind Turbine Engineering Design. New York.
[13] Department of Works Afe Babalola University, Ado Ekiti.
[14] Deshmukh, M.K., Deshmukh, S.S. (2008) 'Modelling of hybrid renewable energy systems', Renewable and Sustainable Energy Reviews 12, pp. 235–249.
[15] Giatrakos et al. (2009) 'Sustainable energy planning based on a stand-alone hybrid renewable energy/hydrogen power system: Application in Karpathos Island, Greece', Renewable Energy 34, pp. 2562–2570.Herb Wade. (2008). Solar PV Design Implementation O& M. Marshall Islands: e8.
[16] Givler, T., Lilienthal, P., (2005) 'Using HOMER® Software, NREL's Micro power Optimization Model, To Explore the Role of Gen-sets in Small Solar Power Systems Case Study: Sri Lanka', Technical Report NREL/TP-710-36774, available from http://www.osti.gov/bridge.
[17] Hafez, O. and K Bhattacharya, 2012, Optimal planning and design of a renewable energy based supply system for microgrids, Renewable Energy, 45:7-15.
[18] Himri, Y., AB Stambouli, B. Draoui and S. Himri, 2008, Techno-economical study of hybrid power system for a remote village in Algeria, Energy, 33(7), 1128-36.

Personal Profile
Oyeleke, Aminat Busayo
Aminat Busayo Oyeleye is a graduate of Electrical Electronic and Computer Engineering with Afe Babalola University, Ado-Ekiti, Ekiti State, Nigeria. She is well-groomed and enthused about excellence and professionalism. She is vast and experienced in the oil and gas upstream industry and is concern with energy and all that is associated with it. She is passionate about the production of effective, sustainable and optimizable means of power generation. Hence, her motivated to research on a prominent problem faced by most institutions in the country in terms of power supply and generation.
Memberships:
- Member, Institute of Electrical and Electronics Engineering (IEEE)
- Int. Associate of Engineers (IAENG)
- Graduate Member, Nigerian Society of Engineers (NSE)
- Graduate Member, Society of Petroleum Engineers (SPE)