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Environmentally Friendly Energy Sources for Sustainable Electricity Generation in Schools

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ABSTRACT

Ensuring a sustainable future necessitates the development of environmentally favorable projects. A safe environment not only supports various energy sources but also lays the groundwork for sustainable plans for future generations. This paper explores the feasibility of utilizing renewable energy sources (RES) within educational institutions, specifically Community High School Akwaeze, to generate electricity. Solar energy, harnessed through photovoltaic (PV) modules installed on the rooftops of 2-storey and 1-storey school buildings, has the potential to generate 27KW and 9KW of electricity, respectively. Biomass derived from human waste in the school hostels can be utilized for biogas production, capable of generating 234KWh of electricity. By leveraging these two energy resources, the school can meet its daily electricity demand of 10.21KW and even produce excess power for sale to nearby businesses, offices, and homes, thereby establishing a sustainability fund. However, the installation of such energy systems requires significant capital investment, potentially necessitating support from government entities, as well as alumni associations, for projects realization.

Keywords: Renewable energy sources, Solar PV (Photo Voltaic), biomass, biogas, electricity generation.

INTRODUCTION

Implementation of Distributed Generation (DG) for providing electricity to its consumers within a locality is key to sustainable energy. The technology of DG is important in getting electricity to every part of the world. It is important to generate electricity for use. Every building, offices, homes, facilities, communities that desire electricity should use available energy sources within its environment to generate electricity for use. Education institutions such as secondary schools, universities with large land mass use for agricultural purposes should think of getting biogas from available agricultural waste from the farmland, bushes, etc to generate electricity. Also, human and animal waste should be use to generate biogas which in turn generates electricity for its use. In similar manner, available roof-tops of buildings within the school facility should be covered with solar panels for electricity generation. Towns and communities close to river, stream, lake, ocean should consider small hydro plant installation for electricity generation. Those communities with ocean waves should work towards utilizing tide energywhich is domicile to their environment to generate electricity. Environment is the immediate surrounding of a place, community, town, state, country and continent. Environment influence the people way of life and interest. Education institution environment simulate people towards the act of teaching and learning thereby creating environment of young people poised with mentoring and training purposes. Utilizing available environmental potentials caused the Rural Electrification Agency (REA) in setting up a 2MW solar/diesel generation DG system making use of available land mass for solar system installation (Nworabude *et al*, 2023). This study presents a case study of an educational institution – Community High School (CHS) Akwaeze Anaocha Local Government Area

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of Anambra State Nigeria. The school immediate environment has many buildings that can accommodate PV modules capable of generate the entire electricity required for the school daily operation. Also available agricultural waste such as weeds, harvested plants, etc as well as human and animal wastes can be used to produce biogas which in turn used to generaterequired electricity for the school.Electricity generated from these energy sources can be used to power electronic gadgets in the school thereby enhancing learning and promoting learning environment. Enhanced learning gadget such as language recognition system used for communications by deaf and hard-of-hearing individuals (Alumona *et al*, 2023).

LITERATURE REVIEW

Lots of literature have been written for the sake of renewable energy system set up from available RES within a locality with the technology of Distributed Generation (DG) and Mini grid utilised I most cases. Countries, states, towns and communities are required to sponsor electricity generation projects to cover up lack of access to electricity suffered in Africa especially in Nigeria. Renewable energy sources such as solar, biomass, hydro, wind, tides are available at different proportions at different locations. Solar energy can be converted and utilized in many useful ways but the most popular are; solar heat and solar PV (Khamisani, 2020). Biomass undergoes some conversion processes into different forms (thermal, liquid, solid or gaseous) of energy, Biomass technologies includes direct combustion, co-firing, gasification, pyrolysis, anaerobic digestion and fermentation (Ghosh et al, 2018). Nworabude (2023) designed a solar PV/biogas system to supplement available grid/diesel generator system at University of Port Harcourt Choba campus. The system design makes use of human waste from students at the hostel to produce biogas that generates electricity. Building on this idea, this paper tendsto replicate such technology for CHS Akwaeze in need of steady power supply devoid of noise pollution to its environment.

METHODS AND PROCEDURES

This paper presents break down of energy sources to be harnessed for electricity generation within the study area – Akwaeze hosting Community High School (CHS) Akwaeze. In presenting energy resources available, the amount of electricity to be generated from these resources is calculated then compared with required amount of electricity in the institution.It is our desire to provide sustainable electricity generation solution for schools such as CHS Akwaeze. This will enable school independent electricity generating systems rather than depending on utility companies to provide electricity with undesired intermittency.

Estimating the available quantity of electricity from energy sources within the Community High School Akwaeze environment, these steps are carefully considered;

1. Itemize energy sources (mostly renewables) available within the environment of study

2. Estimate available energy capacity for power generation implementation

a. Estimate the quantity of solar PV modules to cover the building rooftop areas.

b. Estimate the quantity of biogas available for electricity generation

3. Calculate total electricity consumption of the school

List of Energy Sources Available within the Environment

1. Solar energy sources: Energy from the sun have been available worldwide though it has more potentials in Africa, Nigeria and in Anambra State. Tapping available solar energy require installations of solar PV systems.

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2. Biomass sources: Energy from biomass such as agricultural waste products, human and animal waste.

Estimating available energy capacity for power generation implementation

- **Solar PV modules**

These are to be installed on rooftops of buildings at the institution. The school CHS Akwaeze has two 2-storey and two 1-storey buildings whose roof-tops can be used to place the solar PV modules for electricity generation. The estimation follows thus;

Each 2-storey roof-tops has estimated area of about 25m x 10m = 250m^2.

A 450W solar PV module area is 1.9 x 1.06 = 2.08m^2(Felicitysolar, 2024).

The number of solar PV modules in each 2-storey roof-tops = 250/2.08=120modules

The available capacity for each 2-storey roof-top = 100 x 450W = 45,000W = 45KW. Realizable electricity generation capacity = 45KW x 0.6 = 27KW

Each 1-storey roof-tops estimated area = 10m x 5m = 50m^2.

A 450W solar PV module area is 1.9 x 1.06 = 2.08m^2(Felicitysolar, 2024).

The number of solar PV module in each 1-storey roof-tops = 50/2.08 = 24 modules.

The available capacity for each 1-storey roof-top = 20 x 450W = 9,000W = 9KW. Realizable electricity generation capacity = 9KW x 0.6 = 5.4 KW

- **Biogas generation**

The amount of waste excreted per day for an individual is 135-270 g (Barbosa, 2012). We set waste of human (student) waste per day to be 135g.

The total weight of waste (T_W) produced daily by 100 students = 100 × 135 = 13,500g or 13.5kg. For a month, T_{Wmonth} = 13.5 × 30 = 405kg.

Wet waste is composed of 65% water content and 35% solid content (Banks, 2009). The percentage of solid from human waste (sewage) will be 35% of the total monthly waste. It becomes 405 × 0.35 = 141.75 kg of solid content.

Using the Buswell equation to estimate the products from the anaerobic breakdown, the waste chemical composition is given by Banks (2009) as: Carbon – C – 450, Hydrogen – H – 2050, Oxygen – O – 950, Nitrogen – N – 12, Sulphur – S – 1

Also, from the periodic table, C – 12, H – 1, O – 16, N – 14, S – 32

Total co2 × 1) = 5400 + 2050 + 15200 + 168 + 32 = 22850 g mposition will become = (450 × 12) + (2050 × 1) + (950 × 16) + (12 × 14) + (3

Then the percentage of carbon P_{carbon} = 5400/22850 = 24%

Carbon present in 141.75 kg of solid waste will be = 141.75 × 0.24

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P_{carbon} = 34.02 kg of Carbon

The percentage of carbon present in a month

$T_{c\text{-}p} = T_{carbon}/T_{wmonth}$ = 34.02/300 × 100 = 11.3%

Percentage of biodegradable Carbon content (C_{bg}) in human waste is assumed to be 70% from Buswell equation (Banks, 2009)

Amount converted from Carbon to biogas $T_{c\text{-}b} = T_{carbon} \times C_{bg} = 34.02 \times 0.7 = 23.8kg$

Weight of methane-carbon present in the biogas: $W_{m\text{-}carbon} = T_{c\text{-}b} \times M_P$

Where M_P = Buswell methane percentage = 53% (Banks, 2009)

$W_{m\text{-}carbon}$ = 23.8 × 0.53 = 12.6 kg

Weight of methane present in methane-carbon

$W_m = W_{m\text{-}carbon} \times 16/12$

= 12.6 × 1.33 = 16.77kg of CH_4 (methane)

Energy value of Methane generated will be:

For 16g of CH_4 = 22.4 litres = 1 mole of gas at s.t.p

$$\therefore 16770g\ of\ CH_4 = \frac{16770}{16} = 1048.125\ moles\ of\ CH_4$$

In litres, 16770g of CH_4 = 1048.125 × 22.4 = 23478 litres

But 1000 litres = 1 m^3, 23478 litres = 23.478 m^3 CH_4

Also, 1m^3 of CH_4 is equivalent to generate 10 kWh (Banks, 2009)

23.478 m^3 will generate 23.478 × 10 = 234 kWh

For a 20 kW generator, the duration of operation will be 234/20 = 11.7 h

This work presented a realizable power generation road map for CHS Akwaeze. Taking note of these renewable energy sources, the required electricity load consumption capacity needed for school operation should be noted to ensure the estimated electricity generated will be enough to supply the load demand.

Table 1: Electricity consumption chart of CHS Akwaeze

S/N	Buildings/Offices	Equipment	Power (W)	Total (W)	Hours (h)	Energy (Wh)
1	Principal	TV 1	100	100	5	500
		Decoder 1	10	10	5	50
		Fan 1	100	100	5	500
		Refrigerator 1	350	350	5	1750

2	Manager	TV 1	100	100	5	500
		Decoder 1	10	10	5	50
		Fan 1	100	100	5	500
		Refrigerator 1	350	350	5	1750
3	Classrooms	Fans 17	100	1700	6	10200
		Lights 17	10	170	1	170
4	Science Laboratories	Fans 6	100	600	3	1800
		Lights 10	10	100	5	500
5	Library	Fans 6	100	600	5	3000
		Lights 10	10	100	5	500
		Computer 1	250	250	5	1250
6	Computer Laboratory	Fans 5	100	500	5	2500
		Lights 6	10	60	5	300
		Computers 15	250	3750	5	18750
7	Male Hostel	Fans 2	100	200	5	1000
		Lights 10	10	100	5	500
8	Female Hostel	Fans 2	100	200	5	1000
		Lights 10	10	10	5	500
9	Staff room	Fans 6	100	600	5	3000
		Lights 6	10	60	5	300
	Total			**10210**		**50870**

The total power required is 10.21 KW and total energy of 50.87 KWh.

However, the amount of power required during the day and at night will not be same. Throughout the day, variations in power consumption within the hostels are expected, diverging from the quantities outlined in the provided table. Conversely, consumption patterns within other buildings/offices may remain relatively consistent. During nighttime hours, the consumption levels in most buildings will decrease substantially, with only security lightning and hostel usage persisting. It is noteworthy that the school hall’s energy demands have not been factored into the analysis. However, it is imperative to consider that during events or gatherings necessitating the use of the school hall, electricity demand may increase. Additionally, most classrooms and staff rooms may not require electricity during these periods.

RESULTS AND DISCUSSION

From mathematical calculations implored at the method and procedure section, it clearly showed that electricity generated is more than the school required quantity of power. Presenting the result in a graph, figure 1 showed that power generated from solar and biomass systems are 27KW and 20KW respectively while power demand of the school is at 10.21KW. The power generated from both energy systems is about double the required power, this implies that school may sell off the excess power to nearby businesses, offices or homes to make money for its maintenance and sustainability. During the day, when the sun generates excess power from the solar system, nearby consumers will be supplied and metered to pay for the supplied power. However, during the evening and night hours when the sun is off,battery system installed along with the solar system should sustain electricity needsat the hostels and forsecurity lightnings. An installation of both energy systems of solar and biomass, solar system serves daytime electricity need while biomass system serves nighttime electricity need.

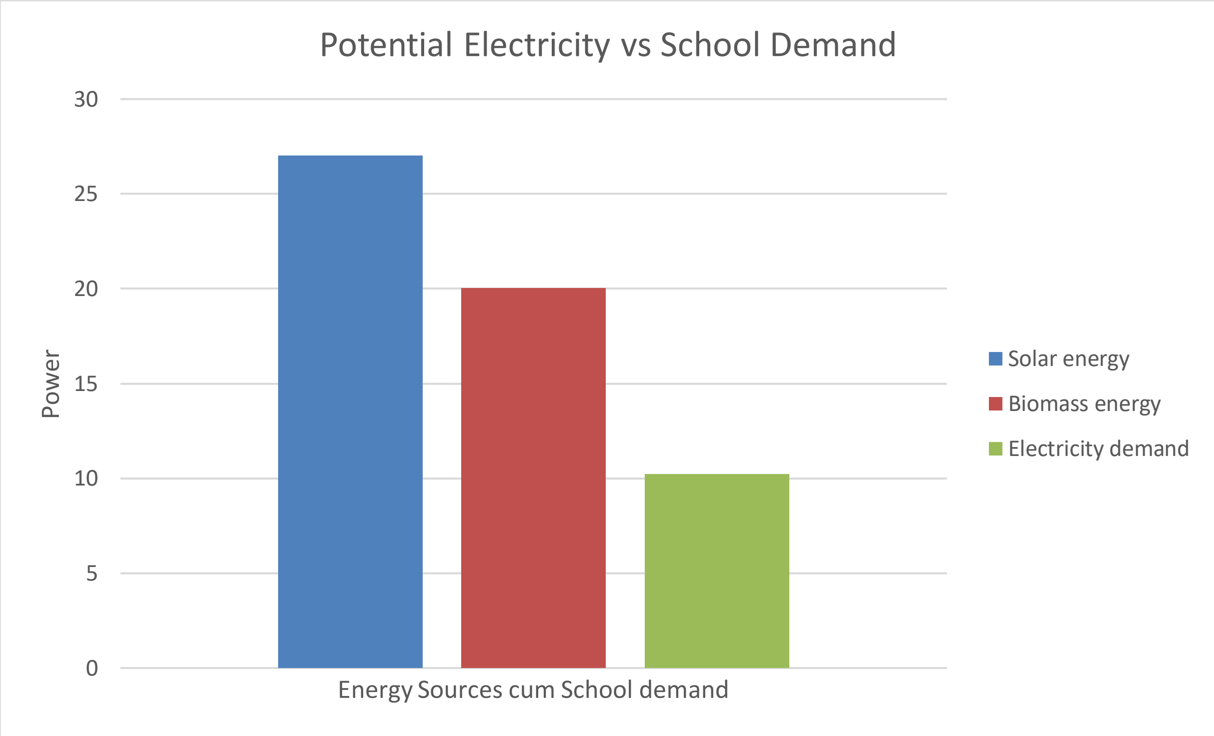

Figure 1: Potential electricity generation vs School electricity demand

CONCLUSION

Having presented a desired road map of a sustainable environmentally friendly electricity generation process for Community High School Akwaeze, implementing such monumental and huge fund demanding project is key towards bringing the institution to a world class academic standard. The knowledge shared in this paper can be replicated to other schools by way of utilizing environmental dependent energy sources within their locality to provide the required electricity for use. The school management board can reach out to school old boys and girls association for possible implementation process initiation. Government should reach out its educational institutions for implementation of electricity generation plan across the schools while investing and re-investing in similar sustainable electricity generationprojects. Recommendations for future work necessitate utilizing biodegradable biomass resources such as plants, weeds and non-biodegradables such as nylon bags, plastic container, paper, water proof materials investigated for use in biogas production for electricity generation.

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