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Solar Energy as A Sustainable Alternative Towards Low Carbon Development In Modibbo Adama University Yola

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ABSTRACT

The Stockholm Declaration of 1972 specifically focused on improving the human environment for present and future generations leading to the movement of sustainability in higher education. In recent times, Initiatives to encourage sustainability as a panacea for climate change are being developed through carbon dioxide (CO2) emission reduction by National Governments and University authorities. Research globally led to innovations to promote low-carbon development in universities with varying best practices. This study aims to assess carbon emissions from annual electric energy consumption to reduce the University's contribution to global warming. The paper presents a case study of energy consumption at Modibbo Adama University (MAU) and analyzes the extent, sources, and quantities of emissions from electricity use towards reducing universities' contribution to global warming. Using annual data of electricity from metered sources to determine the extent of carbon emission, the study showed an average annual electricity consumption of about 1703632 (kWh), estimated to be about 747894.45 kgCO2 (748MtCO2) of carbon emissions. By introducing solar energy sources through PV installations in selected service sectors, a study reveals a 71% reduction in carbon emissions in the Academic Areas. In comparison, the replacement of electricity with solar energy in Students' Hostels and Commercial Centers shows a 15% and 9% reduction in carbon emission respectively and about 5% carbon emission reduction in the Staff Quarters. Finally, integrating fossil-fuel-powered energy sources with renewable/solar energy and promoting training, intensifying research development in solar energy technology as well as granting sufficient financial incentives to encourage local producers of solar energy systems would stimulate low-carbon development in the university.

INTRODUCTION

Most people are concerned about how much carbon the earth produces and how that affects the atmosphere these days. Continuous emission of carbon dioxide due to an increase in fossil fuels energy consumption is threatening the global system and causing an imbalance in the natural cycle (IPCC, 2007). Governments worldwide have been responsible for the various sustainability movements, but the measurement and understanding of sustainability failed to realize appreciable success because the majority consider remote circumstances rather than objective global warming issues such as carbon emission from energy sources (Abdul-Azeez, 2018a).

Universities worldwide strive to pursue the fundamental goals of sustainability through low-carbon development efforts with numerous sustainability projects ongoing in private and public universities. Nigeria Universities will require a blueprint that seeks to deliver a cleaner, more efficient, low-carbon future focusing on direct CO2 emission reduction as the roadmap for low-carbon development. The path to

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successfully limiting the atmospheric concentration of CO2 would require significant changes in energy production as well as major shifts in the energy sector. In addition, a piecemeal approach to reducing carbon emissions from university campuses is very desirable. Several academic institutions have demonstrated their commitment to fostering a sustainable environment by means of diverse projects and research endeavors (Sam-Amobi et al., 2019). The common trend is moving toward energy sustainability, carbon reduction, and low-carbon development initiatives (Abdul-Azeez and Ho, 2015) as a melting point for sustainability practices among universities.

Through creative energy use, energy-saving techniques, and clean power technologies, Universities and colleges have led the way in tackling global warming and sustainability. issues (Eagan, et al., 2008). However, efforts to create a sustainable university in Nigeria are still at the "pioneering and infancy stage" because environmental issues are not given high priority, because key constituencies and advocates do not coordinate, and because there is disagreement over how to define sustainability, absence of adequate measuring tool for carbon emission as well as inadequate planning affecting the performance towards reducing carbon emissions (Abdul-Azeez, 2018b). Solar energy is one of the forms of renewable energy system that can be used as a sustainable alternative in communities, neighborhoods, and campuses (Ambrose, 2021)

Due to energy consumption based on fossil fuels, carbon emissions continue to be the common global sustainability issue (Hardy, 2008, Arrow, 2007, Pope et al, 2004). More broadly and quantitatively than any other element, energy links everything to everything else (Jiusto, 2008). Energy is therefore still essential to sustainability, and without sustainable energy development, university development cannot be sustainable (Abdul-Azeez and Ho, 2015). Despite evidence of high carbon emissions related to energy use among Nigerian universities, unsustainable energy practices are among the current issues. There is little awareness about carbon reduction strategies among the campus community and very few are conscious of the potential of the university to mitigate global warming through carbon emission reduction on the campuses. Due to regional obstacles and other factors, Nigerian universities have not yet adopted this sustainability trend.

Determining the current CO2 emission levels through effective measurement is necessary to manage and effectively plan CO2 reduction to reduce global warming. This necessitates evaluating the resources used in energy use. However, the criteria considered for the rating in the various environmental sustainability assessment tools currently in use are varied (Abdul-Azeez and Ho, 2015, Helmers et.al; 2021). Also, there is very little regularity between the described Carbon Footprints (CFs) among the very few universities that are collecting and publishing their carbon footprints, given different methods of analysis.

Notwithstanding, energy remains very significant to university campus activities. Universities feature a large concentration of people, permit heavy traffic, generate a substantial amount of waste, and consume a reasonable amount of energy while producing a large quantity of carbon which when totaled may significantly affect the global environment. Universities play a major role in depleting the environment being built-up environments organized into various land uses and activities, all of which require energy use for production and operation processes, as well as movements and other purposes.

Consequently, the belief that universities can offer leadership in sustainability and

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provide solutions to global environmental problems may be responsible for the country's enrolment in various campus sustainability movements among which is the Inter-University Sustainable Development Research Program (IUSDRP) which currently has over 100 member universities from across all continents including developing countries, focusing on sustainability research, publishing and Ph.D. training (ULSF, 2022). Notwithstanding, the practice of sustainability assessment is still relatively new Nigerian Universities given local barriers and other criteria. It is very doubtful if any carbon assessment approach exists among Nigerian universities owing to many factors including the high cost of carbon assessment tools, suitability of criteria considered, availability of data, and the inability of the tools to address local issues among others.

According to Caves et al. (2007), the transportation, household energy use, and energy consumption patterns of university students contribute to CO2 emissions and global warming. Most of the university campuses' energy comes from a combination of fossil fuels, which produces electricity with large carbon footprints. This can be mitigated through alternative methods of reducing carbon footprint by replacing the conventional electricity consumption of the high energy-intensive sector with renewable energy such as solar energy option, being an important dual-purpose alternative to carbon emission reduction.

Reducing CO2 emissions will require knowledge of the existing quantity of emissions from energy use. It is against this background that a case study was conducted using annual energy data from metered sources of Modibbo Adama University. The study considered sources and quantities of energy consumption and carbon emission from electricity energy use, assessed electric energy usage for selected sectors/units, analyzed the extent, and highlighted the prospects of considering PV installation to substitute with solar energy as an effort towards promoting low carbon development within MAU, Yola. This would assist in combating increasing global warming because of the energy derived from fossil fuels and promote low-carbon development in the university.

LITERATURE REVIEW

Recent concerns about CO2 emissions from energy use and global warming have recently surfaced. It is imperative to restrict the escalating global warming and avert hazardous climatic shift (Hare, 2009). Reducing carbon emissions is seen as a key instrument to support the transition to sustainability, as evidenced by the growing interest in university campuses and the evolving concept (Rappaport, 2008, WBCSD, 2005). The growing number of students attending universities suggests that energy consumption will rise and that carbon dioxide emissions from the burning of fossil fuels will continue. Mitigating carbon dioxide emissions via low-carbon development is a suitable approach to address climate change (Abdul-Azeez, 2021).

The American College and University Presidents' Climate Commitment (ACUPCC) is one of the initiatives that challenges universities to measure, cut, and eventually eliminate their greenhouse gas emissions to achieve sustainability in higher education (Dautremont-Smith et al., 2009). To pursue sustainability goals, other universities are banding together to form partnerships. Comparably, in 2008, the New Jersey (USA) Higher Education Partnership for Sustainability (NJHEPS) was established with the goal of lowering greenhouse gas emissions and encouraging improvements to member universities' surroundings (Vasishth, A., 2018). To counteract the ensuing ecological disaster of increasing global warming, most universities worldwide are

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now looking for ways to reduce their carbon footprint. As a result, carbon emission inventories have become the norm.

Recent works of literature focus more attention on the relevance of the University campus in reducing carbon emissions and global warming (Hare, 2009). The growing interest in views reducing carbon emissions is a crucial tool for facilitating the transition to sustainability in the university campus environment (Rappaport 2008). Therefore, concerns are associated with CO2 emission from energy use as the majority of universities are in the midst of a movement to lessen campus environmental effects by cutting back on energy use and carbon emissions. (Lukman, 2009, James, 2009). Consequently, the trend is that universities are moving towards becoming more sustainable by reducing their negative impact on the environment, economy, and society (Dehghanmongabadi and Hoşkara, 2018, Abdul-Azeez, et al., 2023) and by picking the challenge to lead the great transformation toward a carbon-neutral society (Helmers et.al, 2021).

In recent decades, the idea of sustainable universities has grown in importance and popularity. Sustainability is incorporated in teaching, research, and campus operations as well as in innovative projects, and clean technologies, in many Higher Education Institutions and universities worldwide. Some of these sustainable initiatives include greenhouse gas emissions, renewable energy, energy efficiency, water management, recycling systems, and on-grid solar photovoltaic projects, among others (Mac-lean et al., 2020).

Achieving renewable energy drive is a desirable sustainability goal of most Universities globally. However, despite much literature on the existing potential of renewable energy and prospects for the development of solar energy as an alternate source of energy in Nigerian Universities, until recently, qualitative studies that focus on its development have received less attention.

According to current estimates, solar energy has the third-highest potential for energy harvesting in the nation. Power generation from abundant renewable resources has a great deal of potential if the related obstacles to technological advancement are overcome (Olaoye, et al., 2016). The main goal of solar energy, which is cheap, clean, and renewable, is to provide a long-term, economically viable source of power as an alternative to fossil fuel-based energy sources. Photovoltaic solar panels are a common technology used to harvest solar energy, converting solar radiation into electrical power that can be used.

Even though solar energy is free, Nigerians are unable to fully utilize it due to the high cost of collection, conversion, and storage (Akinboro et al., 2012). As a better alternative for electricity generation, the advantage of using solar energy is enormous in terms of functionality, however, lack of knowledge and awareness of the benefits as well as the absence of appropriate technologies affects its efficiency and hinders its use in many sectors of the country.

However, given massive prospects for carbon emission reduction, low carbon development, and a green economy, among others, the adoption of solar energy in university campuses is of immense profit in the medium and long term. The option of solar energy as a source of power is an important alternative to carbon emission reduction. Hence, investment in photovoltaic or solar energy to power buildings and replacing the conventional electricity consumption of identified high energy demand sectors in MAU with solar energy would save costs in the long run and cut emissions significantly as well as reduce the global warming potential (GWP) of the university. Considering the above, it is easier and more sustainable to gradually

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replace the highly intensive fossil fuel-based energy consumption sectors of the university with solar energy towards renewable energy development and environmental sustainability.

Nigerian Universities were among the original signatories to the Tallories Declaration (ULSF, 2008) that recommended Universities take action to focus attention on the environment, population, human activities, and development issues, and develop strategies for an environmentally sustainable future. Nigeria is also a member of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (Abdul-Azeez, 2020, Abdul-Azeez, 2021) and has made international commitments to promote low-carbon development and become a high-income nation that is inclusive and sustainable by 2020. Therefore, the country should also key into the wave of reducing carbon emissions by encouraging the development and use of renewable energy in the nation's university campuses.

Solar energy has great potential for Nigerian Universities. The country is naturally endowed with abundant renewable energy resources, especially solar radiation. It is a significant source of renewable energy that can be captured and converted into electric and thermal energy whose utilization is environmentally friendly (Zarma et al., 2017). Nigeria is situated in a region with abundant sunshine, offering significant opportunities for solar energy service providers offering solar thermal or photovoltaic (PV) power.

Solar radiation is well distributed within the country which receives about 4.85×1012kWh of energy per day from the sun (Osueke and Ezugwu, 2011). Annually, an average of 6,372,613PJ/year (≈1,770,000TWh/year) of solar energy falls on the entire land area of Nigeria. This is because the average annual solar energy intensity varies from about 12.6MJ/m2 per day (3.5kWh/m2) in the coastal latitudes to about 25.2MJ/m2 per day in the far north. (Zarma et.al. 2017).

Implementing renewable energy technology in existing university buildings is not without attendant challenges (Fuentes-del-Burgo, et al., 2021). Numerous solar photovoltaic projects that are being installed across this nation do not meet the required minimum life-span due to poor fundamental designs and poor installation procedures, inexperienced personnel, use of substandard components, as well as poor construction and civil works among others, therefore satisfaction derived from the performance of projects is not commensurate to the heavy investment. On the other hand, when projects are properly designed and carried out by skilled technical professionals, utilizing the right components and technical procedures, maximum performance output can be achieved (Zarma et.al. 2017).

The absence of sufficient economic incentives, economic-financial, administrative, and legislative/ institutional as well as technological, factors, among other obstacles affect the development of solar energy in Nigerian universities. In addition, for the solar energy resource to be used effectively, the industrial infrastructure must be reinforced. More advanced technologies are needed to manufacture the components of photovoltaic systems, especially photovoltaic cells.

Increasing the use of renewable energy such as solar power through an ambitious energy policy focused on reducing CO2 emissions, would improve energy efficiency among Nigerian universities. Coincidentally, the study area lies in the Northeastern part of the country where the annual average of solar radiation is about 25.2MJ m2 per day. Therefore, the potential solar energy source can adequately be harnessed into useful energy to promote carbon emission

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reduction and encourage sustainable energy development in MAU.

METHODOLOGY

Measuring current CO2 emission levels is necessary to accurately plan and manage future emissions to reduce or stop global warming from university energy use resources. The survey was conducted to determine electricity consumption based on purchased energy from the National grid and electricity service provider. The study relies on primary data gathering methods include direct measurements of energy consumption, oral interviews, and questionnaires. The analysis of energy consumption for the university campus reveals three (3) major districts of the university namely: Main campus, Professorial Quarters, and Bukar Mele district of the university. It was not possible to obtain specific energy consumption according to classrooms, faculties, or departments given the absence of metering facilities in such buildings. Also, very few buildings and energy use sectors were metered; hence it was not possible to produce a detailed pattern of energy consumption for lighting, cooling, ICT, or Laboratories in the university that could have eased implementation according to these sectors.

Assessment of energy supply to various sub-units in Modibbo Adama University, Yola was carried out by identifying the various subunits in the University. The subunits were categorized into: Academic Units (i.e., Administrative Area, Academic Lecture Halls, Departmental Buildings, etc.), Commercial Units (i.e., 129 shops of the major 5 commercial centers and other communal support facilities within the campus), and Residential Units (i.e., staff quarters – 80 flats with 6 boy's quarters; and Student Hostels – 9 Hostels, 900 Rooms, with stores). Data on energy consumption based on appliances was obtained from the unit in charge of managing electricity within the campus (i.e., the electrical unit of the Works Department). Energy requirement in Kilowatts (kWh) for various appliances and corresponding CO2 emission was determined in the various subunits within the campus.

Very few buildings and energy use sectors were metered; hence it was not possible to obtain specific energy consumption according to classrooms, faculties, or departments given the absence of metering facilities in most buildings. It was also difficult to produce a detailed pattern of energy consumption for lighting, cooling, ICT, or Laboratories in the university. Despite these constraints, information relating to energy consumption based on electricity facilities such as appliances in the Commercial Centers, Academic Areas, Hostels, and Staff Quarters were obtained and statistically analyzed using clustering methods of analysis based on annual consumption and metering where possible. Electricity data for some years were incomplete due to the breakdown of the metering system and technical hitches among others. Therefore, a constant and steady power reading for four years (2018 – 2021) was established as the common basis for energy evaluation for the study.

The university's active power demand sectors have been categorized, which is a very helpful tool for understanding and projecting changes in energy consumption. It also marks the beginning of the adoption of energy efficiency policies and the pursuit of more cost-effective and environmentally sustainable energy use. It was observed that electricity from the national grid is the primary energy source for the MAU, Yola, while other energy sources include power from petrol and diesel power generating sets. Emissions from the power-generating sets could not be computed because data on total annual fuel consumption for such energy sources was not available.

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However, the use of grid electricity in the university will simplify the determination of total annual consumption and grossly ease the reduction of the carbon emissions produced by energy consumption. Although diesel is a primary energy source, it should be noted that emissions from petrol and diesel power generating sets and other sources of energy such as non-carbon dioxide greenhouse gases generated in fuel combustion, mainly methane (CH4) and nitrous oxide (NO2), were not calculated in this study. The emission factor of 0.439 kgCO2/ kWh was used for the calculations of carbon emissions from electricity, based on the fuel mix of Nigeria's National energy grid as given by the International Energy Agency (iea.org) to determine the extent of carbon emission from corresponding energy consumption in the university.

DATA ANALYSIS AND FINDINGS

The research utilized data that was accessible from 2018 to 2021. The data obtained for the year 2022 could not be used due to a technical breakdown of the metering system for the months of October to December in the main campus and Professorial quarters and for the entire year in the case of Bukar Melle. The survey conducted regarding the university's energy usage campus reveals that very few buildings and energy use sectors were metered. Therefore, adequately defining Based on the data collected, the university's energy usage pattern becomes a limitation. Table 1 presents the annual electricity energy purchased from Yola Electricity Distribution Company (YELDC) by MAU based on kilowatt-hour kWh and cost in Naira.

Table 1: Annual Electricity Consumption Based on Purchased Energy (YELDC)

	The main campus (kWh)	Professorial Quarters (kWh)	Bukar Mele (kWh)	Total energy (kWh)
2018	1636582	131228	24847	1792657
2019	1703513	94334	27209	**1,825,056**
2020	**798127**	**90978**	**15791**	**904,896**
2021	**1703632**	**78474**	**20467**	**1,802,573**
2022	624408*	73248*	NIL	*Incomplete data

Analysis of Energy Consumption in University Campuses

The energy management policy of the university aims to lower the amount of energy used on university campuses through a central controlling unit by switching off power from the mains between 8.00 am - 11.00 am and between 3.00 pm - 6.00pmthereby enforcing a shortfall of 6 hours or 25% reduction of energy supply to the classrooms, residential quarters, and hostels within the university. However, the university administrative office block, Library, and other essential service units were powered by an electricity-generating set during the shortfall. Notwithstanding, fuel consumption by this source of energy supply was considered for the assessment of carbon emission.

Despite the role of such policy In order to lower carbon emissions and save energy expenses, the policy is not popular among the respondents who claimed that it is negatively affecting the overall performance of pedagogy given the implication of energy to development For energy production and consumption ought not to jeopardize the standard of living of present and future generations or surpass the ecological carrying capacity of ecosystems, replacing the energy requirement of the campus with

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an alternative source of solar energy is the right move in the direction of sustainable energy development.

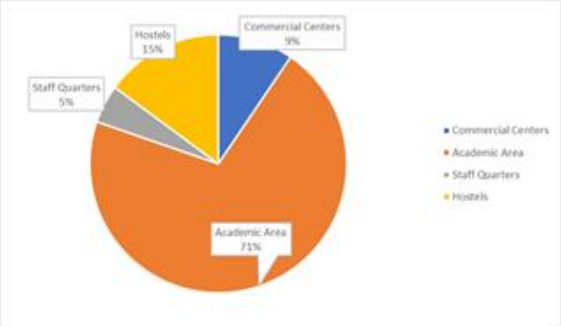

Figure 1: Percentage of total energy consumption by Service Sectors in the campus.

Figure 1 shows the percentage of energy consumption according to service sectors. Since the overall pattern of electricity use is related to CO2 emission, the assessment and calculations of the electricity sub-component would ensure the understanding of the intensity of CO2 emission within the study campus.

Considering CO2 emission according to electrical energy, the study found that the Academic area is responsible for about 71% of the University's overall carbon emissions from its power use. The Students' Hostels constitute about 15%, while Commercial Area and Staff Quarters have 9% and 5% respectively. Therefore, the proposal to power the hostels with solar energy would reduce the university's CO2 emission by 15%, while the policy to power the entire academic area with solar energy would reduce emissions by 71%. This information would assist in making informed decisions and is very important for a piecemeal approach to carbon emission reduction in the university.

Energy Consumption and Carbon Emission Profile

Energy is indispensable for economic growth and continued human development, nevertheless, the amount of energy consumption at the university campuses is huge. Reducing contribution to greenhouse gas emissions through the reduction of energy consumption on university campuses is therefore desirable and may encourage the spreading influence of sustainable energy consumption initiatives among students.

Primary data on the university's energy consumption pattern were gathered through questionnaires, and a thorough analysis of the existing state of energy consumption was carried out. An estimate of Greenhouse Gas emissions based on the structure of energy consumption within identified service areas of the university and sectors of intensive carbon emission due to large energy consumption is presented in Table 2.

Table 2: Estimating Greenhouse Gas Emission from Annual Electricity Consumption by Service Sectors

Service Sectors	Annual Electricity consumption (kWh)	Carbon Dioxide emission kg CO_2	Percentage of CO_2emission
Commercial Centers	162144.04	71181.23	9%
Academic Areas	1205556.55	529239.33	71%
Staff Quarters	81770.83	35897.39	5%
Students' Hostels	254140.92	111567.86	15%
Total	1703632	747894.45	100%

The average annual electrical energy consumption for the university is given as1703632 kilowatts (kWh), estimated as 747894.45 kgCO2.For the Academic sector, 1205556.55 (kWh) was estimated as 529239.33 kg of CO2, constituting 71% of

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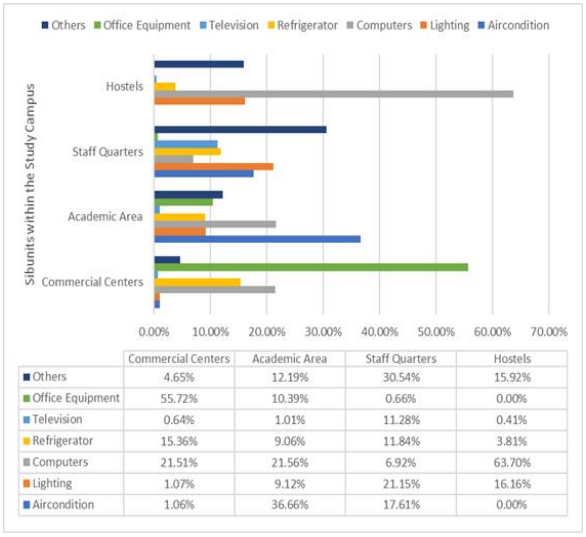
the total emission, while 162144.04 kWh was observed in the Commercial Unit estimated as 71181.23kgCO2 and 9% of the total university emission for electricity. The Residential staff quarters Unit accounted for 35911.76kWh (i.e., 81770.83kWh and 254140.92kWh for Staff Quarters and Student Hostels and estimated as 5% and 15% emissions respectively).

Of all the sectors, the academic services industry accounts for 71% of them. amount of energy consumed within the campus. Most of the consumption is used for cooling offices, lighting, and running equipment in the laboratories as well as in the library and for Internet Communication Technology (ICT). Replacement of the source of consumption for this sector with solar will reduce the university's greenhouse gas emissions significantly and could be more profitable in the long run.

The residential subunit (i.e., Hostels and staff quarters) is the second major energy-intensive unit with a cumulative 20% carbon emission from energy consumption. Finally, the Commercial unit is the least energy consumer that needs the least number of solar panels in the proposal for solar energy sources. The percentage of emission presented in the table could be used for administrative purposes to plan emission reduction of the university accordingly and in phases.

These appliances are categorized into seven (7) categories namely, Air conditioning, Lighting (Illumination Devices), Computers, Refrigerators, Television Sets, Office Equipment, and others. The Air conditioning Appliances include 1.5HP and 1 HP AC; while Computers include items like Phones phone chargers, desktops, and Laptop computers. The Office Equipment includes Projectors, Printers, Hardcover binding machines, Photocopy, and Laminating machines; others include Iron, Ceiling Fans, Microwave, cooker units, and heaters.

Figure 1 presents a graphical visualization of the Energy requirement by the various subunits of the university concerning existing appliances within. The figure provides an understanding of the spatial distribution of energy consumption and requirements in space within the various subunits of the study campus.



	Commercial Centers	Academic Area	Staff Quarters	Hostels
Others	4.65%	12.19%	30.54%	15.92%
Office Equipment	55.72%	10.39%	0.66%	0.00%
Television	0.64%	1.01%	11.28%	0.41%
Refrigerator	15.36%	9.06%	11.84%	3.81%
Computers	21.51%	21.56%	6.92%	63.70%
Lighting	1.07%	9.12%	21.15%	16.16%
Aircondition	1.06%	36.66%	17.61%	0.00%

Figure 2: Percentage of Energy consumption by appliances in the sectors

Among the appliances observed are office equipment, Television sets, Refrigerators, computers, Air conditioning, Lighting, and Others. The category of 'Others' includes appliances including Electric irons, Ceiling fans, Microwave, Cooker units, and Heaters.

Considering carbon emissions from using energy, Figure 2 presents a summary of data on which estimate of large Greenhouse Gas Emission may be based according to identified service areas of the University and the intensity of carbon emission due to energy consumption by the appliances. This may be helpful for decision-making purposes.

About 56% of the total energy consumption in the commercial center is used to operate Office Equipment such as printers, projectors, laminators, internet, power backups, and other essential equipment. Also, 22% of the power consumption in the commercial centers' sector is attributed to

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Computers, while Refrigerators consume 15% of the commercial sector's overall electricity use.

Similarly, electricity consumption by Computers is relatively high among the sectors. For instance, energy consumption in the commercial and the academic areas is about 22% respectively, while about 64% of the total energy consumption in the Hostels is used to operate computers alone.

The residential staff quarters are also a major energy consumption subunit of the main campus of MAU. The category of "Other appliances" refers to appliances that are not commonly owned by most people such as Electric Iron, Microwave, Blenders, Dish Washers, Toasters, Ovens, Mixers, Toasters, Juice Makers, Rice and Pressure Cookers, Vacuum Cleaners, Coffee Makers, Washing Machines among others. These categories of appliances consume about 31% of the total energy consumption of the staff quarter subunit while computers consume 21%, and lighting consume 18%, while Television and Refrigerator have a combined consumption of about 23% of the total energy use in the staff quarters.

Air conditioning was identified as the major energy consumption appliance in the Academic sector, and about 37% of the total energy consumed by the sector goes into cooling the offices. Office equipment such as Photocopier, Laminating machines, and Printers are the major appliances responsible for 56% of the total amount of energy consumed by Commercial Centers, while refrigerators and computers consume about 36% of the total consumption in the Commercial subunit.

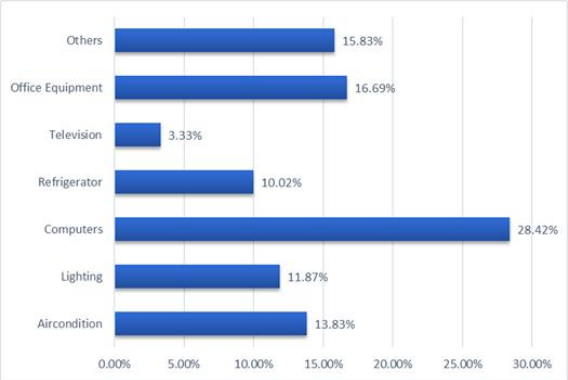

Figure 3: Cumulative Energy consumption by itemized appliances on the campus.

General information related to energy consumption based on facilities is given in Figure 3. The figure represents the cumulative energy consumption according to appliances on the campus. Integrating fossil-fuel-powered energy with renewable energy sources will enable emission reduction performance based on eliminating intensive energy consumption appliances by replacing electricity with solar energy. It would be noted that consumption by Computers (28%) ranks highest among the appliances, followed by Office Equipment (17%) and Air Conditioning (14%).

The energy usage analysis for selected appliances offers an opportunity for the substitution of intensive carbon emission appliances with renewable energy sources to reduce carbon emission through a piecemeal approach. Energy for such appliances could be substituted with solar energy to lower the university's potential for global warming. The determination of such higher energy-consuming sectors or appliances constitutes the first stage of carbon emissions reduction analysis for the university. Such information could be used for planning purposes and would be beneficial in phasing the emission reduction process.

Although the introduction and use of Low Energy Devices (LED) for office equipment, Lighting, Air conditioning, and computers would eliminate about 70% of the sources of carbon emission, replacement with solar

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energy would permanently reduce the global warming potentials of the campus and yield a lower cost of energy consumption in the long run. This shows that the use of Photovoltaic solar power could be a sustainable alternative to low-carbon development in Modibbo Adama University Yola.

CONCLUSION

Solar power is a clean energy source with no negative environmental effects. Solar energy with photovoltaic is freely generated from the sun and requires minimal maintenance. The technology is largely unsuccessful among Nigerian universities given poor research development in solar energy technology and poor access to training. Usually, the project is contracted out to foreign developers, resulting in poor performances owing to a poor after-sales maintenance policy.

Therefore, promoting training, intensifying research and manpower development as well such is offering sufficient incentives to regional producers of solar energy systems would benefit the university and may support the local solar energy industry in Nigeria.

A piecemeal approach to reducing contribution to greenhouse gas emissions by integrating fossil-fuel-powered energy sources with renewable/solar energy consumption and the introduction and use of LED appliances on university campuses is achievable. However, providing financial incentives for the purpose of installing solar energy installations and putting policies in place to solar technology into the energy sources of Nigerian universities would reduce contribution to global warming. Therefore, granting sufficient financial incentives to encourage local producers of solar energy systems would reduce the overall energy cost of universities in the long run and encourage the spreading influence of sustainable energy consumption initiatives among students as well as stimulate low carbon development in the university campus.

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