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Greening the School Energy System: A Nigerian Case Study

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ABSTRACT

The sustainable development goals (SDGs) of the United Nations incorporated inclusive and quality education for all as a key component. In this respect, technology-based education is best suited for achieving the purpose. Meanwhile, energy is central to the modern school system as it is used to power Information and Communication Technology (ICT) equipment needed as bedrock for technology-based education. Given the low energy access in Nigeria and the need for environmentally friendly energy systems, the adoption of clean energy options appears to be the preferred direction for schools in the urban and rural areas. Hence this study examines the concept of energy transition especially as it relates to the school system and uses a case study to demonstrate its application in the context of Nigeria. The study adopted the qualitative approach using observation schedule and interview guide in addition to secondary data obtained from school documents, vendor specifications and technical details of clean energy installation. The study found that two main factors influenced the adoption of clean energy for the school. The first was the need to access a cheaper and cleaner form of energy in the long run given the epileptic and rather expensive supply from the national grid and the carbon intensive alternatives that are readily available. Secondly, the school wanted to align with the environmental sustainability preferences of the founders of the school, who are very conversant with best practices in sustainable development and sustainable school management. Hence, the transition to clean energy was an aspect of an overarching green agenda which encompasses different environmental sustainability activities. The major challenge is the huge capital outlay needed to install and maintain the clean energy system. The greening program provided school age children who will eventually become the policy makers of tomorrow, the proper orientation they need for their future roles as stakeholders in the physical environment. In addition, the high cost of installation and maintenance of the system suggests that incentives are needed to encourage an increased uptake of clean energy systems not only in the school system but also across other building types.

Keywords: Case study, challenges, green energy adoption, green school, Nigeria.

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I. Introduction

The built environment has continued to elicit a lot of interest in the discussion of environmental sustainability. This is due to the profound impact of the built environment on the sustainability of the environment in terms of carbon emissions, resource use, energy consumption and overall environmental impact. In general, the built environment is a high consumer of resources, accounting for up to 50 per cent of global materials resources, 50 per cent of energy resources, 40 per cent of global water use, 60 per cent of prime land and 70 per cent of global timber use [1].

Specifically, it has also been determined that the built environment is responsible for 38% of global GHG emissions [2], [3]. A further breakdown indicates that 28% is directly accounted for by energy use in buildings while 10% is traceable to materials for building construction and maintenance. It has further been determined that about 55% of global electricity consumption is associated with building operations [2]. Hence, energy use in buildings is very critical for overall sustainability of the built environment.

The environmental impacts of buildings can be broadly divided into embodied impacts and operational impacts with the operational impact accounting for over three quarters of the total built environment impact [4]. Most of the operational impacts are associated with energy use. Hence, there is consensus that adoption of low impact energy will greatly reduce the environmental impact of buildings attributable to energy use. It is therefore understandable that the call for the adoption of green, clean or sustainable energy is on the increase. An added impetus is the huge and rising global building stock currently estimated at 255 billion square meters with an estimated annual increase of about 5.5 billion square meters [3]. This growing stock will have to be

operated with more energy.

The increased uptake of clean energy options appears to have focused on residential, commercial and industrial buildings. School buildings are usually grouped under commercial buildings where collectively they are estimated to constitute about 50% of entire building stock [5]. In addition, education, mercantile, office, warehouses and storage buildings make up about 60% of commercial floor space [5]. More specifically, school buildings in the USA account for a sizeable footprint of public infrastructure [6]. The situation is not too different from what obtains in other contexts, especially in Europe [7]. Appropriate regulations have been in operation in several jurisdictions to address energy use and GHG emissions in these predominant building types.

Notwithstanding the above scenario, school buildings appear not to have received adequate attention in terms of energy use and GHG emissions. This may be attributed to the fact that school buildings are subsumed under commercial buildings even though they possess some unique characteristics. Schools are predominantly used by young people, for whom the school environment is also an environment for the formation of their young minds. In addition, the physical environment of a school plays an important role in the health, wellbeing and learning outcomes of the learners [8]. Meanwhile energy use in school buildings has assumed a new dimension due mainly to two factors: the first is the advent of technology-based education which makes teaching and learning fully dependent on steady, reliable and affordable energy supply. The second is the emergence of COVID-19 which has accelerated the requirement for technology-based online education due to physical distance restrictions. Schools are now emerging as centres for sustainability with the realization that the education sector holds the key to a sustainable future [9].

Meanwhile, effective energy access for buildings in Nigeria is still a major issue. In the context of this paper, electricity is regarded as the most usable form of energy at the level of buildings. Hence, in a survey conducted in 2014, the World Bank estimated that Nigeria has the highest electricity access deficit in Africa [10]. Energy access for schools is also low in the study context during the same period. A study of schools in Sub-Saharan Africa indicated that many schools do not have access to electricity [11]. Another report estimated that in 2017, 65% of public primary and junior secondary schools in Nigeria do not have access to electricity [12]. Meanwhile, the importance of electricity access for schools has been underscored in the sense that electricity access has a strong effect on education [13]. A comparative study of energy and internet access for schools in the Global South indicates that Sub-Saharan Africa has the lowest access of 29% and 6% respectively [14]. Even though the energy access scenario alluded to earlier has improved substantially especially in Nigeria as captured in a report by [15], the efficiency and impact of energy use remain major concerns. This is because the environmental impact of energy production and use in the study area is high. According to the International Energy Agency (IEA), the energy mix in Nigeria is lopsided in favour of non-renewable hydrocarbon energy sources [16]. Similarly, Nigeria is the highest user of hydrocarbon fired back-up electricity generators in Africa [16]. As a result, advocacy for renewable energy adoption in the study area has been on the ascendance. The general energy outlook in Nigeria favours the adoption of renewables [17]. Renewable energy is also often referred to as clean energy and green energy. Hence, a major concern is the uptake of renewable energy options as a deliberate way of minimizing impact of energy use. In order to harness energy and maintain a sustainable environment, clean energy options are preferable.

Energy consumption is the second largest cost item in the budget of most schools [18]. Hence, there is also an economic sense in reducing the energy consumption in schools. Adoption of green or clean energy in schools can be very challenging. This is mainly because green strategies are largely voluntary driven efforts rather than statutorily mandatory efforts. Several voluntary initiatives aimed at improving adoption of green energy in schools have evolved over time. It is against the above background that this study examines the experiences of a Nigerian high school in the adoption of green energy and the prospects this adoption holds for overall sustainability in the Nigerian school system. Specifically, the study sought to provide answers to the following questions:

1) What factors influenced the adoption of green energy in the school?
2) What were the stages of implementation of the green energy system?
3) Is the green energy system part of an overall green agenda for the school?
4) What are the general and specific challenges in the adoption of the green energy system?
5) What is the impact of the adoption on the students, staff and the immediate community?

II. Literature Review

Sustainability as a concept refers to a development paradigm that emphasizes resource conservation, resource efficiency and environmental impact mitigation. Being at the root of existence, sustainability is associated with every aspect of human life. Research in the area of sustainability indicates that the built environment is very critical to the achievement of holistic sustainability [2]. The built environment consists of anthropogenic activities such as buildings, structures, features and facilities meant for work and habitation. It impacts on the environment through resource use, energy use and their associated carbon emissions. This impact is broadly divided into embodied impact and operational impact. Resource and energy use are always linked to carbon emissions which in turn determine how sustainable a product or process is. The primary goal of a sustainable built environment is to reduce the quantity of carbon being released to the environment through carbon emissions [19]. Hence, the de-carbonization of the built environment is a sure way to making the built environment more sustainable.

Hence, sustainability of the built environment is a movement towards transiting from carbon-intensive processes to low carbon technologies. In this respect, concepts such as green buildings, energy efficient buildings, zero energy buildings have all evolved to address the various strategies for reduction of environmental impact of buildings

towards achieving overall built environment sustainability. When applied to the built environment, the green concept is an approach to the built environment design, construction and use that tends to minimize the harmful effects of the built environment on humans and the environment [20]. The green approach safeguards air, water and the earth by choosing eco-friendly solutions to the built environment design, construction and use. Energy efficiency refers to deliberate strategies adopted to reduce both the energy consumed in buildings and the environmental impact of such energy consumption. Zero (net-zero) energy building is the goal of energy efficiency, and it describes the scenario where the actual annual delivered energy is less than or equal to the on-site renewable exported energy [21].

Buildings are broadly categorized as residential, commercial and industrial. School buildings make up the third largest subsector of commercial buildings in terms of energy use [6]. Research in the area of sustainability has progressed steadily from the earlier efforts at clearly defining and delineating the concept of sustainability to more practical and applied research directed at how to contribute to sustainability in various facets of life. In this respect, sustainability education has emerged as a potent research area that can fast track the adoption and implementation of sustainability across several facets of life. In the area of sustainability education, attention is shifting to the younger, school age generation who are believed to be in a better position to implement sustainable practices aimed at protecting their future and future generations. So, green school awareness has emerged with the aim of focusing on sustainability education and building the capacity of the younger generation to understand and address environmental challenges.

Some specific environmental challenges have been outlined one of which is environmental pollution arising from industrialization in developed countries and poverty in less-developed countries [22], [23]. Industrialization and other human-induced activities have created the phenomenon of global warming and climate change occasioned by large amounts of carbon in the environment. Energy generation and use constitute one of the greatest contributors to global warming and climate change. Also very important is the phenomenon of plastic pollution which has been described as one of the potent threats against biodiversity. In this respect, the menace of single use plastics has been underscored [24].

Green schools evolved in response to the environmental concerns generated at the United Nations Conference on Environment and Development UNCED 1992 [25]. The goal of green schools is to create a healthy environment that is conducive to learning while saving energy, resources and mitigating carbon emissions. Specifically, green schools are a response to the need for school buildings and the overall school surrounding to be responsive to the environment and to act as veritable locations for the inculcation of sustainability ideas in the younger generation who are the leaders of the future. Green schools have been established on two main planks namely:

1) The need for sustainable school buildings and school environments [26].
2) The need to use the sustainable school buildings and environments as formation tools for the future generation of leaders [27].

Green schools are variously referred to as eco-schools, sustainable schools, green flag schools, ECOLOG schools, among others [25]. The objectives of green schools as enunciated by [25] and [28] include the following:

1) Reduction of the environmental impact and footprint of school buildings
2) Reduction of the cost of operating school buildings especially in the area of energy consumption and maintenance of school facilities
3) Helping students as young leaders to develop requisite knowledge and skills to help deal with current and future environmental challenges
4) Helping in creating a healthy school environment for teaching and learning

The thematic focus of green schools varies from one to the other. However, they fall into such sustainability areas as:

1) Sustainable energy [29].
2) Water conservation [30].
3) Biodiversity conservation [26], [27].
4) Sustainability education [27], [31].
5) Green infrastructure [32].
6) Sustainable waste management [18].
7) Healthy Indoor and Outdoor Environment [33].

Most green schools focus on several thematic areas with emphasis on the holistic impact of the green intervention. However, the all-pervasive characteristic of green schools is their disposition towards environmental and sustainability education. Adoption of green energy could therefore be seen as a subset of holistic green programmes for schools. Green school programmes have been largely propelled by voluntary, green-based initiatives. The Eco-school initiatives started in Europe soon after the UNCED 1992, which inspired it. The Center for Green Schools was inspired by the US Green Building Council [34]. Also, the Green School Alliance GSA was envisioned in 2006 and publicly introduced in 2007 [35]. The GSA is an alliance of individuals comprising over 9000 schools and affecting over 5 million students in almost all states of the USA and in 84 other countries, working towards sustainable school communities [35]. There is also the Green Schools Initiative (GSI). The Green Schools Initiative was founded in 2004 by parent-environmentalists who were shocked by how un-environmental their children's schools were and mobilized to improve the environmental health and ecological sustainability of schools in the U.S [36]. Hence, adoption of green energy and other green programmes by schools has largely been propelled by voluntary, green-based initiatives such as the Green Schools Initiative (GSI), the Green Schools Alliance (GSA), and the USGBC Centre for Green Schools are some of the examples. However, all the initiatives were inspired by the aftermath of UN Conference on Environment and Development.

In Nigeria, green schools' awareness is increasing. The National Climate Change Awareness Program (NCCP) through the Glow Initiative has pioneered the formation of Green Guild School Initiative for the purpose of disseminating awareness on climate change to secondary schools [37]. Also, the Green Institute Nigeria has established a Green School in Ondo town aimed at inculcating environmental education to the secondary school students [38]. There is also the Green Schools Initiative pioneered by Notore Chemical Industries with the objective of directing attention of secondary school students on the need to go back to agriculture as a mainstay of the economy [39]. In addition,

there is the Geography Green Schools Project, a technology-based intervention pioneered by GIS Konsult Ltd to promote sustainability awareness using geographical soft-wares and protocols [40]. It is also noteworthy that the Development Bank of Nigeria (DBN) launched the Green Clubs in schools to help drive positive environmental practices in schools [41].

Some barriers have been identified as militating against the speedy adoption of green energy in general, especially in less developed countries such as Nigeria. Literature has identified barriers such as high initial cost of installation, availability of technical expertise, low level of awareness, absence of government policies and incentives, and availability of green energy components [42] – [44]. As a result, solar energy use in Nigeria falls short of the expectations of government [45].

It is evident from the foregoing that most of the green schools' projects in Nigeria are mostly advocacy and education programs aimed at imbibing the positive aspects of the environment. Not many of the green schools are green in terms of energy use. However, schools in Nigeria are gradually embracing green energy as a way of contributing to a sustainable school system. At the University of Ibadan and University of Nigeria, Nsukka, green energy installations are up and running [46]. The Nigerian government through the Energizing Education Programme (EEP) under the auspices of the Rural Electrification Agency (REA) is implementing a phased installation of clean electricity to 37 federal universities and 7 teaching hospitals [47]. The German Agency for International Development, GIZ is also partnering with the Nigerian government in supporting renewable sources of energy at Nigerian universities [48]. At most primary and secondary schools, green energy installations are few and far between and are typically of low capacity meant to power a few items. They are mostly deployed as back-up in case the mains supply fails. Large scale installation of green energy to serve a whole school has been reported for Abba's Heart School, a private elementary school in Lagos [49]. The case adopted for this study is a further addition to schools running purely on green energy in Nigeria.

III. Case Study Description

Saint Francis Catholic Secondary School is located in Idimu in Alimosho Local Government Area of Lagos State, Nigeria. The school was founded in 1990 by an American Jesuit Priest, Francis Cusimano as a co-educational high school under the auspices of the Catholic Archdiocese of Lagos but directly supervised by a local parish, Saint Francis Catholic Church. In 2005, the Lagos Archdiocese separated the school from the local parish and handed over the school to the Jesuits (Society of Jesus) of the Africa Northwest Province [50]. The Jesuits are well known all over the world as great educators, running schools, colleges and universities for over four hundred years [51]. In order to fully understand the background to the case study context, it is important to review the provisions of the guiding principles of Jesuit engagement in all their apostolates, referred to as the Universal Apostolic Preferences (UAP). The UAP is a framework which guides the work of the Jesuits. The current UAP covers the ten-year period from 2019 to 2029.

Four distinct but related directions were clearly articulated in the UAP [52]. One of such directions is the desire "to collaborate in the care of our common home" - the earth [52]. UAP also states that the Jesuits will 'collaborate with others in the construction of alternative models of life that are based on a sustainable development capable of producing goods that, when justly distributed, ensure a decent life for all human beings on our planet" [52]. Hence, the Jesuits, through the UAP intend to raise awareness of environmental responsiveness and practice same in their various apostolates, one of which is the education arm. The Green School agenda agrees with the Jesuit notion of environmental responsiveness.

The environmental aspect of the UAP drew substantially from *Laudato Si*, which is the Encyclical of Pope Francis on the Environment. *Laudato Si* complies substantially with the social teachings of the Catholic Church with respect to the common good and places the responsibility of protecting the earth on all human beings. The document addresses the environmental challenges directly as well as the philosophical, theological and cultural roots of the challenges [53]. As a Jesuit-run school, the objective of Saint Francis Catholic Secondary School is to imbibe the ideals of the UAP and the principles of *Laudato Si* in the school.

From modest beginning the school has grown to become a reference point for quality education and in green energy use in Lagos State, Nigeria. Originally conceived as a day school, the school later introduced boarding facilities which exerted a lot of pressure on available land area. The core academic area is delineated with the blue line. There are five main buildings in the academic core of the school – Jubilee Block, Cusimano Block, Salamone Block, Okogie Block and Olorunfunmi Block all shown with green-coloured roofs in Fig. 1.

There are two hostels – one female and the other male. Support buildings are Chapel, Refectory/Kitchen, Clinic/Female Toilets, Service Building, Male Toilet Building and the Afiawari Jesuit Green Park. The Green Park is the official vehicular park for the school. It is partly covered with canopy where building integrated photovoltaic (BIPV) panels are mounted.

Fig. 1. Aerial View of core academic area and related areas [54].

The Male Hostel and the Green Park are not spatially contiguous with the other buildings due to limited space for expansion. Both facilities are located across the two main surrounding roads to the school. In addition, the Female Hostel and the Refectory were built on lands acquired from

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adjoining owners to accommodate the expansion of the school. For privacy and proper control, the Male Hostel is accessed through a tunnel underneath one of the surrounding roads.

IV. Research Methods

The study adopted as main research method, the qualitative approach using observation schedule and interview guide as sources of primary data. In addition, secondary data were obtained from school documents, vendor designs and specifications as well as technical details of green energy installations. Relevant drawings and details were obtained from the architects and other consultants of the project while the technical details of the green energy installations were obtained from the installation company. The interview was with the then outgoing School Administrator, who oversaw the whole green energy installations being investigated. It was conducted on September 26, 2021. There was a follow-up interview with the current School Administrator on December 26, 2021 to ascertain the working conditions of the green energy systems. The vendor for the solar installations was also interviewed through the phone several times in 2021 and physically on January 15, 2022. Informed consent of the interviewees was sought and obtained before the interview. The main interview questions were sent in advance. The school was also informed of the research and the intention to publish the findings and no objection was received. The interview was accompanied by a physical inspection of the installations. The interview questions were framed from the research questions of the study. The interview was recorded. The data collected were subjected to content analysis and the results presented in explanatory notes with tables, photographs and annotated drawings where necessary.

V. Findings and Discussion

The findings for the study are presented according to the objectives of the study. Hence, the findings are presented under five sub-headings.

A. Factors that Influenced the Adoption of Green Energy

The study sought to know the factors that influenced the adoption of green energy by the school. From the interview the School Administrator identified five factors that influenced the adoption of sustainable practices in the school of which green energy is one.

The school realized the need to join the rest of the world in promoting sustainability practices. Top members of the school administration, by the nature of their training and experience are widely travelled and have come to understand best practices regarding the management of schools and its effect on the environment in other jurisdictions. As observed in the earlier sections, the Jesuits have a lot of experience running schools all over the world and such experiences came to play in the build-up to the adoption of green energy. The School Administrator cited an instance of a pilgrimage to Israel where he observed crops being grown in the deserts using modern technology. The experience inspired a desire to do more with the positive environmental attributes of the school location in the warm-humid tropical region where solar energy is in abundant supply. According to the Administrator, there is an ongoing and increasing consciousness that green energy is the way to go to ensure a low-carbon and sustainable environment.

The second factor is the need to align with the policy direction of the proprietors of the school. As an institution run by the Catholic Church, there was the need to key into the call by Pope Francis through the encyclical *Laudato Si* and contribute to the preservation of the earth for present and future generations. Through the principles established by *Laudato Si*, the school promotes what the Administrator referred to as ecological ethics. Ecological ethics in this respect is multi-faceted and encompasses other aspects of environmental responsiveness other than green energy. The other dimensions of the ecological ethics are examined in section 5.3.

Closely related to the foregoing is the adoption of the Jesuit UAP for the 2019 – 2029 period. One of the four pillars on which UAP stands is collaboration in the care of the earth. This aspect of the UAP is inspired by the principles enunciated in *Laudato Si*. After the adoption of the UAP at the highest level of the Jesuit organisation, all Jesuit apostolates were required to domesticate and apply the policy. In response, the school management through a strategic committee outlined the specific areas of intervention to make the school more sustainable in their activities and processes. Green energy was one of the prominent thematic areas.

In addition, the school observed rising cost of electricity provided from the national grid. According to the School Administrator, the electricity undertaking in the area sent outrageous bills running into millions of naira to the school at monthly intervals in spite of the epileptic supply. The electricity undertaking operates mostly an estimated billing system rather than metered billing system. This created the anomaly where bills were outrageous and not commensurate with consumption. Hence, the increasing cost coupled with unreliability of grid electricity supply was an added impetus to the adoption of green energy.

Moreover, in order to ensure steady supply of electricity due to unreliable service from the national grid, the school had to procure giant electricity generating plants which contribute to noise and air pollution. At a point, the school had three generators the least of which is a 150KVA generator. Moreover, the school determined that it will contribute towards ensuring that Nigeria is not a dumping ground for electricity generators given that Nigeria is Africa's highest user of electricity generators, most of which are imported.

Finally, the need to be contextual even in choice of energy source played a key part. The school is located in the tropics where there is abundant solar radiation. By opting for green energy in the form of solar energy, the school is being contextual and truly African in its operation and processes.

B. Stages o Implementation of the Green Energy System

Given the huge capital outlay for green energy, the school adopted a phased approach to the implementation. The first phase was a pilot project for the Girls Hostel which involved the use of thirty-six (36) polycrystalline solar panels. The pilot project was largely unsuccessful but provided a good

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learning experience. Efforts were made to identify experienced green energy practitioners and the school was fortunate to identify a parent whose job is green energy installation.

After the pilot phase, the first major solar installation was the Main Administrative and Academic Building (Jubilee Building) which was constructed between 2016 and 2018. The building has a gross floor area of about 3800 square meters and houses five laboratories, a bookshop, library, school central administration and school multi-purpose hall. Right from the onset, the building was designed with green principles in mind. It incorporated natural lighting and ventilation, low energy lighting, low energy mechanical fans and low building maintenance through the incorporation of brick finishing both internally and externally. On the roof, there are 180 solar panels of 280 watts each.

For Phase 3, this solar/inverter system sustains the operations of 31 classrooms and staff rooms in the four academic buildings (Olorunfunmi, Cusimano, Okogie and Salamone Blocks), refectory, chapel, clinic and some perimeter fencing bulbs. The Solar Panels are installed on the roof of the academic blocks, while the batteries, charge controllers, Inverters and other accessories are installed at the central point between the academic buildings. Altogether, 378 panels of 300watts each were installed. Other installation parameters are indicated in Table I. Low energy LED bulbs, fans and computers were adopted for energy optimization purpose. The aforementioned areas have been sustained by the solar/inverter system described in Phase 2. This system is supported by three wind turbines with 300watts combined capacity deployed to power the internet server system of the school.

The fourth and most extensive phase of the solar installation is the Afiawari Jesuit Green Park. It is built on a land outside the main school premises as delineated in Fig. 2. The plot of land doubles as car park for the school with the roof of the car park made of building integrated photovoltaic panels (BIPVs) as roof covering on steel framework. Altogether, there are 611 solar panels. The installation caters for electricity needs in the male hostel, female hostel, kitchen/cold room, giant LED screens in the school and for water pumping.

Low energy pressing irons for laundry purposes, low energy ceiling fans, energy efficient electric bulbs and other low energy appliances were adopted for energy optimization purpose. The solar panels are installed as the roof covering of the school's car park which was specially designed for this purpose. The power generated from the car park is transmitted to the control room located on the ground floor in one of the academic buildings housing the batteries, charge controllers, inverters and other accessories. With the commissioning of the Afiawari Jesuit Green Park, the school is running fully on green energy with a combined daily generation capacity of 1750KW. The details of the various components of the installations are as shown in Table I and Table II.

An intervening phase veered into other energy sources namely biogas plant and wind turbine. The biogas plant was conceived to supply gas to the laboratories, school restaurant using the waste from the reconstructed male toilet. The wind turbine (three in all) is dedicated to powering the school server rooms uninterruptedly. However, the biogas plant has not worked effectively due to the quality of the bio-waste being used.

Fig. 2. Aerial view of car park, hostels and academic areas [54].

C. *Green energy and Green Agenda*

The third objective of the study sought to know if the green energy adoption was part of an overarching green agenda for the school and to identify the other components of the green agenda. The green agenda includes other components. The school is a zero-plastic zone where single use plastics are prohibited. Single use plastics have been identified as a serious source of ecological damage especially in Africa where regulatory control is weak [24]. In the school, no PET bottles are allowed, and plastic based packaging materials are prohibited. Students drink treated water from designated fountains or from water dispensers.

TABLE I: SOLAR INSTALLATION DETAILS

Details	Jubilee Building	Academic Buildings	Car Park
Number of Panels	180	378	611
Capacity of Panel	280W	300W	330W
Manufacturers of the Panels	Yingli Solar	Yingli Solar	Yingli Solar
Maximum Generation Capacity	50.4kWh	113.4kWh	201.6kWh
Average Daily Generation	250KW	500KW	1000KW
Average Annual Generation	90MW	182MW	365MW
Average Generation from date of commissioning	273MW	365MW	20MW
Date of commissioning	July, 2018	September, 2019	September, 2021
Date of measurement	September, 2021	September, 2021	September, 2021

Each student is provided with a non-plastic drinking water bottle. Only paper-based and bio-degradable packaging materials are permitted. The school is also transiting to paperless operation as a way of conserving forest resources. Correspondence from the school to her various stakeholders is by electronic means. Students' results are also managed and transmitted electronically. Staff and related meetings are projected online to limit paper use.

The adoption of smart boards for teaching is to minimize or completely eradicate the use of board markers. Within the setbacks of the buildings, the school has established a botanical garden to promote a green environment. Disused school vehicle tyres are reused as vases for flowers and similar plants. The school compound is paved with concrete inter-locking tiles which are good for storm-water management. The school has a Green Club, which is a co-curricular activity aimed at promoting green principle among students.

TABLE II: DETAILS OF BATTERIES, INVERTERS AND CHARGE CONTROLLERS

Details	Jubilee Building	Academic Buildings	Car Park
Inverter Type	Victron	Victron	ATESS/GROWAT
Number of Inverters	3	3	2
Inverter Capacity	10kVA	10KVA	100KVA
Combined Capacity	30kVA	30KVA	200KVA
Type of Charge Controller	Victron	Victron	ATESS/GROWAT
Number of Charge Controllers	9	21	9
Capacity of Charge Controller	250V 100A	250V 100A	1000V 350A
Combined Hourly Capacity	60KVA	60KVA	60KVA
Manufacturer of Battery	Exide	Exide	Exide
Type of Battery	2V-1500AH	2V-1500AH	2V-681AH
Number of cells	48	48	200
Capacity	144kWh	144KWH	272.4KWH
Capacity (70%) DoD	100KWh	100KWH	190KWH
Day Load	15kWh	25KWH	50KW/H
Night Load	500Wh	2KWH	15KW/H

D. Challenges in the Adoption of the Green Energy System

The biggest challenge of installing a green energy system for schools is the cost. According to the installers of the green energy system, an installation of a 250KW (daily PV generation) and 30KVA inverter system may cost up to 30 million naira (about 60,000 dollars). The highest cost components are the batteries, solar panels, the inverters and the charge controllers. In a typical solar installation, the relative distribution of the costs of the components is as shown in Table III. The components are expensive because they are mainly imported from China, India, Europe, Japan and USA. Even though the battery component constitutes about 35% of total cost, this is often the most problematic aspect of the installations. Batteries lose potency quite rapidly and may require replacement before their expected life span.

According to an experienced solar PV installation vendor, battery life is often affected by depth of discharge (DoD) and the operating temperature at the place where the battery array is located. The depth of discharge is the amount of a battery's storage capacity that is utilized. A correlation has been established between depth of discharge (DoD) and battery life cycle. The more frequently a battery is charged and discharged, the shorter the life span. A DoD of 50% is usually recommended. The green installations in the school is between 40% and 50%. With respect to the environment of the batteries, the recommended operating temperature is 25 degrees Celsius.

Another challenge is availability of the technical knowhow needed to support green energy installations. Well trained installers are not readily available in the industry. As a result, some ill qualified personnel do fill the gap with very negative consequences.

TABLE III: RELATIVE COST OF SOLAR PV COMPONENTS

S/N	Solar PV Component	Percentage of Total Cost
1	Batteries	35
2	Solar Panels	25
3	Inverters	13
4	Charge Controllers	10
5	Installation Cables	5
6	Mounting Structure	5
7	Breakers and Safety Installations	2
8	Installation Costs	5

(Percentages are calculated from actual costs of installation of an existing project)

Solar renewable components are not readily available. Most solar installers only place order when the commission is approved. Moreover, batteries cannot be stored over a long period of time as potency would be lost. Sometimes, replacing malfunctioning systems can take several weeks and this may affect the efficacy of the solar system. There is also the challenge of refurbished batteries being sold as new batteries. Settlement of dust particles on the solar panels especially during the dry season can also impair the efficiency of the solar panels.

Similarly, according to the solar installation vendor, government policy has not been favourable for green energy installations. There are no import duty waivers for the importation of solar PV components. Sometimes, the clearing procedure at the seaports for imported solar components are cumbersome due to bureaucratic bottlenecks. Import duty on solar PV components range from 5% to 20%. There is no tax or other incentives for people who opt to install solar energy system.

E. Impact of the Adoption on the Students, Staff and the Immediate Environment

The adoption of green energy in the school has enhanced the image of the school as an institution projecting the values of sustainability. The students have adjusted well to the sustainable orientation of the school and have become green ambassadors themselves. The behavioural change in the students is very noticeable. The Habitat Club of the school promotes extra- and co-curricular activities targeted at improving the green rating of the school. The staff of the school are also fully involved in implementing the green agenda. For both staff and students, the adoption of green energy and other green practices by the school has engendered attitudinal changes. Practices such as turning off electricity when a room is not in use and effective disposal of solid wastes have become well established. The green energy adoption has also positively affected the immediate community. Other schools have made inquiries regarding the

green energy adoption with the view to adopting same. The immediate community to the school has been provided access to treated and clean drinking water facilitated by the green energy installation.

The adoption has also facilitated linkages between the school and some organizations involved in promoting sustainability in schools. The school now belongs to some green initiatives such as Youth Catholics for Nature. According to the School Administrator, the school has also been integrated into the school outreach programme of the Jesuit Global Task Force on Ecology.

VI. Conclusion

This paper presented the case of a Nigerian high school which fully adopted green energy for all operations. It was determined that the adoption of green energy was a well thought out plan and was executed with clearly defined objectives. The driving force for the adoption was the need to access cleaner, more sustainable and cheaper energy in the long run for the school. The school was also inspired by the pro-environmental stance of her proprietor base. It therefore implies that pro-environmental policies at the highest level of an organization can cause that orientation to cascade down the ladder to all facets of the organization.

Given the relative low level of adoption of clean energy in the study context and the high cost outlay required for such installations, the school proceeded cautiously and phased the project in such a manner that the finances of the school could support. After an experimental stage and the very successful experience of the Jubilee Building, two other major phases all followed within a time frame of four years. However, this phased approach made interconnectivity among the phases difficult such that each phase is a stand-alone installation.

Green energy adoption can only be very meaningful if it is integrated with other aspects of greening the environment for increased sustainability. The transition towards sustainability is a holistic one and should adopt an integrated approach. Other components of the green agenda were cheaper to implement that green energy. Hence, it is advisable for schools and other organisations to adopt the holistic approach and progress gradually but steadily towards incorporating all aspects.

The challenges of adoption of green energy are manifold and can be a major barrier to adoption. The initial cost is very high and can discourage many people. In addition, maintenance of the installation especially with respect to battery replacement can render the whole installation uneconomical.

In terms of the ripple effect of the green energy adoption, the school community and surroundings and other stakeholders are better informed about environmental issues. The students of the school have benefited from real-life examples of sustainability practice which has placed them in good stead to spread environmental education to other members of society. The pay-back period for the installation calculated in terms of amount spent on installation relative to the amount that would have been due to the public grid using current billing methodology is estimated to be about 6 – 8 years. Most importantly, the school has contributed to sustainability education and overall sustainability and has become a benchmark for other schools desirous of adopting clean energy. However, a mini-grid approach would have synergized the stand-alone systems currently in operation. Going forward, grid connectivity should also be considered. This is because greater efficiency is achieved when the advantages of renewable installations are integrated with grid connections.

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