

# **AN OVERVIEW OF ENERGY EFFICIENCY AND MANAGEMENT; A CASE STUDY OF RURAL ELECTRIFICATION AGENCY BUILDING IN ABUJA**

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## **ABSTRACT**

Sustainable energy management essentially plays a critical role in the socio economic activities of man and in the overall productive processes of a nation. Consequently, efficient energy utilization and robust management are key parameters that drive energy sustainability. Energy efficiency in this context can be viewed as a function of technological advancement, owing to the fact that what are regarded as efficient products in the 1970's and thereafter, have in contemporary time been replaced by the modern efficient ones. In the industries, obsolete equipment are giving way to more efficient and automated ones. Architects too have improved considerably in the design of energy efficient buildings, while in the transport sector, energy efficient automobiles that are eco -friendly are gradually emerging.

Energy Audit Devices deployed in the power sources of the building with behavioral and bioclimatic information as collated produced a reliable data that were used in this study and thus gave broad knowledge of Energy Efficiency and Management for our national economy.

**Key Words:** Audit, Efficiency, Green House Gas, Sustainability, Waste stream

## **1. Introduction**

As the socio economic activities of man continue to be on the increase with the population growth, there is also an inevitably proportionate rise in the energy demand, supply, consumption and the resultant cost. Globally, energy being the major driver of the activities of man and the world economy will certainly continue to be relevant in every facet of human endeavours. Energy gives life in everything man does, and that is why it is indeed unequivocal to emphasize that its indispensability leads to the issues of sustainability which is therefore a component of energy management.

Basically Nigeria is naturally endowed with energy resources such as crude oil, gas, biomass and huge potentials of renewable energy. Taking a closer look at the management of some of these resources from the various stages of exploration, production, transportation, distribution and consumption, there abound various energy waste streams which require urgent attention to swiftly curtail these wastages. A typical example is the case of the transportation sector where there are regular accidental explosion of PMS tanks on the highways and commercial city centres which quite often results to loss of human lives and other colossal damages that impact negatively on our economy. The inability of TCN to evacuate the bulk of energy been generated by GENCO as the result of insufficient and weak transmission, the unwillingness of DISCO to accept and inject the generated power as the result of weak distribution network among other issues often results to huge losses of energy. This among others points to the level of inefficiencies and lack of commitment in the energy management in our nation's economy. This work will however confine the discussion of energy efficiency and management in the consumption sector where the end user activities drive the processes

Over the years, successive administrations have invested a lot of efforts and resources to close the gap between electricity supply and demand in the country. However, such efforts focused largely on capital investments at supply side with little considerations to the demand side management, which is Energy Efficiency and Conservation. Energy efficiency and conservation globally is regarded as the cheapest and fastest form of generation and one of the main drivers of sustainable development in modern energy based economy. The efficient use of energy will enhance the sustainable use of natural resources and in turn contribute to national growth and sustainable development of a nation ECN technical report (2017). In addition, it is a means of climate change mitigation through greenhouse gas (GHG) emissions reduction. It is a major enabler of the United Nations' Sustainable Energy for All initiative.

Energy management can therefore be broadly defined as the process of carrying out planning and operation of energy production, transportation, distribution and consumption with the overall objectives of resource conservation and cost savings in the most environmentally friendly manner, while the users are guaranteed adequate access to the energy they need. In another perspective, it could be viewed as a means of controlling and reducing a building's energy consumption, which enables reduced energy costs of up to 25% ECN technical report (2017) in an office building thus mitigating carbon emissions in order to meet sustainability goals and regulatory requirements

It is therefore very essential to periodically carry out a study on energy management aimed at initiating a comprehensive and result oriented energy audit in public, industrial, commercial and the household building sectors, which could serve as a baseline data for energy management policy of nation. Energy waste stream could be noted to be very obvious in all these building sectors; the public building of Rural Electrification Agency (REA) was therefore considered to serve as a case study for this work. For emphasis, energy management can be classified as Energy Management System (EMS) and Energy Management Program (EMP).

## **2. Energy Management Systems (EMS)**

EMS is a form of energy control devices that display verities of functions which determine the procedures processes and sequential guidelines and established protocol that results to reduction of energy. It plays an important role in the systems operation as it aims at eliminating inefficiencies and energy conservation to the barest minimum; thereby leading to cost savings and resource optimization Capehart B. L, et-al (2003). EMS performs numerous functions that are based on the level of their complexity. Some of the familiar ones are as illustrated below for emphasis.

### *2.1. Supervisory Control and Data Acquisition (SCADA)*

This is one of the most complicated EMS which plays an outstanding role in power system control and operation. It forms the heart of EMS and performs data acquisition, updates the system status through alarm processing. It also updates the user interface, and executes control actions. Remote terminal units (RTUs) which are integral parts of the system perform the role of sensors and actuators in SCADA network. Other parts of the SCADA system are different types of telemetering and communication protocols. EMS/SCADA plays veritable roles in power system control and optimization.

### *2.2. Door Regulation Device (DRD)*

DRD as EMS is commonly found in some of the public buildings arena such as hospitality outfits where there are constant movements of people in and out. This type of EMS minimizes energy loss as the sensor inbuilt has the capacity to detect signals generated by the body movement and consequently sends the detected signals to the actuator that triggers opening and closing actions of the door way. This mechanism therefore maintains the ambient temperature with resultant energy cost savings.

### *2.3. Light Regulation Device (LRD)*

This EMS is one of the simplest EMS usually installed in public building in areas that require intermittent lighting for illumination where the practice of turning off lighting point at intervals is often nobody's responsibility. The inbuilt sensor detects instantly any vibration of body movement and activates the lighting functions to turn on and to turn off when the signal is lost. This action over time saves unimaginable energy cost.

## **3. Energy Management Program**

Energy management efforts usually been carried out by energy companies, agencies or institutions of government essentially comes up as a set of functions known as Energy Management Program (EMP). For clarity and vivid conceptualization of these sets of functions,

they are hereby presented and properly illustrated to give a holistic overview of energy management.

### *3.1. Awareness Creation/Sensitization*

Quite often, it is noted that overwhelming majority of energy end users are ignorant of some basic information on the application and usage of energy devices and facilities for optimum performance in a manner that would result to energy conservation. Also vital knowledge of some energy saving devices and procedure to be applied for maximum energy conservation might be lacking. This ignorance can therefore be overcome by the creation of comprehensive awareness program that would go a long way to sensitize the general public about the existing products and practices.

### *3.2. Promotion of Energy Efficiency*

This is another energy management program that tend to encourage energy users to imbibe the attitude of energy saving. It can be in form of incentives or labelling on energy products for end users the products being categorically classified for end users to have variety of choices. This offers the opportunity to have options of buying energy efficient devices even at a high price but with short payback period. This also enlightens the general public about the availability of the latest energy saving devices.

### *3.3. Education and Training*

This leads to enlightenment and broad knowledge on energy management which might be designated to a particular area of energy training. It could be of formal or informal program that would expose the energy end user to various processes of acquiring knowledge on the practices, process design, installations, maintenance and usage of energy facilities in the most efficient and environmentally friendly manner. This approach tends towards certification in various areas of energy management.

### *3.4. Capacity Building*

This is the aspect of training that leads to empowerment and possession of the innate ability to have control over energy products and devices in terms of its functionalities and usage. The goal is to ensure that the interested parties develop the required skills that are result oriented in a specified area of energy management.

### *3.5. Energy Audit*

This is one of the energy management programs that determine how energy can be efficiently managed or conserved. It is a means of exposing all energy waste streams in a clustered energy end use sources within a system or a building structure. There are two major aspect of energy audit which could be in form of 'walkthrough' that enables energy auditor to quickly verify

various areas that energy is been wasted and measures that could be taken in a building structure for energy savings. The second aspect which is detailed but diagnostic tend to have a holistic approach in the exposure of the energy waste streams.

### *3.6. Energy Codes and Standards*

This is a means of classifying structures such as building and end use devices in terms of their efficiency levels and Minimum Performance Standard (MPS). This enables the energy end users to have options for the types of products that could give the desired value for money. This also creates the policy instrument for phasing out obsolete products that are environmentally unfriendly.

### *3.7. Research Development and Demonstration*

Energy Efficiency improvement is understood to be a function of technological advancement which is consequently a product of research efforts. Every breakthrough in the manufacture of energy efficient devices and products are as a result of much commitment in research development and demonstration.

### *3.8. Energy Pricing*

Cost saving is basically the overall objective of energy management, therefore, by implication; efficiency is a function of energy pricing.

### *3.9. Efficiency Policy*

What derives compliance and enforcement in the issues of energy management and efficiency is policies which sets the guidelines for the implementation of the functions of energy management

### *3.10. Demand Side Management*

Demand side management addresses the challenges that arise with energy end use especially in power utility companies for the area of access and power stability during peak load. This leads to the issues of efficiency, load shedding, pick clipping etc.

### *3.11. Database for Energy Efficiency*

This serves as a repository for energy efficiency products such as structures and end use devices that are duly classified in forms of codes and labelling which can from time to time be referred as a guide for awareness and decision making and choice in time of need.

### *3.12. Awards for Energy Efficiency*

This type of award is to serve as incentive for companies and institutions that might attain the required benchmark for being energy efficient compliant and in the utilization of energy

efficiency devices; this could from time to time be determined by the Energy Commission of Nigeria in collaboration with stakeholders.

### *3.13. Promotion of Energy Services Companies (ESCOs)*

These are the private entities that play a vital role in energy efficiency implementation since their services can often be required by individuals and organizations in private or public sectors that might be desirous of reducing their energy cost. This approach would encourage the companies to put in their best in the course of the discharge of their functions if encouraged.

### *3.14. Networking for Improved Energy Efficiency*

Networking among energy management teams plays a vital role and gives room for energy improvement. This can be noted among household energy managers and industrial energy auditors. This essentially reduces energy cost as the collaboration creates room and opportunities for improvement in their respective efforts to cut down their energy cost.

### *3.15. Technical Cooperation/International Collaboration*

Collaborations amongst some international organizations in energy management such as International Renewable Energy Agency (IRENA), International Atomic Energy Agency (IAEA), UNIDO, GIZ etc. with the public and private sector of the country essentially create room for robust improvement in the nation's energy management program and consequently for national development.

## **4.0 Energy Audit of Rural Electrification Agency - Building**

For elaborate emphasis on energy management, and further illustration, we therefore present the energy audit of REA building carried out in the past by our energy audit team on behalf of the Energy Commission of Nigeria in collaboration with Japan International Corporation Agency (JICA). Rural Electrification Agency Building is one of the public buildings among others that were audited by the team. Public buildings can be observed as structures where the occupants/energy users are not property owners and therefore individually, they are not the ones paying the energy bills, in addition, it has multitude of occupants hence, the high possibility of negligence to energy management practices. Along with residential and service/commercial buildings, public building has many energy saving opportunities being a large consumer of energy. GEF (2011) illustrated that buildings use about 40% of global energy, 25% of global water, 40% of global resources, and emit approximately 1/3 of GHG emissions; making building sector one of the largest contributors to global GHG emissions. According to Thumann A. and Younger W. J. (2008) Residential and commercial buildings consume approximately 60% of the world's electricity. Yet, buildings also offer the greatest potential for achieving significant GHG emission reductions, at least cost, in both the developed and developing countries. Furthermore,

energy consumption in building can be reduced up to 30 to 80% with proven and commercially available technologies.<sup>1</sup>

#### *4.1. The Objectives*

The study was carried out to:

- a) Identify current energy consumption pattern and energy waste streams in public building
- b) Find out low-cost measures of reducing energy consumption
- c) Deduce baseline information to develop a National Energy Efficiency Programme and policy
- d) Demonstrate the advantage of integrating all the three components of energy audit studied; Behavioural, Renewable Energy and Bioclimatic Design.

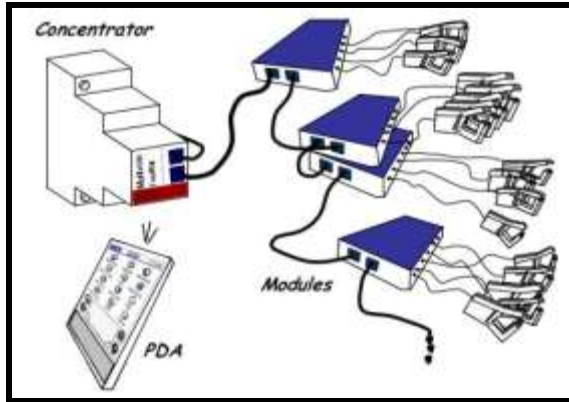
#### *4.2. Methodology*

The study monitored the real-time energy consumption of all electrical appliances in the Rural Electrification Agency buildings; assessed the attitudes of the users to electrical appliance and energy consumption in general, as well as verified the need and technical possibility of integrating renewable energy source(s) into the building's energy mix and, the building's compliance to bioclimatic design requirement and opportunities for improvement. Data was collected using Focus Group Discussions with the maintenance units of the building; review of existing literature/documentations such as monthly electricity bills, previous energy audit reports and others were carried out. Questionnaires were administered to the occupants to assess their level of awareness and compliance with issues on energy management. Also, there were direct measurements of actual energy consumption of the appliances in the building using energy logger devices; measurement of solar irradiation; orientation and inclination of roof-top; building orientation and sun path using Cardinal Compass.

##### **4.2.1 Energy Audit Devices**

##### **4.2.2 The Multivoies System**

The Multivoies System in fig.1 was developed by the French OmégaWatt Company. The logger device is designed for the measurement of several channels of power consumption and energies through the electrical Distribution Board. It has a rail-mounted concentrator to measure voltages and electrical power and several modules equipped with current sensors. The system interfaces with the user's Personal Digital Assistant (PDA) using infrared communication or low power radio (Bluetooth).



**Fig. 1: Multivoies system**



**Fig. 2: Serial wattmeter**

### **The Serial Wattmeter**

This logger device measured the active energy and voltage for single-phase appliances with power level lower than 2.6kW, with over one month autonomy. The Serial Wattmeter was developed by ENERTECH and it is placed in series between the standard socket outlet (up to 230V) and the plug of the appliance to be measured.

The other equipment used by the Energy Audit Team that enhanced the installation of the logger devices included portable aluminum ladders with collapsible property that can reach a height of over 1.5 meters; PVC gloves with protection against electric shock; standard tool box to enhance the installation of the logger devices and; Digital Multimeter that can measure up to 800V to test the quality of voltage before installing the logger devices.

### *4.3. Result Obtained*

The result as obtained on sources of power supplied to the building, power consumption of the air conditioners with other power appliances, behavioural energy audit and bioclimatic energy audit are hereby presented.

#### *4.3.1. Source of Power Supply*

There are two sources of power supply – power supply from the national grid and the use of standby generator during power outages. Fig. 3 shows the monthly electricity consumption of the REA building from 2014 to 2016 in kWh. The electricity consumed in the building was highest in the year 2014 followed by the year 2016. From the data made available to the Energy Audit Team, the electricity consumed in kWh was the same from July 2014 to February 2015. These values seem to suggest that the building was placed on estimated billing as it is not possible to have same value for six consecutive months.



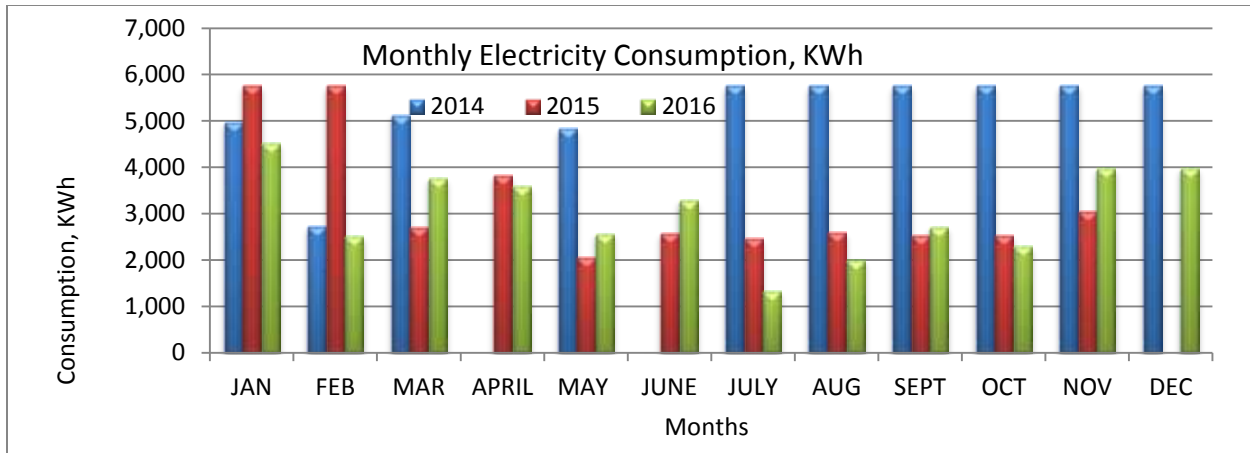


Fig. 3: Monthly Electricity Consumption for Years 2014–2016 in kWh

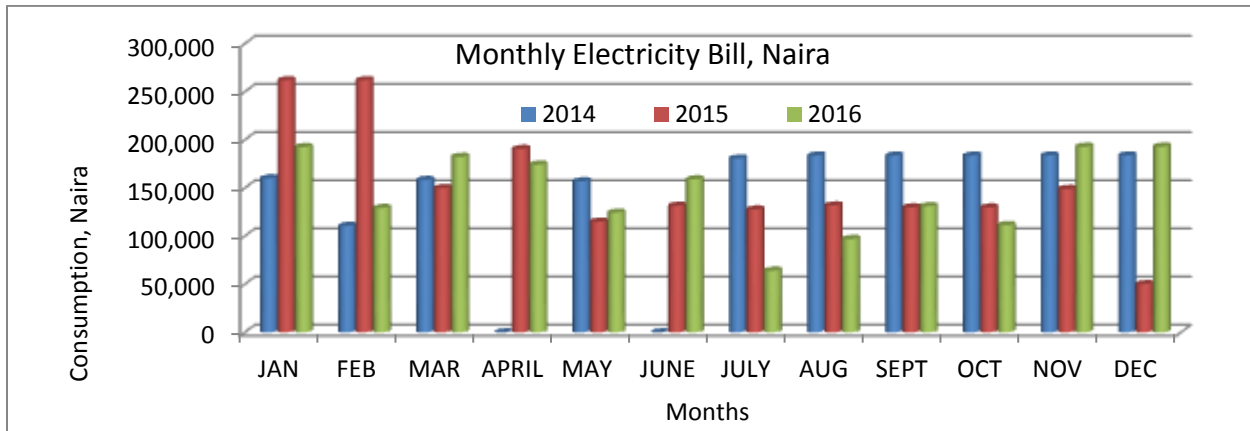


Fig. 4: Monthly Electricity Bill for the Years 2014–2016 in Naira

Conversely, the total electricity bill was highest in the year 2015 followed by the year 2016. The inverse relationship between the total energy consumed and the total cost is due to the difference in the unit cost of electricity. The unit cost for electricity in the year 2014 was N32/kWh, while the unit cost for electricity in the year 2015 was N50/kWh and the unit cost of electricity for the year 2016 was N48/kWh. REA building has two standby generating sets each rated 110KVA (pf=0.8) and each supply power to the building separately.

#### 4.3.2. Air conditioners

The air conditioners audited in the building were 50 in number and all are split unit. 21 of the ACs were installed on the ground floor, 15 units and 14 units on the second and first floors respectively.

From the measured values using the Multivoies System, the energy consumed by air conditioners in the building ranged from 535.1 to 2513.6kWh/yr. The total energy consumed by all air conditioners in the building was estimated to be 71,696.6 kWh/yr.

### 4.3.3. Measured Average Hourly Energy Consumption for Air Conditioners

The measured average energy consumption per hour of many air conditioners in the Agency are within plate label rating specified by the manufacturers except one of the many monitored in Fig.5, possibly because they are new and also split units.

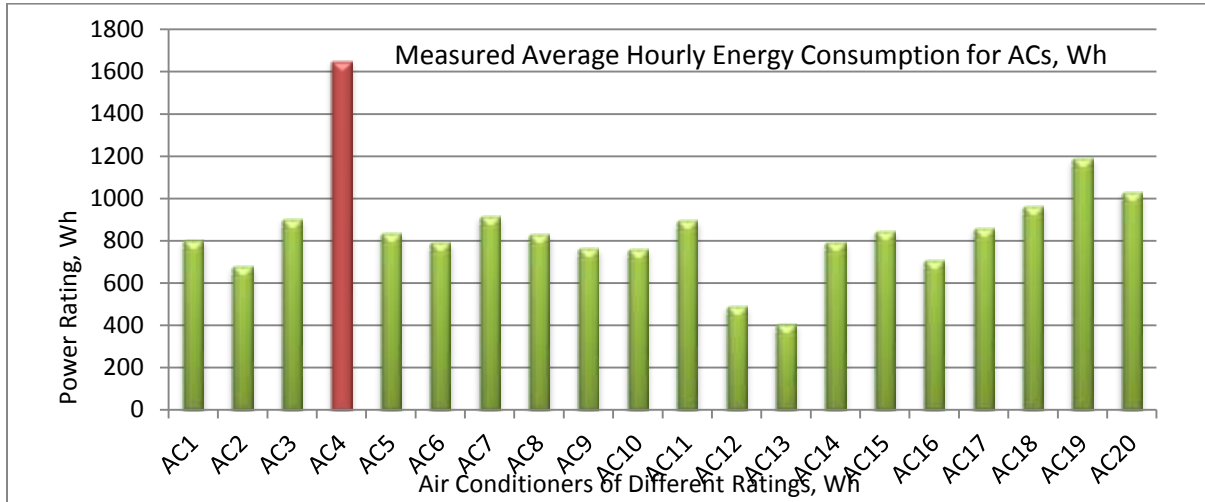


Fig.5: Measured Average Hourly Energy Consumption of Air Conditioners

### 4.3.4 Measured Average Hourly Energy Consumption for Other Appliances

The total energy consumption, lighting and individual air conditioners in the building were measured using multivoies system while serial wattmeters were used to measure the energy consumption of the Plug loads such as computers, printers, fans, refrigeration equipment, electric kettles, television sets and the results are as presented in the chart:

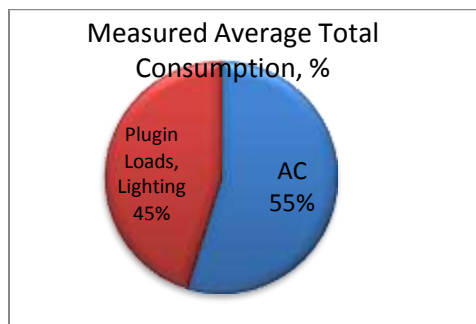


Fig. 5: Percentage of Total energy Consumption

## 5.0 Behavioural Energy Audit

Behavioural energy audit was planned at the Rural Electrification Agency for 37 interviewees, but only 32 were administered. The responses of the interviewees are summarized under three headings below:

### *5.1. Occupants' Awareness and Compliance*

Affirmative responses of the occupants to questions on turning off light switches after working hours, shutting down ACs when the office was unoccupied during working hours, closing the doors and windows of their offices when AC is in use, shutting down their desktop/laptop when not in use during working hours showed that most occupants are conscious of and comply with some energy management practices and requirements. Low culture of using desktop/laptop hibernation mode was the major non-compliance deduced from the energy audit results.

### *5.2. Management Responsiveness*

The strong affirmative response on the use of energy efficient lighting in the Agency is an indication of management responsiveness. Contrary to this is the non-availability of energy management devices, absence of window blinds. The building could make substantial gains by taking advantage of energy efficiency opportunities in the areas of efficient use of computers, laptops, and ACs; these will lead to cost savings and reduction in greenhouse gases (GHG) emissions.

### *5.3. Building Envelope*

REA occupies a residential estate meaning the buildings were originally not designed for office accommodation hence the inadequacy of the day light in many office rooms. Fixing of window blinds as requested by many respondents will increase occupants comfort and productivity.

## **6.0 Renewable Energy and Bioclimatic Design Energy Audit**

Energy assessment for possible integration of solar PV was carried out on the building and the results were presented in table 3.3.3 showing the possibility and availability of space for solar PV integration on the roofs and the parking lots. Table 3.3.4 shows the assessment of space for solar PV power house.

The irradiation, average sunshine hours, humidity and temperature for the location were all measured in relation with available values from literature as shown in table 3.3.6 this is to enhance effective design and optimum performance of solar PV system.

The entire building circuitry is made up of conduit system and integrating Solar PV System into it is possible. The building is made up of six flats each flat with separate distribution board, and all of them are available for use and require no modification, the electrical feeder pillar can equally be used but will require modification.

### *6.1. Summary of the Cost of Integrating Solar PV into the Energy Mix*

Below is the summary of Technical Specifications and cost of Integrating Roof-Top Stand Alone Mini Grid to Energy Mix of REA as alternative to Diesel Generator.

#### Option A: Powering the Entire Electrical Loads

1. Load (Mini Grid Capacity) = 59.162kW

2. Energy (Wh/day) = 236,651.04Wh/day at 4 hours
3. Module = 263Nos. (300W, 24V)
4. Battery = 19Nos. (1000Ah, 2V)
5. Charge Controller = 14Nos. (60A, 24V)
6. Inverter = 75kVA=1Nos @ 75kVA each (48Vd.c, 230Va.c)
7. Space for 263 Modules: = 609.26m<sup>2</sup>
8. Space for Battery Bank and Accessories = 12.056m<sup>2</sup>
9. Total Cost = N65,644,792.51

#### Option B: Powering the Entire Loads Less ACs

1. Load (Mini Grid Capacity) = 26.78kW
2. Energy (Wh/day) = 107,103.25Wh/day at 4 hours
3. Module = 120Nos. (300W, 24V)
4. Battery = 9Nos. (1000Ah, 2V)
5. Charge Controller = 7Nos. (60A, 24V)
6. Inverter = 35kVA = 1No. @ 35kVA; (48Vd.c, 230Va.c)
7. Space for 120 Modules: = 277.992m<sup>2</sup>
8. Space for Battery Bank and Accessories = 12.056m<sup>2</sup>
9. Total Cost = N31,983,053.00

The Energy Audit Team could not access the cost of supplying diesel for running the generators. However, going by the literature, a generator of 110kVA/88kW at half load consumes an estimated quantity of 12liters per hour. The two generators in REA operate below half load, hence, a 10litres per hour consumption was assumed; and at prevailing price of ₦260 per liter during the time of the study, it was computed that about ₦5.14million would be expended to run the two (2) generators four hours daily for 247 official working days. Assuming the maintenance cost of both systems (RE and diesel generator) are equal, the simple pay-back period was calculated to be about thirteen (14) years for option ‘ A’ and (13) years for option ‘B’. It is expected to be shorter with time because the operational cost of diesel generator is expected to be higher as result of continuous increase in price of diesel per litres.

#### *6.2. Bio-Climatic Design Energy Audit*

The building is residential converted to office space; hence most of the partitioning is permanent and made of blocks. There are no huge trees serving as shading to the solar radiation entering the building. The building has some buffer spaces and sun breakers.

##### *6.2.1 Building Orientation:*

This is very important in the aspect of minimizing heat gains. The orientation of the building with respect to the sun-path is very important. The location of the agency’s two building is at angular to the sun-path which implies there is some heat gain into the building. The majority of windows in the two buildings are facing north and south which is the best orientation for this climate. However some windows are located on the east and west side of the building which allows some solar radiation directly into the building; but, the presence of large balconies (buffer spaces) and sun breakers completely and partially respectively prevented solar radiation entering into the building.

S/N	Assessment parameters	Availability	Possibility	Inclination (°)	Orientation	Remarks
1	Roof-top 1	Yes	Yes	≤ 30	North, South	S40W, N40E
2	Roof-top 2	Yes	Yes	≤ 30	North, South	S40W, N40E
3	Roof-top 3					
4	Parking lot 1	Yes	Yes	-	-	Uncovered
5	Parking lot 2	Yes	Yes	-	-	Uncovered

Roof- top 1: Main Building, Roof-top 2,3: Annex Building, Parking lot (PL) 1: Management PL, Parking lot 2: Staff PL.

Item	Availability	Possibility	Size(m)
<b>Space for control room</b>	Yes	Yes	Vacant Plot Unquantified.

S/N	Assessment Parameter	Readings	
		Measured	Literature
1.	Irradiation (kW/m <sup>2</sup> )	7.80kW/m <sup>2</sup>	5.337 kW/m <sup>2</sup>
2.	Average sunshine daily hours (Hr)	10hours	6hours
3.	Humidity of the area (%)	38.5%	(36 - 46)%
4.	Temperature (Degree Celsius)	41.3 <sup>0</sup> C	(19-45) <sup>0</sup> C

Instrument: solarimeter; NIMET data for the last 5 years

## 7.0 Findings

- a) Among the key findings observed was inadequate sizing of back-up generating set.
- b) Most of the plug loads surveyed during this study were found to be efficient when compared with the manufacturer's rating
- c) The study discovered that occupants' ignorance and/or neglect of the in-built energy saving mechanisms and procedures in appliances contributed to energy waste stream in public buildings.
- d) Disregard for operational procedures of some electrical appliances and violation of standards of electrical circuitry and accessories in buildings. For example, the cumulative percentage of the

users/occupants in all the three buildings that were in the habit of leaving the ACs on when their offices were un-occupied during working hours for an average of 30 minutes weekly wasted 195,309kWh or over ₦9 million per year.

e) Other findings were reported delays in attending to repairs, maintenance and replacement of appliances/equipment and other components such as doors, windows, partitioning etc. For instance, a faulty switch in an office room in ECN that was not fixed promptly wastes 407kWh of electricity or over ₦19,000 annually.

f) Windows with small area made it impossible to take advantage of day lighting and ventilation. Similarly, poor design and materials of partitioning and, poor-geometry of doors and windows in the buildings surveyed were discovered to be additional energy waste streams, especially for cooling; where lowest achievable temperature was 25°C despite continuous working of AC.

g) The assessment of integration of Solar PV into the public buildings showed that it was a completely viable alternative to diesel generator and will cost from ₦32m (26.78kW) to ₦184m (156.25kW) depending on the option and building. The pay-back period ranges from 13 years for 26.78kW Solar PV Plant.

### **7.1 Benefits of the Study to the Environment and Economy**

It has been established that one third of the Green House Gas emission emanate from buildings since buildings consume 40% of global energy; buildings also offer the greatest potential for achieving GHG emission reductions at least cost, GEF (2011). Significant reduction of energy consumption and highest energy savings was therefore realized in this work by combination of energy audit of electrical appliances/equipment, behavioural energy audit, renewable energy audit and bioclimatic design energy audit. Reduction in energy wastages, bills as well as GHG emissions was attained. The reduction of energy wastages and bills has addressed the issue of energy pricing since price reduction drives energy efficiency as was illustrated above. The baseline data which was generated could be used to draw the benchmark for an effective policy planning and it therefore, addresses policy issues in energy management of the economy.

### **8. Conclusion**

In line with the study's objective, all the three components, namely, electrical energy audit (real time measurement of energy consumption of appliances/equipment), behavioural energy audit and, renewable energy and bioclimatic design energy audit were successfully conducted in all the Rural Electrification Agency Building. Each of the four components strengthens the other and produces the highest energy savings.

Evaluating achievement of the study's objectives; the energy consumption pattern in public buildings was assessed and major energy waste streams identified, attitude of energy users or building occupants was linked to energy consumption and wastages, impacts of bioclimatic design of building on its energy consumption were assessed and viability of solar photovoltaic electricity as alternative to age-long diesel generator was established.

The study therefore successfully covered the objectives though it is not exhaustive, further researches on the findings of the present study using the integrated energy audit approach (adopted in this study) in public buildings in Abuja and other cities around the country will avail the nation the opportunity of generating comprehensive and representative baseline data that would be used in defining the general energy use/consumption pattern in public buildings. Such baseline data will assist the government as the owner of the buildings to develop remedying policies, implementation plan and regulations geared towards reduction of energy consumption in public buildings.

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