Promoting Energy Efficiency and Conservation

Initiatives and Lessons from Nigeria

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Abbreviations and Acronyms

AC	Alternating-current
ADEME	French Environment and Energy Management Agency
AEC	annual energy consumption
Amp	Ampere
ASYCUDA	Automated System for Customs Data
BEEC	Building Energy Efficiency Code
BEEG	Building Energy Efficiency Guideline
BTU	British Thermal Units
CFCs	chlorofluorocarbons
CFLs	Compact fluorescent lamps
CLA	Country Lighting Assessment
CO_2	carbon dioxide
CPC	Consumer Protection Council
CREDC	Community Research and Development Centre
DisCos	Distribution Companies
EC	European Commission
ECC	Environmental Controlled Chamber
ECN	Energy Commission of Nigeria
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EEI	Energy Efficiency Index
EER	Energy Efficiency Ratio
EPR	Extended Producer Responsibility
EU	European Union
FCCPC	Federal Competition and Consumer Protection Commission
FCT	Federal Capital Territory
FMP	Federal Ministry of Power
FME	Federal Ministry of Environment
GEF	Global Environment Facility
GenCos	Generation companies
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOGLA	Global Off Grid Lighting Association
GWh	gigawatt hour
HID	High Intensity Discharge
HOFA	Hotel Owners Forum Abuja
ICLs	Incandescent lamps
ICREEE	Inter-Ministerial Committee on Renewable Energy and Energy Efficiency
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
Kg	Kilogram
kW	Kilowatts
kWh	kilowatts hour
LCC	Life Cycle Cost
LED	Light emitting diode
LFLs	Linear Fluorescent Lamps
MAN	Manufacturers Association of Nigeria
MDAs	Ministries, departments and agencies
MEPS	Minimum Energy Performance Standards
$MJ/m^2/day$	Megajoule per meter square per day
MT	Metric ton
Mtoe	Million tons of oil equivalent
MV&E	monitoring, verification and enforcement
MW	Megawatts
NACOP	National Council on Power
NARWOA	National Association of Refrigeration Workshop Owners Association
NCEEC	National Centre for Energy Efficiency and Conservation
NCS	Nigeria Customs Service
NEEAP	National Energy Efficiency Action Plan
NEP	National Energy Policy

NERC	Nigerian Electricity Regulatory Commission
NES	National Energy Savings
NESP	Nigeria Energy Support Programme
NGOs	Non-governmental organizations
NIS	Nigerian Industrial Standard
NOA	National Orientation Agency
NPV	Net Present Value
NREEEP	National Renewable Energy and Energy Efficiency Policy
NUC	National Universities Commission
ODP	Ozone depleting potential
OECD	Organization for Economic Co-operation and Development
OEMs	Original Equipment Manufacturers
PAMS	Policy Analysis Modeling System
PDA	Personal Digital Assistant
ppm	Part per million
ppmv	Part per million by volume
PSR	Power Sector Reform
PTAC	Packaged Terminal Air Conditioners
PV	Photovoltaic
R&D	Research and Development
RAC	Refrigeration and Air Conditioning
REA	Rural Electrification Agency
RETS	Renewable Energy Technologies
S&L	Standards and label
SE4ALL AA	Sustainable Energy for All Action Agenda
SE4ALL	Sustainable Energy for All
SEA	Swedish Energy Agency
SFM	Sustainable Fuelwood Management
SON	Standards Organization of Nigeria
ST	Subtropical
T	Tropical
TWh	Terawatts hour
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USA	United States of America
USD	United States Dollars
V	Volts
W	Watts

Preface

Energy efficiency is defined as improvements in practices and products that essentially help to reduce the energy necessary to provide services such as lighting, cooling, heating, manufacturing, cooking, transport, entertainment, among others. To be specific, energy efficient products help to do more work with less energy. Energy efficiency is one of the bedrocks of sustainable development. It has also been described as one of the cost-effective instruments to help slow the global growth in energy demand. Improvements in energy efficiency practices can enhance energy security, lead to load reductions and higher reliability of energy systems. Furthermore, energy efficiency will help to reduce vulnerability to high and volatile energy prices, and lower environmental impacts, including greenhouse gas emissions. Promoting energy efficiency best practices is a win-win option, providing benefits to the government, energy consumers and the environment.

In Nigeria and other West African countries, the governments and other stakeholders have taken tremendous steps to promote energy efficiency and conservation. This is particularly relevant for Nigeria because of the numerous challenges in the country's power sector. The aim of this book is to help readers understand the basic concept of energy efficiency and the link to the subject of climate change. More importantly, the book highlighted the several initiatives, studies and activities embarked upon in Nigeria to strengthen the policy and regulatory environments in order to adopt energy efficiency best practices. As an outcome of these activities, the Nigerian government, within the past decade, has put in place several policy and regulatory instruments that will help to encourage stakeholders to imbibe energy efficiency and conservation. These policy documents and their relevance to the Nigerian environment and economy are described in this Book.

The several energy-related market studies that were carried out in Nigeria were designed to provide the needed information to help government make the right policy decisions to drive the energy efficiency subsector. Several of these studies, their findings, and their contributions in shaping the policy and regulatory environment in Nigeria are discussed in this Book. The communication strategies that were implored to educate stakeholders on government policies are also discussed. Capacity development, especially of public personnel is pivotal to sustain the energy efficiency initiatives and programmes. These activities that were carried out to build the capacity of stakeholders in the process to promote energy efficiency are described in this Book. Also presented in this Book are the brief description of donor-supported projects to promote energy efficiency in Nigeria.

CHAPTER ONE

ENERGY EFFICIENCY AND CONSERVATION

Definition of Energy Efficiency and Conservation

If you have been using an incandescent lamp of 60W to light a standard room, you can as well use LED lamp of 10W and still get the same or better illumination. By replacing the 60W bulb with 10W LED bulb, you have made significant saving in your energy bill. Energy efficiency entails using energy in a manner that will minimize the amount of energy needed to provide certain services. It can also be defined as the improvement in practices and products that reduce the energy necessary to provide services[1]. If we use energy efficient appliances, it will help to reduce the energy necessary to provide services like lighting, cooling, heating, manufacturing, cooking, transport, entertainment etc. Hence, energy efficiency products essentially help to do more work with less energy. Energy efficiency describes how much useful work can be obtained from a system from a given amount of input energy. Energy efficiency was further defined as the ratio of energy required to perform a specific service to the amount of primary energy used for the process[2]. Hence, improving energy efficiency increases the productivity of basic energy sources by providing given services with less energy resources.

The term energy efficiency may sometimes be used interchangeably for energy conservation; these two terms do not exactly have the same meaning. Energy conservation refers to practices that help to reduce the need for using energy particularly electricity to achieve greater overall efficiency. For example, the use of solar water heater helps to capture thermal energy of the sun and heat up water and stored it in an insulated storage tank. With the solar heater, the use of electricity to produce heat will be minimized or completely avoided. This practice can also be seen in the transport sector when workplaces are located closer to public transport or closer to living areas. This will help to minimize or avoid the use of automobiles to go to workplaces. Energy conservation could also mean actions taken to reduce the amount of energy used by changing behavior, such as turning off personal computers when not in use. It can also involve using technologies, such as room occupancy sensors for lighting, which reduce energy use without someone having to remember to turn-off the light.

End-use efficiency refers to technologies, appliances or practices that improve the efficient use of energy at the level of the final user, such as the electrical appliances we use in our houses and offices. Though this term is not limited to electrical appliances, it can also be used for other forms of energy such as measures to improve the ability of houses to absorb and retain heat in winter and keep out heat in the summer. Governments can work with electricity distribution companies to implement policies that will encourage consumers to use less electricity. This can be done using demand-side efficiency. Demand-side efficiency is interchangeably used as demand-side management. Demand-side efficiency can be policies implemented by utilities and energy planners that encourage consumers to use energy more efficiently. An example of this is load shifting, which include encouraging consumers to move their energy use away from peak period.

There are two important ways we can approach energy efficiency and conservation. The first approach requires changing the type of technology we use in our buildings. We can replace our energy intensive appliances with more efficient ones. The second approach requires change in human behavior, that is changing the ways we do things. For example, we can replace our incandescent light bulbs rated 100W with LED light bulb of 20W. As shown in Table 1.1 below, by simply replacing an incandescent lamp (ICL) of 100 W with a compact fluorescent lamp (CFL) of 20 W, resulted in cost saving of N5234.69 annually and 83.81 Kg of CO_2 abated annually. If we are to leave our hotel room for a couple of minutes, we can simply

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[1] GEF-UNDP. Promoting Energy Efficiency in Residential and Public Sector in Nigeria: Project Training Manual. An unpublished document of the GEF-UNDP Energy Efficiency Programme, 2011

[2] Kreith, F. and Goswami, D. Y. Handbook of Energy Efficiency and Renewable Energy. CRC Press, Taylor & Francis Group, 2007.

switch off the air conditioners, and other appliances since the room will not be occupied for a period of time. By simple change of behavior could result in significant saving in our energy bill.

Table 1.1: *Energy and emission savings from transiting to energy efficient lighting product*

Appliance	Wattage (W)*	Estimated Daily Use (hrs)	Annual Electricity Consumption (kWh)	Emission Factor (kg CO_2/kWh)	Annual CO_2 Emission (kg)	Electricity Cost (₦/kWh)	Annual Cost (₦)
Bulb (ICL)	100	3.5	127.75	0.82	104.76	51.22	6543.36
CFL	20	3.5	25.55	0.82	20.95	51.22	1308.67
Savings					**83.81**		**5234.69**

Importance of Energy Efficiency

Reduction in GHG Emission: Emission resulting from energy generation contributes significantly to the concentration of greenhouse gases (mainly CO_2) in the atmosphere. In the process of converting primary energy sources such as fossil fuel to secondary forms of energy such as electricity, much energy is lost. Over 65% of the fuel energy used in a thermal power plant is lost in the process of generating electricity[3]. About 9% of the generated electricity is lost during transmission and distribution. Thus, the amount of electricity entering a building or facility represents only 30 percent or less of the original fuel energy. Promoting energy efficiency at the level of the end users can help to avoid the building of more power stations, as well as abate the emission of greenhouse gases.

Access to Energy: Energy efficiency can help to free more energy in a system and the freed energy can be made available to others. UNEP estimated that Nigeria can save 3.7 TWh of electricity (equivalent to the energy produced by 500 MW power plant) annually if she transits to the use of energy efficient lighting products; this will lead to an annual saving of $230.6 million and a payback period of 10 months (Fig. 1.1)[4].

Sustainable Resource Management: For non-electricity forms of energy such as the use of biomass materials, energy efficiency will play a pivotal role in the sustainable management of these resources. The rate of deforestation can be greatly reduced if consumers are encouraged to use energy efficient cooking stoves. In the transport sector, engaging in massive energy efficiency practices can greatly reduce the use of fossil fuels thereby enhancing the quality of the environment and the economy. Improving energy efficiency across all sectors of the economy is an important national objective because achieving a savings potential through energy efficiency could increase national energy security.

System Optimization: Utilities can also apply energy efficiency best practices to optimize their systems. Furthermore, energy efficiency will help to encourage the use of environmentally friendly energy sources such as renewable energy sources as well as increase energy security[5].

[3] Kreith, F. and Goswami, D. Y. Handbook of Energy Efficiency and Renewable Energy. CRC Press, Taylor & Francis Group, 2007.
[4] UNEP enlighten Initiative. On-grid Country Lighting Assessment – Nigeria. 2010
[5] Turkoglu, S. P. and Kardogun, P. S. O. The role and importance of energy efficiency for sustainable development of countries. Springer International Publishing AG, part of Springer Nature 2018. First S. et al (eds) Proceedings of the 3rd International Sustainable Buildings Symposium (ISBS 2017).

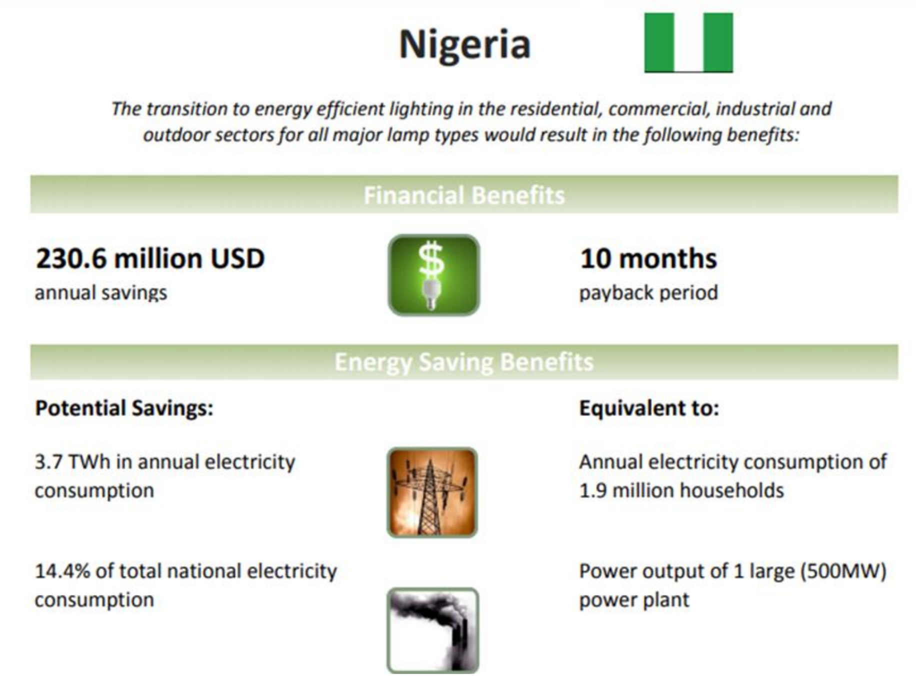


Fig. 1.1: Benefits of transiting to energy efficient lighting products in Nigeria
(Source: UNEP, 2010)

In general, the benefits of energy efficiency are summarized in Table 1.2 below.

Table 1.2: Importance of energy efficiency

Access	**Enables expansion of energy supply to more people from the existing infrastructures**
Development/Growth	support economic growth, via improving commercial and industrial productivity and reducing fuel import bills
Local pollution	Both supply and end-use efficiency can help to reduce the need for generation – and lower associated emissions – while supporting economic growth
Climate change resilience	Less need for energy infrastructure, thus reduces the amount of energy assets exposed to extreme weather events.

Energy Efficiency and Relationship with Climate Change

In simple terms, climate change refers to the modifications in the earth's climate caused by natural and man-made (anthropogenic) factors. The energy from the sun is the driving force of climate change. The variations in the incident solar energy on the earth's surface naturally alter the climate. The natural causes of climate change are not considered as highly significant factors. The presence of certain gases also called greenhouse gases present in the atmosphere help to maintain the earth's increased temperature because they prevent the infrared radiation coming from the earth surface to escape into the atmosphere. Thus, the climatic conditions of the earth, mainly temperature are defined by these gases. The atmosphere is a mixture of gases which include nitrogen, oxygen, water vapor and other gases such as carbon dioxide (CO_2), methane, nitrous oxide and chlorofluorocarbons (CFCs)[6]. Nitrogen and Oxygen are transparent to infrared radiation, this means that they do not block infrared radiation from escaping into the atmosphere.

[6] Walker, G. C. J. (1977). *The Evolution of the Atmosphere*. Macmillan Publishing Company

However, the other gases such as water vapor, CO_2, methane, nitrous oxide and CFCs block infrared radiation from escaping into the atmosphere, water vapor being the most efficient infrared blocker.

It is worthy to note that without the presence of these gases - CO_2, methane, water vapor and nitrous oxide, heat emitted from the surface of the earth would be lost entirely. Many of these greenhouse gases are found naturally in the atmosphere, while some of them such as CFCs are introduced into the atmosphere as result of human activities. However, the concentration of some the naturally occurring gases such as CO_2, methane and nitrous oxide are increasing in an alarming rate due to human activities and development. The concentration of CO_2 and methane in the atmosphere reached 387 ppm and 1.5 ppmv respectively. Although the concentration of CO_2 is much higher than the concentration of methane, the latter is 20 times opaquer to infrared radiation than CO_2. Naturally, CO_2 is released into the atmosphere from the respiration of living organisms, volcanic eruptions and decomposition of organic materials. Methane is produced naturally from the anaerobic decomposition of organic materials in the temperate regions and from the activities of ruminant animals. Nitrous oxide is produced naturally from the activities of bacteria in land and sea ecosystems.

The basic causes of climate change come from the anthropogenic activities, chiefly the emission of CO_2 and other greenhouse gases into the atmosphere. There are three fundamental factors leading to the emission of greenhouse gases. The first one is the exponential growth of species population, the second which is much more important than the first is the demand for energy and resources and the third is the type of technology that has been deployed by man for industrial and economic development activities. From 1850 to 1970, global population increased by a factor of 3 while the demand for energy increases by a factor of 12. Similarly, while the world population increased by 68% in 2002, the demand for energy generated by the burning of fossil fuel increased by 73%[7]. The atmospheric CO_2 concentration was relatively stable prior to the industrial revolution, hovering between 200 and 280 ppm. But human activities have increased the concentration of CO_2 to more than 387 ppm in less than two centuries and over 400 ppm as of 2018 (Fig. 1.2). Carbon dioxide is the most important of Earth's long-lived greenhouse gases. It absorbs less heat per molecule than the other greenhouse gases such as methane or nitrous oxide, but it is more abundant, and it stays in the atmosphere much longer. Increases in atmospheric carbon dioxide are responsible for about two-thirds of the total energy imbalance that is causing Earth's temperature to rise[8].

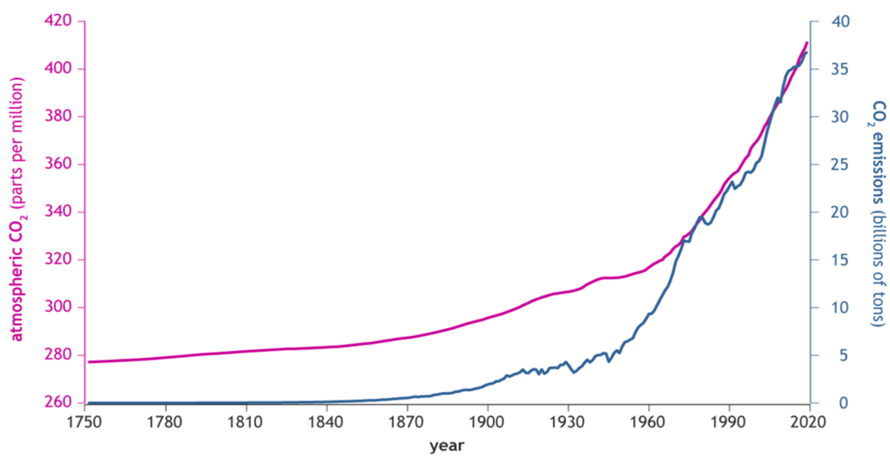


Fig. 1.2: CO2 in the atmosphere and annual emission 1750-2019
(Source: NOAA climate.gov)

[7] Carabias, J., Molina, M. and Sarukhan, J. (2010). *Climate Change: Causes, Effects and Solutions*. A publication of DGE/Equilibrista, SA de CV/Fundacion Coca-Cola and Secretaria de Relaciones Exteriores, Mexico. ISBN: 978-607-7874-295

[8] Climate change: Atmospheric Carbon Dioxide. https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

The global responses to addressing the threats posed by climate change are in two folds – climate change mitigation and adaptation. Mitigation measures involves actions, projects or activities carried out to reduce the emission of greenhouse gases. Well known climate change mitigation measures are the use of renewable energy technologies and promoting energy efficiency. Climate change adaptation involves measure put in place to help countries cope with the impacts of climate change. The Intergovernmental Panel on Climate Change (IPCC) defined adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploits beneficial opportunities. Climate change adaptation can also be defined as an understanding of how individuals, groups and natural systems can prepare for and respond to changes in climate or their environment[9].

Many parts of the world are already impacted by the effect of climate change; some are experiencing flooding, sea level rise, frequent natural disasters, drought and famine etc. Programmes and activities embarked upon to help those already affected by these changes are referred to as adaptation. While mitigation tackles the causes of climate change, adaptation tackles the effects of the phenomenon. The potential to adjust in order to minimize negative impacts and maximize any benefits from changes in climate is known as adaptive capacity. A successful adaptation can reduce vulnerability by building on and strengthening existing coping strategies.

Energy Efficiency Best Practices

It is important to discuss the energy efficiency best practices that have been adopted in different parts of the world. Energy efficiency best practices can be applied in difference sectors; it can be applied in the building sector, industrial, appliance, transport, forestry, and agricultural sector. Below are some of the energy efficiency and conservation best practices:

Energy Standards and Label

Energy standards and labels (S&L) are used in many countries of the world, including Nigeria to enhance the efficient use of energy. They offer a huge opportunity to improve the energy efficiency of buildings, equipment and appliances and are effective to implement energy policies and regulations. They have the potential to transform any market by gradually removing inefficient products from the market and proliferate the use of energy efficient products.

Energy Standards

Energy standards, also referred to as minimum energy performance standards (MEPS) or sometimes "efficiency standards" are specified minimum energy efficiency levels products must meet before they can be legally sold in any country. MEPS can also be defined as descriptions containing performance requirements for devices using energy, that limits the maximum amount of energy that the device consumed in the process of performing task. Energy efficiency standards are defined as procedures and regulations that prescribe the energy performance of manufactured products, sometimes prohibiting the sale of products that are less efficient than a minimum level[10]. Energy standards are set before products are allowed into a country and sold. MEPS are mandatory standards and are done in a manner that they balance technical possibility with economic viability and the competitive force within a particular market (Fig. 1.3).

[9] Mitchell, T. and Tanner, T. (2006). Adapting to Climate Change: Challenges and Opportunities for the Developing Community. A Publication of Tearfund, UK.

[10] Wiel, S. and Mcmahon, J. E. Energy Efficiency Labels and Standards: A Guidebook for Appliances, Equipment and Lighting – Second Edition. Collaborative Labeling and Appliance Standards Program (CLASP), Washington DC, USA. 2005

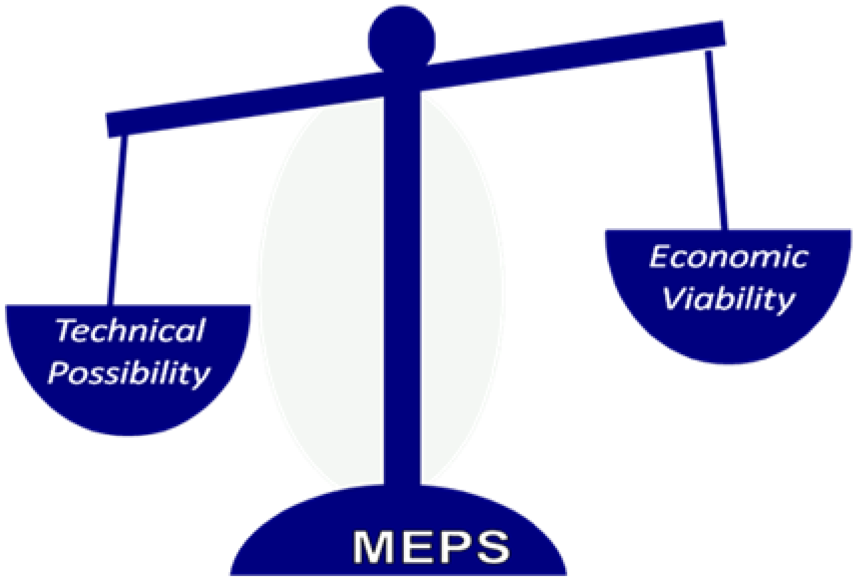


Fig. 1.3: MEPS should balance between technical possibility and economic viability

There are three types of energy efficiency standards – Prescriptive Standards, Minimum Energy Performance Standards (MEPS) and Class-average Standards. Prescriptive Standards require that a particular feature or device be installed in all new products. MEPS prescribe minimum efficiencies (or maximum energy consumption) manufacturers must achieve in each and every product, specifying the energy performance but not the technology or design details of the product. Class-average Standards specify the average efficiency of a manufactured product, allowing each manufacturer to select the level of efficiency for each model so that the overall average is achieved[10]. Table 1.3 provides the overview of existing MEPS in Nigeria.

Table 1.3: Nigeria energy performance standards

Reference Number	Title	Description
NIS 747:2012	Self-ballasted lamps for general lighting services – Performance requirements	This standard specifies the performance requirement together with the test methods and conditions required to show compliance of compact fluorescent lamps with integrated means of controlling starting and stable operations
NIS ECOSTAND 071-1:2017EE	Minimum Energy Performance Standards – Part 1: Refrigerating Appliances	It prohibits the manufacturing and importation of any refrigeration equipment with Energy Efficiency Index above 80
NIS ECOSTAND 071-2:2017EE	Minimum Energy Performance Standards – Part 2: Air Conditioning Products	Prohibits the manufacturing and importation of air conditioners with Energy Efficiency Ratio (EER) below 2.8

Sources: SON Gazettes, 2012, 2017

Energy Labels

Energy labels are fixed to electrical appliances to show the accurate energy consumption information on the products. This information will help the consumers to take decision on the products, that is whether to buy the product or not. Among others, energy label provides information on the amount of energy an appliance consumes as well as the energy efficiency level of the equipment. The appliances that are commonly labeled in many countries include refrigerators, freezers and air conditionals and a range of other appliances such as rice cookers, boilers, lighting products and washing machine. Two categories of labels are widely used - Endorsement Labels and Comparative Labels.

Endorsement label: Endorsement label points out to consumers that products meet a predetermined energy standard or eligibility criteria. They are essential “seal of approval” placed on a product according to specified criteria. This type of label informs the consumer that the products meet certain required standard.

Examples of an endorsement label are the Energy Star Label used in the USA and NIS Quality Mark used in Nigeria, Fig 1.3. The Energy Star Programme is implemented by the United States Environmental Protection Agency and the US Department of Energy. The goal of the Programme is to help consumers, businesses, and industry save money and at the same time protect the environment through the adoption of energy efficient products and practices. The ENERGY STAR label help consumers to identify top-performing, cost-effective products, homes, and buildings[11]. The Energy Star program has helped drive investment in energy efficient products, technologies, and practices[12]. The program uses a variety of strategies to catalyze market transformation. The Nigerian Industrial Standard (NIS) Quality Mark certification is awarded under the Voluntary Product Certification Scheme (NIS Mark of Quality) to products for their compliance with the Nigerian Industrial Standards at production and on the market level. The mark shows quality standard production and products.

Fig. 1.4: Energy Star Label (USA) and Nigerian Mark of Quality

Comparative Label: As the name implies, comparative label allows consumers to make comparison and choose among the same type of products the one that is more efficient. The label gives the ranking of products in terms of the energy consumption and the level of energy efficiency. Comparative labels comprise of a scale with defined efficiency categories. This type of label allows consumers to easily assess the efficiency of a product in relation to an absolute scale, by means of a simple numerical or ranking system[13].There are different types of comparative labels, and they may be particular to a country or region. The different types are discussed below:

[11] https://www.energy.gov/eere/buildings/energy-starr

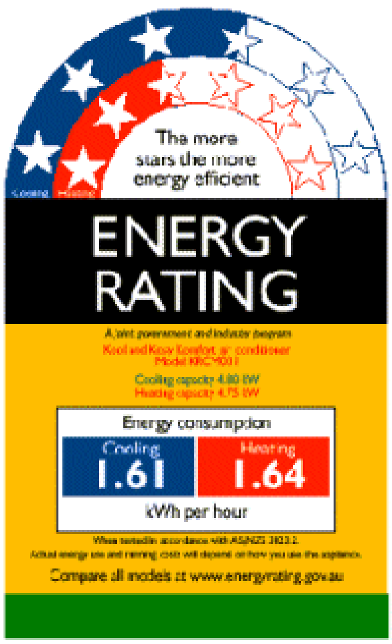
[12] US Environmental Protection Agency, Office of Inspector General. Energy Star Label Need to Assure Superior Energy Conservation Performance: A Summary Report 2010

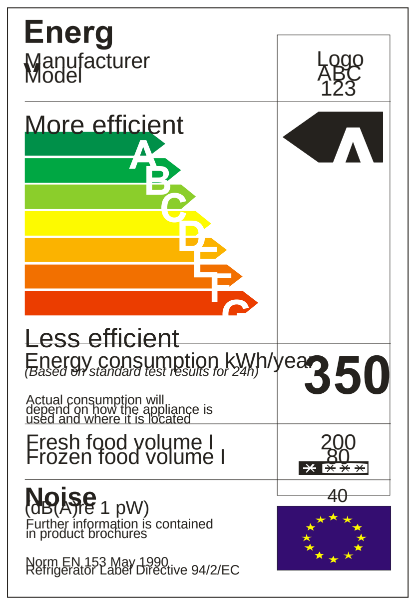
[13] Harrington, L. and Damnics, M. Energy Labeling and Standards Programme Throughout the World. A publication of the National Appliance and Equipment Energy Efficiency Committee, Australia. NAEEEC Report 2004

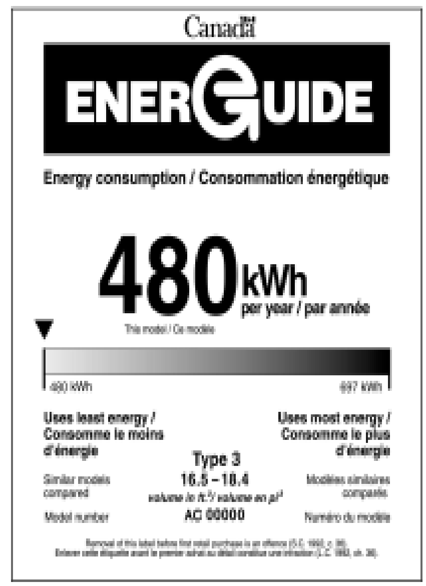
Dial Label: This type of label has a clock shape or gauge, and the greater efficiency is linked to advancement along the gauge; the more efficient is represented by a clockwise arc. It is used in countries like Australia, Thailand, Korea and Nigeria.

Bar Label: This type of label uses a bar chart with a grading from best to worst. All grade bars are visible on every label with a marker next to the appropriate bar indicating the grade of the model. This label is used primarily in Europe and South America.

Linear Label: This type of label use energy value for making comparison. It has a linear scale indicating the highest and lowest energy use of models on the market, locating the specific model within that scale[14].







Dial label (Australia) **Bar Label (Europe)** **Linear Label (Canada)**

Fig. 1.5: Different types of labeling (Source, *Lebot, 2009[15])*

The Nigerian authorities adopted the use of the dial energy label after conducting a market assessment to determine which of the label types will be most appropriate for stakeholders in Nigeria (Chapter Six). The label utilizes a star-rating system where the higher the star value, the more efficient the appliance. The efficiency level is rated from Star-1 to Star-5, and the higher the star rating, the more efficient the equipment. For example, an equipment rated Star 2 is more efficient than the equipment rated Star 1.

[14] GEF-UNDP. Promoting Energy Efficiency in Residential and Public Sectors in Nigeria: Project Training Manual 2011. An unpublished document prepared during the implementation of the GEF-supported energy efficiency programme in Nigeria.
[15] Lebot, B. (2009). Energy Efficiency and Market Transformation: A Short Overview of Best Practices. A paper presented during the Inception Workshop of the UNDP-GEF Project to Promote Energy Efficiency in Residential and Public Building in Nigeria, 14th July 2009.

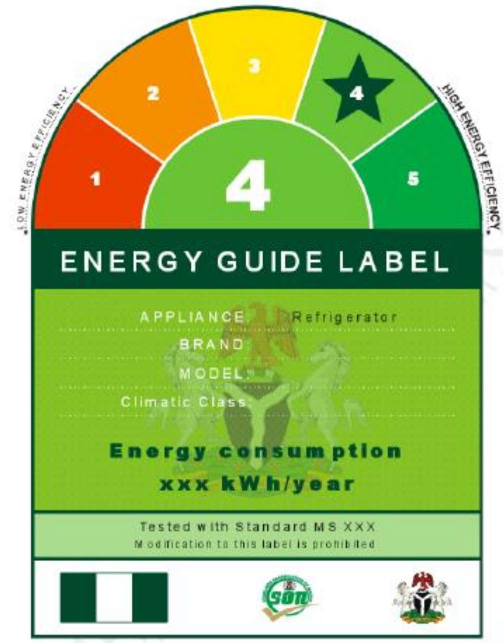


Fig. 1.6: Nigeria energy label

Retrofitting Homes and Public Buildings

The energy efficiency concept may be relatively new in many countries and existing buildings in these countries were constructed without putting into consideration the need to use energy efficiently. For such buildings, whether residential or public buildings, it is now a common practice to replace the energy intensive appliances in these buildings with more efficient ones. Retrofitting of buildings also means making structural changes that will help to minimize the energy consumed in the building. For using incandescent lighting, households and offices spend more energy than necessary for lighting. The energy spent for lighting can be reduced by about 60% if they are replaced with energy saving bulbs such as compact florescent lamps (CFLs) and light emitting diodes (LEDs). CFLs and LEDs are much more efficient than incandescent bulbs and they last six to ten times longer. In some parts of the world, the government had put a ban on the use of incandescent bulbs.

A good example is Cuba, where the Cuban Government put a ban on the use of incandescent bulbs and developed programmes to phase them out. Cuba was the first country in the world to totally ban incandescent lighting and replaced the existing ones with high quality energy savings compact fluorescent lamps. Furthermore, Cuba provided technical assistance to the government of Nigeria to phase out incandescent lamps. In a pilot programme to replace 1 million incandescent lamps (ICLs) with high quality CFLs, the Cuban government donated 0.5 million CFLs to the Nigeria government while the Nigerian government also provided another half a million CFLs with support from ECOWAS Commission. The project was implemented through the Energy Commission of Nigeria[16]. The ICLs were replaced in selected estates in the Federal Capital Territory (FCT), 10 states of the country, 14 tertiary institutions, 6 ECN research centers, 7 hotels in the FCT and public buildings in different locations in Nigeria including military and paramilitary institutions[17].

[16] GEF. Promoting Energy Efficiency in Residential and Public Sectors in Nigeria. The project document published by the Global Environment Facility (GEF). June 2011. https://www.thegef.org/news/promoting-energy-efficiency-residential-and-public-sector-nigeria

[17] Bala, E. J. Energy efficiency as a driver for economic transformation and sustainable development. A paper presented during the 4th National Energy Efficiency Summit held on the 10th of March 2015 in Abuja, Nigeria

The insulation of houses to reduce heat loss is another way to retrofit existing houses. Heating and cooling equipment account for a large percentage of the energy consumed in residential and office buildings and it estimated to be 44% of utility bill. The energy spent on heating and cooling can be reduced if owners of houses invest money for the proper insulation and weathering of their houses. By insulating walls could reduce heat loss by over 50% and prevent wastage of energy. Also, there are modern and more efficient air conditioning and heating equipment. By combining proper equipment maintenance and upgrades with insulation, weatherization and thermostat setting, energy consumption can be reduced drastically. In the United States, the heating and cooling systems emit more than half billion tons of CO_2 into the atmosphere each year, thus adding to global warming and generating about 24% of the nation's Sulfur Dioxide and 12% of Nitrogen Oxide, which are the chief ingredients of acid rain[18].

Landscaping

Proper landscaping can help to reduce the energy need of our homes and offices. Landscaping involves the use of natural elements to keep our homes comfortable and at the same time reduce energy bill. For example, the shade from trees can keep our home cool. Landscaping is a natural and beautiful way to keep your home comfortable and reduce your energy consumption by up to 25%. Apart from adding aesthetic value and environmental quality to your home, trees, shrub or vine can help deliver effective shade and act as windbreak. A well-designed home can reject heat to reduce the energy spent for cooling. Low quality windows can cause your air conditioner to work two or three times harder. In warm climates, it is advisable to use windows with special coating that will help to reduce heat gain. Replacing single paned windows with double-paned windows can help to reduce heat gain and reduce the energy spent on cooling[14].

Providing Incentives

One of the ways to encourage people to purchase and use energy efficient appliances and equipment is to give incentives. This will help to change human behavior and tilt it towards a direction which will naturally not occur. In terms of the upfront cost of purchasing energy efficient products, they are relatively more expensive than the inefficient ones. For example, the cost of a 60 W incandescent lamp in Nigeria is about N100 in the market while the cost of 9 W LED lamp is about N1000. The huge difference in price will naturally tilt many consumers especially the low-income ones to use the incandescent lamp. It is unknown to many consumers that the 9 W LED lamp will be cheaper in the long run than the 60 W incandescent lamp; when the life cycle cost (which is the running cost of a product over the lifetime plus the cost of the product) of the two products are compared. The life cycle cost (LCC) of the LED lamp will be lower and lead to more saving in electricity bill compared to the use of incandescent lamp. The LED lamp will last longer than the incandescent lamp, LED lamp can last up to 15 years while the life span of incandescent lamps is about 3 years. Providing incentives can help to push consumers to buy energy efficient lamps.

A good example of an incentive programme is the rebate programme implemented by the Ghanaian Government to encourage consumers to use energy efficient refrigerators. In the programme, consumers brought their old and inefficient refrigerators to government approved vendors and were given new and efficient refrigerators after paying a specified amount which is less that the cost of the new refrigerators. The swap-out programme in Ghana started with the registration of importers (most importers had retail outlets as well) and manufacturers of refrigeration and air conditioning (RAC) appliances by the authorities. All the refrigerators approved for the programme had to comply with the mandatory minimum energy efficiency requirements (one-star classification), which had to be demonstrated by test reports against the applicable national standards. Table 1.4 shows the average annual energy consumption and savings for each star rating of new refrigerator compared to an old refrigerator.

[18] Foundation for Community Association Research Best Practices Report No. 6 Energy Efficiency 2007. Pp. 18

Table 1.4: Energy consumption and savings for each star rating of MEPS in Ghana

Star Rating	Annual Energy Consumption of Refrigerator, kWh	Annual Energy Savings of Refrigerator, kWh
5 Star	250	**950**
4 Star	350	**850**
3 Star	400	**800**
2 Star	500	**700**
1 Star	**600**	**600**

Source: UNDP 2013[19]

The rebate programme targeted two categories of old refrigerators – old functioning refrigerators and old non-functioning refrigerators. The process began when the owner of an old but functioning inefficient refrigerator hands the equipment over to the representative of the National Association of Refrigeration Workshop Owners Association (NARWOA) in person and collects a coupon which carries a monetary value. The justification for this is that it will require some measure of monetary compensation for a volunteer to hand over a functioning refrigerator. The coupon was then submitted to the participating bank for redemption or use as part payment for a new and energy efficient refrigerator.

Similarly, the owner of an old non-functioning refrigerator hands it over to an accredited retail outlet (called Zoomlion agent) in his/her community and take a receipt for it. The receipt which contains key information of the client is taken to a designated NARWOA collection point indicated by the Zoomlion agent. At the tender of the receipt, the NARWOA representative would verify from the duplicate submitted by the Zoomlion agent and issue the client with a coupon which can be redeemed for cash in a participatory Bank. The collected inefficient refrigerators were sent to appliance retail shops for exchange under the Refrigerator Rebate Scheme. The old appliances were collected by the various participating retailer outlets and then transported to a recycling plant and the refrigerants were recovered using mobile recovery facility (Fig. 1.7).

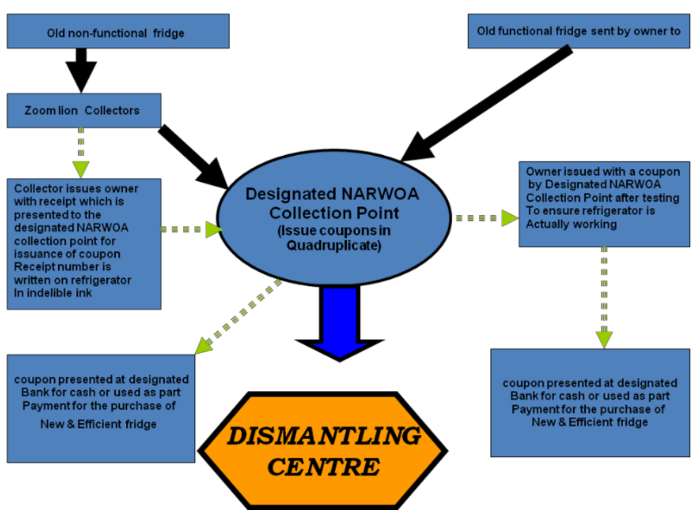


Fig. 1.7: Schematic representation of the swap-out programme in Ghana
Source: UNDP 2013[20]

[19] UNDP Project Document – EE of Refrigerating Appliances in Ghana: https://www.undp.org/content/dam/ghana/docs/Doc/Susdev/UNDP_GH_SUSDEV_Refrigerator%20energy%20efficiency%20project.pdf
[20] Promoting of Appliance of Energy Efficiency and Transformation of the Refrigerating Appliances Market in Ghana. UNDP Project Document

Use of Renewable Energy Technologies

The use of renewable energy to generate electricity for residential, commercial and industrial purposes can help to reduce the dependency on the national electricity grid. In many countries, electricity transmitted through the national grid are generated from fossil fuel. In Nigeria, over 80% of the electricity transmitted through the national grid come from gas-fired plants[21]. The use of renewable energy will help to reduce electricity bill. For example, the use of solar water heaters can contribute significantly to system optimization and as this can help to reduce the load on the grid. Public buildings such as hotels and households can take advantage of the energy from the sun and other renewable energy source to complement electricity from the national grid in order to reduce energy bills.

Renewable energy sources include wind, ocean wave and tides, solar, biomass, rivers, geothermal (heat of the earth), etc. They are 'renewable' because they are regularly replenished by natural processes and are therefore in endless supply. They also can operate without polluting the environment. Technologies have been developed to harness these energies and such technologies are called renewable energy technologies (RETs) or sometime also called "clean technologies". Because renewable energies are constantly being replenished from natural sources, they have security of supply, unlike fossil fuels. They have important advantages which could be stated as follows:

- Their rate of use does not affect their availability in future; thus, they are inexhaustible.
- The resources are generally well distributed all over the world, even though wide spatial and temporal variations occur. Thus, all regions of the world have reasonable access to one or more forms of renewable energy supply.
- They are clean and pollution-free, and therefore are sustainable natural form of energy.
- They can be cheaply and continuously harvested and therefore sustainable source of energy.
- Renewable energy can be set up in small units and is therefore suitable for community management and ownership. In this way, value from renewable energy projects can be kept in the community.

Of all the renewable energy resources available in Nigeria, solar energy appears to be the most promising one. Nigeria is located in the tropical region where sunshine is abundant and well distributed. The country's average annual solar radiation ranges between 25.2 $MJ/m^2/day$ in the north and 12.6 $MJ/m^2/day$ in the south. With an average sunshine of 6.5 hours per day, the available annual solar energy is about 27 times the country's total fossil fuel resources and over 115,000 times the electrical power generated[22]. In Nigeria, this has particular relevance since the electricity grid does not extend to many rural areas and it is prohibitively expensive to extend the grid to remote areas. This presents a unique opportunity to construct power plants closer to where they are needed. In this way, much needed income, skill transfer and manufacturing opportunities for small businesses would be injected into rural communities. Transition from fossil fuels to renewable energy will not result in net job losses or cause harm to the economy. Renewable energy technologies (RETs) are labor intensive and can produce more jobs than fossil fuel or nuclear industries. When RETs are properly integrated into national development plans and implemented, they can substantially reduce greenhouse gas emission and simultaneously increase employment. Moreover, it will also enhance energy security by reducing reliance on oil, preserve the competitiveness of energy, lead to savings for consumers and provide transitional assistance to workers in negatively affected industries and communities.

[21] Daily Trust Newspaper, 5th July 2016

[22] Nigeria's Third National Communication under the United Nations Framework Convention on Climate Change (UNFCCC), Draft Report, March 2020

Plate 1.1: Solar array in Umon Island, Cross River State

Energy Audit

Energy Audit has been defined as a systematic procedure with the purpose of obtaining adequate knowledge of the existing energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective energy savings opportunities, and reporting the findings[23]. The purpose of an energy audit is to identify energy conservation and cost saving opportunities from energy consuming systems and site practices. The goals of energy audit are to clearly identify types and costs of energy use; understand how energy is being used and possibly wasted; identify and analyses more cost-effective ways of using energy; improved operational techniques - new equipment, new processes or new technology; perform an economic analysis on those alternatives and determine which ones are cost-effective for business or industry; and develop an action plan with responsibilities, timelines and budgets for implementation. Energy audit is an integral part of an energy management system as shown in Fig. 1.8.

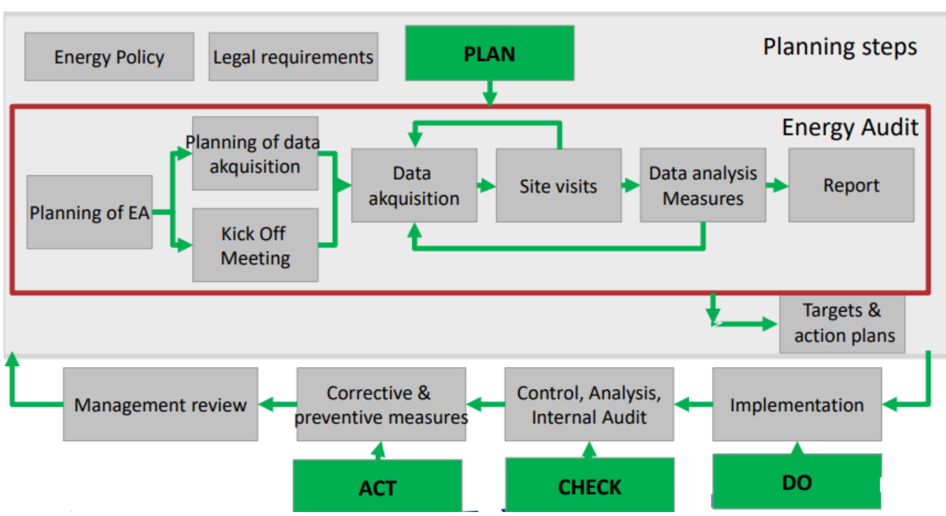


Fig. 1.8: Energy management system

[23] European Union Directive 27/2012/EU

Source: GIZ training module on energy audit for engineers, 2019

A well conducted energy audit will complement financial auditing of an establishment or facility. It will help to conserve energy and subsequently help to manage financial resources in households and industries. Moreover, an energy audit will help to identify areas of wastage and areas where energy can be minimized for the overall efficiency of a system, household, or industry. It will provide information on the minimum practical or theoretical energy required for the different activities, the actual energy used and the variance between the expected minimum and the actual. The overall objective of energy conservation is to reduce the variance to a minimum by identifying wasteful practices and opportunities for saving. In the households, industries, corporations and public institutions, energy auditing can assist in budgeting and taking managerial and financial decisions. Energy auditing will help to identify areas that require further analysis or improvement and to be able to determine the energy flow in the factory[24].

Energy Efficiency Application

Energy efficiency is applicable in virtually all sectors of the economy. Below are some of the key sectors where energy efficiency best practices can be implemented to achieve substantial savings, however, energy efficiency applications are not limited to these sectors.

***Building Sector*:** Buildings in this context refers collectively to residential, public and commercial buildings. Buildings consume over 30% of global energy, where it is used for space heating, cooling, ventilating, lighting, cooking, water heating, refrigerating, and operating electric and mechanical devices. Energy use in buildings is expected to grow as cities in developing countries continue to modernize and per capita income levels continue to increase[25]. The building sector consume most of the electricity generated in Nigeria and the demand for electricity from the sector will continue to increase in the coming years due to increasing population, rural-urban migration, and improved standard of living[26]. Households accounts for about 50% of the electricity consumed in Nigeria[27]. Investment in policies, projects, and strategies to improve the energy performance of buildings will lead to significant saving in energy and help improve the state of energy supply in Nigeria. There are many ways to improve the energy efficiency of buildings. Studies has shown that by simply improving the basic designs of buildings can reduce energy consumption by about 40%. Other ways to increase the energy efficiency of building is to improve on the building envelops and promote the use of energy efficient appliances within the building. The use of solar panels can further contribute to less use of electricity generated from fossil fuel.

***Industrial Sector**:* The industry accounted for 29% global energy consumption and 36% of CO_2 emission in 2015[28]. The demand for raw materials and finished goods in developing countries are likely to increase, consequently, this will increase the demand for energy in the industrial sector. Unless the energy potential is exploited, the Intergovernmental Panel on Climate Change (IPCC) estimates that industrial emissions of CO_2 will rise 50% to 150% by 2050, impairing global efforts to mitigate climate change[29]. In Nigeria, the cost of energy often ranges between 20% to 40% of production costs due to self-generation of power and inefficient practices (compared to 5% to 15% in Europe) and over 40% of total energy used in the industries is wasted due to the use of old, obsolete, and inefficient equipment[30]. Although, industrial activities in Nigeria are minimal compared to some countries, this is likely to grow over the next decades. This will further exert pressure in our energy grid. Energy efficiency will be a viable instrument to reduce energy

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[24] GEF-UNDP. Promoting Energy Efficiency in Residential and Public Sector in Nigeria – Training Manual. Unpublished report

[25] ESMAP Knowledge Series 019/14. Improving energy efficiency in buildings. https://openknowledge.worldbank.org/bitstream/handle/10986/21306/936750NWP0Box30ent0MayoralNote02014.pdf?sequence=1

[26] Federal Ministry of Works and Housing. Building Energy Efficiency Guideline for Nigeria, 2016. A publication of Federal Ministry of Works and Housing and supported by the Nigeria Energy Support Programme of the GIZ

[27] Energy Commission of Nigeria (ECN). Renewable Energy Master Plan, 2014.

[28] International Energy Agency (IEA). www.iea.org/statistics

[29] World Bank Group, supported by ESMAP. Energy Efficiency in Industry. A knowledge Note Series for the Energy and Extractive Global Practice 2018/96. https://openknowledge.worldbank.org/

[30] Nigeria Energy Support Programme. Overview of Policies and Programmes in Nigeria on Energy Efficiency in Industry 2019. A paper presented during the training on Industrial Energy Audit

consumption from the industrial sector, while meeting the developmental objectives. Promoting the use of efficient motors, using capacitor banks to correct power factor, keeping simple housekeep rules and regular maintenance of industrial equipment are some of the ways to ensure the efficient use of energy in the industry.

Transport Sector*:* Transportation is one of the most important elements required for economic growth, for example, goods produced in the industries must be transported to the end-users. The act of transporting people and goods is energy intensive and a significant source of GHG, as most of the modes of transportation (roads, rail, water, and air) rely on the combustion of fossil fuel. The transportation industry was responsible for the emission of 26% of global CO_2 emission in 2018[31]. Urbanization and industrialization cause transport needs to expand, for example, middle class households aspire to use private cars and as more goods are produced in the industries, more vehicles will be required to transport them to the final users. Therefore, the efficient use of energy in the transport sector will lead to significant savings and benefits to the environment. There are several ways to enhance the efficient use of energy in the transport sector. This can be done by improving vehicle efficiency, which involved reducing or avoiding travel distance or travel needs by optimizing the infrastructural organization of human activities. Another way is to improve on the travel efficiency, that is making people to shift to less energy consuming mode of transportation like public transport. Authorities, through enabling policy can also enhance system efficiency by improving the overall transport system to optimize vehicle operations.

Agricultural and Forestry Sector: As mechanized agriculture becomes more popular and adopted in many developing countries, the energy consumption from the agricultural sector will continue to increase. In the sector, energy can be consumed directly with the use of machineries, heating of livestock stables and greenhouses or indirectly from the production of agrochemicals, farm machinery and buildings. In the OECD countries, about 3-5% of total final energy consumption is used directly in agricultural sector. In the developing countries, this estimate is difficult to make, but it is likely that it ranges from 4-8% of the final commercial energy use[32]. By improving the energy efficiency of agricultural machineries and optimizing agricultural processes coupled with the right policies can lead to energy saving in the sector.

The resources from the forest have been a major source of livelihood to man and man's dependency on the forest may be as old as man's existence on earth. Up till the present age, many people, especially those leaving in the rural areas in developing countries still rely on forest resources as their primary source of energy for cooking and heating. Subsequently, forest resources are being depleted in an alarming rate. The rate at which forest resources are being depleted can be minimized by enhancing the efficiency at which these resources are being used. A good example is to promote the use of efficiency cookstove such as the Save 80 Cook Stove. This can minimize the use of fuel wood for cooking.

Plate 1.2: Save 80 cookstove (Source: CREDC, 2008[33])

[31] International Energy Agency https://www.iea.org/data-and-statistics/charts/global-co2-emissions-by-sector-2018
[32] www.fao.org/3/x8054e
[33] CREDC 2008. National Dialogue to Promote Renewable Energy and Energy Efficiency in Nigeria. The proceedings of workshop organized by the Community Research and Development Centre www.credcent.org

CHAPTER TWO

ENERGY EFFICIENCY POLICIES AND REGULATIONS IN NIGERIA

The Nigerian government has taken some bold steps to promote energy efficiency and conservation in some sectors. This is a pointer to the fact that the government has realized the importance of energy efficiency, as an instrument to address the energy deficit in the country and at the same time optimize the power systems and increase access to power. Meeting the energy needs of the Nigerian citizens has been a major policy objective of government for decades. Still only about 45% of the Nigerian population have access to electricity from the national grid and many Nigerians, mostly those residing in the rural areas still depend extensively on the use of biomass resources to meet their energy needs[34]. This session will x-ray the policies and regulations put in place by the Nigerian government that encourage the efficient use of energy.

National Energy Policy

One the earliest steps taken by the Nigerian government to promote energy efficiency and conservation is seen in the National Energy Policy (NEP) which was approved by the Federal Government in 2003. Historically, the NEP was promoted by the Energy Commission of Nigeria (ECN). In the year 1990, the ECN set up a committee which was chaired by the Director-General of the ECN with the mandate to produce the NEP. The draft NEP was later submitted to the Government in 1993. At the instance of the then Head of State, the draft policy was reviewed by an Inter-ministerial Committee in 1996, under the chairmanship of the Minister of Science and Technology. Further review of the draft NEP was carried out in 2002, in response to prevailing and major developments issues in the nation's economy, especially the restructuring of the energy sector towards greater private sector participation. The review was carried out by an Inter-ministerial Committee which comprises of stakeholders from the major energy sub-sectors, professional and financial institutions. The reviewed document was approved by the Federal Government in April 2003 and was launched by the President on 20th June 2005.

The primary objective of the NEP is to ensure that Nigeria's energy resources are developed with emphasis on the need to diversify energy resources. The NEP also aimed to guarantee increased contribution of energy-based productive activities to national income as well as guarantee adequate, reliable and sustainable supply of energy at appropriate costs and in an environmentally friendly manner. Other objectives of the NEP are to guarantee an efficient and cost effective consumption pattern of energy resources; to accelerate the process of acquisition and diffusion of technology and managerial expertise in the energy sector and indigenous participation in energy sector industries, for stability and self-reliance; to promote increased investments and development of the energy sector industries with substantial private sector participation; to ensure a comprehensive, integrated and well-informed energy sector plans and programmes for effective development; to foster international co-operation in energy trade and projects development in both the African region and the world at large; and to successfully use the nation's abundant energy resources to promote international co-operation.

Furthermore, the NEP aims to identify new opportunities, accelerate research and development in clean energy technology deployment to mitigate the impacts of climate change; to promote systems that support innovations and eliminate barriers to the adoption of sustainable low-carbon technology and development of green growth strategies; to undertake the life cycle analysis of the nation's abundant biomass resources to determine their relative climate change benefit; to encourage efficiency, conservation and carbon management best practices in the nation's energy supply chain; to establish a national energy supply and demand database; to coordinate national energy planning, programmes and implement the national energy policy as and when appropriate; and to ensure that the factors pertaining to environmental protection are not neglected in the pursuit of energy supply and utilization.

[34] Nigeria Economic Summit Group. Mini Grid Investment Report, 2018. A report published by the Nigeria Economic Summit Group.

The NEP provide the intents of government to cover both primary and secondary forms of energy as well as the utilization of energy. In the area of energy efficiency and conservation, the NEP vividly express the need for the government to develop codes, standards, regulations and guidelines to promote energy efficiency and conservation in appliances, agricultural and industrial equipment. The policy also stated that government will put in place the necessary regulations and codes to promote energy efficiency in buildings. Furthermore, the NEP stated the need to strengthening appropriate institutional arrangements and provide incentives for the promotion and monitoring of energy conservation and use of energy-efficient methods[35].

A reversed version of the NEP was developed through stakeholders reviewed process and championed by the Energy Commission of Nigeria. The revised edition of the NEP was then approved in April 2022. The overall objective of the revised NEP is to optimally utilize Nigeria's energy resources in an environmentally sustainable manner to pursue sustainable development with the active participation of the private sector.

National Renewable Energy and Energy Efficiency Policy

Prior to the development of the National Renewable Energy and Energy Efficiency Policy (NREEEP), many agencies of government prepared draft of different forms of documents that allow them to pursue ventures in renewable energy and energy efficiency. An inter-ministerial committee comprising of stakeholders from ministries, departments, and agencies (MDAs) was constituted and mandated to come up with a national renewable and energy efficiency policy that would attract investment into the electricity sector. The inter-ministerial committed was presided over by the Ministry of Power. The NREEEP was developed in line with the objectives of the National Energy Policy, Rural Electrification Strategy and Plan, Millennium Development Goals and the National Economic and Development Strategy. As the name implies, NREEEP advances renewable energy and energy efficiency policy; both being twin pillars of the sustainable energy policy.

The NREEEP clearly identified energy efficiency as a form of energy generation. Thus, if there is improvement in the efficiency of energy utilization, more energy will be made available for supply, thereby providing greater access to electricity. One of the main objectives of the NREEEP therefore is to increase access to electricity and at the same time moving the power sector to greater sustainability. The policy document also set the framework for actions to address the nation's challenges of access to modern and clean energy services as well as improve energy security and climate benefits. It recognizes the significant of renewable energy in meeting the electricity need of the nation and advances the need to develop, operate, maintain and upgrade new and existing renewable electricity generation activities. Furthermore, it defines target for the proportion of renewable energy and energy efficiency's contribution to the nation energy mix which meets or exceeds the target set in the ECOWAS regional policy.

The NREEEP declares energy efficiency as a large, low-cost and underutilized energy resources that will lead to saving in energy bills, create jobs, improve industrial competitiveness and reduce greenhouse gas emission. It recognizes that the efficient use of primary energy such as oil and gas will help to mitigate poverty and protect the environment. NREEEP has broadened the scope of energy security to include the use of renewable energy and energy efficiency as equally important indigenous resources in addition to oil and gas. It advances the need to incorporate renewable energy and energy efficiency generation activities into state policy statements and plans and recognizes the importance of having the enabling framework to attract private investment into the renewable energy and energy efficiency sectors. Moreover, the NREEEP sets national targets for generating electricity from the renewable energy and energy efficiency by 2020 and beyond.

It further advances the need to develop national action plan for renewable energy and energy efficiency and set time frame for implementation. The document called for the need for agencies that are signatories to the Policy to work in partnership to achieve the objectives and targets set in the document. The Ministry of Power was mandated by the NREEEP to develop an Integrated Resource Plan (IRP) and to ensure the

[35] Energy Commission of Nigeria. National Energy Policy, 2003

continuous monitoring and review of the implementation and effectiveness of the action plan prescribed by the Policy. It was also to facilitate the establishment of a framework for sustainable financing of renewable energy and energy efficiency projects and programmes.

The NREEEP stipulated key policy statements to drive the promotion of energy efficiency in Nigeria. First, it promises that Nigeria will promote the adoption of energy saving appliances and devices through awareness creation and training. Secondly, the policy stated that the nation will provide incentives to consumers, retailers and importers of energy efficiency devices as well as promote the local manufacturing of these devices. It further stated that the Federal Government shall take the lead in the implementation of programme to replace inefficient devices with energy efficient ones and promote same at the state and local government levels. Finally, it stated the government role of monitoring the progress being made in the adoption of energy efficiency best practices.

The policy also stated strategies to achieve the energy efficiency goals. One of the strategies include declaring energy efficiency as a source of energy that can be bought and sold through tariff provisions for the electricity distribution companies (DisCos) that will promote and achieve high energy efficiency within their customers. Others strategies provided by the policy include provision of institutional arrangement and incentives to promote energy efficiency and conservation; development of energy efficiency building codes; promoting the importation of energy efficient equipment and machineries; promoting research and development in the energy conservation and efficiency subsector; encouraging the production and use of energy efficient cook stoves; create awareness on the benefits of imbibing energy efficiency culture; promote energy efficiency in the transmission and distribution of electricity; and mandate the deployment of energy saving light fixtures in federal government offices and facilities.

The policy, also stated as part of its strategies, was to develop the National Building Code that will require every new building to incorporate energy saving measures while encouraging all buildings in Nigeria to install renewable energy technologies as source of energy. It is also encouraged the implementation of a nationwide energy audit programme and enforcement of energy efficiency standards. In addition to other strategies, the NREEEP has stated the need to task the Nigerian Electricity Regulatory Commission (NERC) and other responsible entities to implement tariff and regulations that will form the bases for more meaningful renewable electricity targets. The policy also enumerated strategies to finance energy efficiency activities in Nigeria[36].

National Energy Efficiency Action Plan

The National Energy Efficiency Action Plan (NEEAP) is a follow-up policy document to the NREEEP; the NREEEP mandated the Federal Ministry of Power to develop the NEEAP within 6-12 month of it approval. The NEEAP was developed with effort from over 25 ministries, departments and agencies (MDAs) of the Federal Government, representatives of the 36 states government and the Federal Capital Territory, private sector, NGOs, civil society organizations, academia and development partners. It was supported by the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and other development partners. The NEEAP was developed primarily to achieve the SE4ALL goals through the gathering of data, exchanges and suggestions from various actors in the public and private sectors. The content of the NEEAP includes baseline data and information on energy efficiency activities and programmes in Nigeria. It also enumerated the barriers that will hinder the adoption of energy efficiency best practices in the country and suggested achievable energy efficiency targets as well as indicators based on national potentials and socio-economic assessments. The NEEAP also provided the overview of policy, regulations, laws, incentives and other measures to be implemented to achieve the set targets. The National Energy Efficiency Action Plans was approved by the National Council on Power (NACOP) in July 2016.

[36] Federal Ministry of Power. National Renewable Energy and Energy Efficiency Policy, 2015

Sustainable Energy for All Action Agenda

The Sustainable Energy for All (SE4ALL) initiative was launched by the UN Secretary General in 2011. The global objectives of the SE4ALL initiative are to ensure universal access to modern energy services, double the rate of improvement in energy efficiency and double the share of renewable energy in the global energy mix by 2030. Premised on these objectives, national governments are expected to design and implement in-country actions to drive transformational changes in the energy sector as well as create the right investment environment for private sector participation. Furthermore, to achieve these objectives, national governments are expected to engage the civil society organizations to identify, advocate and monitor public policy and business actions; mobilize social innovation and grassroots actions; take the lead in behavioral change; and helping to create awareness on best practices and capacity development of stakeholders in partnership with businesses.

The SE4ALL Initiative was officially launched in Nigeria in August 2012. The Nigeria's SE4ALL energy efficiency objectives are to ensure that by the end of 2015, 20% of households in Nigeria will be using efficient lighting (5 times more efficient than incandescent lamps), 40% of households will be using efficient lighting by 2020 and almost 100% by 2030. Secondly, energy efficient technologies will be progressively introduced into the high-energy consuming sector as well as promote other demand-side energy management measures. Energy audits will be made mandatory for all high energy consuming sectors and public buildings by 2016.

The Sustainable Energy for All Action Agenda (SE4ALL AA) sets out the following energy efficiency actions:

- put in place the regulatory framework and a coordinating group for the implementation and administration of energy efficiency programmes arising from the NREEEP;
- disseminate information, advocate and create awareness on energy efficiency across the country;
- conduct research and development (R&D) and embark on demonstration to shape the emerging market of the energy efficiency sub-sector; embark on national programmes to adopt technological standard for improved cookstoves and appliances to promote their energy efficiency in accordance with international bodies;
- develop national programmes to implement an ISO-compactible energy management standard (ISO 50001) and introduce requirement for energy audit;
- put in place a monitoring, verification and enforcement policy to facilitate the implementation of minimum energy performance standards (MEPS);
- introduce and implement voluntary international standards or align national standards with international standards;
- strengthen the capacity building efforts of the Standards Organization of Nigeria (SON);
- and develop support schemes and financial mechanisms for the energy efficiency sub-sector.

The SE4ALL AA stipulated that the management of the actions proposed in the document will be built on existing structure of the already established Inter-Ministerial Committee on Renewable Energy and Energy Efficiency (ICREEE). Consequently, it advanced the need for the Federal Government to establish the SE4ALL Secretariat which will be domiciled in the Federal Ministry of Power, the focal point of the country's SE4ALL activities. It further advanced the establishment of SE4ALL Steering Committee to support the Secretariat with membership drawn from ICREEE Team, relevant MDAs, state and local governments, electricity distribution companies (DisCos) and electricity generation companies (GenCos). The SE4ALL

AA further stated that a Donor Executive Committee, comprising of national banks, private sector, civil society representatives and international organizations will be established. The SE4ALL Secretariat will report directly to the Minister of Power and inform the SE4ALL Steering Committee and the Donor Executive Committee.

Energy Performance Standards for Self-Ballasted Lamps

With support from the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP), the Standards Organization of Nigeria (SON) developed the energy performance standards for self-ballasted lamps of rating equal to or less than 60 W. The standard was approved by the Nigerian authority in 2013 and the information about the standard was immediately communicated to the importers of light bulbs by the leadership of the SON. The standard is titled "NIS 747:2012 Self-ballasted Lamps for General Lighting Services – Performance Requirement". It was reviewed by a Technical Committee set up by the SON and comprises of members of the Nigerian Electrotechnical Committee, representatives of manufacturers of light bulbs, academia, UNDP, Council for the Regulation of Engineering in Nigeria, Association of Illumination Professionals and the SON. The standard specifies the requirements, the test methods and conditions required to show compliances of tubular fluorescent and other gas-discharge lamps with integrated means of controlling starting and operations used for domestic and other general lighting purposes with electrical specifications of up to 60W, operating between 100-240V and having Edison Screw or Bayonet base.

The normative references for the Standard are NIS-IEC60081:1984 titled "Tubular Fluorescent Lamps for General Lighting Services" and NIS-IEC 60968: 1988 titled "Self-ballasted Lamps for General Lighting Services – Safety Requirement". The standard defined specific requirement for lamps in terms of their dimensions, test conditions, starting and run-up time, luminous flux, colour, lumen maintenance, life span and harmonics[37]. Furthermore, it defines conditions for compliances for compact fluorescent lamps (CFLs) in the following areas:

- *Dimensions:* This should comply with the requirement as indicated by the manufacturer or the existing standards NIS-IEC 60061-1 for the base and NIS-IEC 60901 for the lamp
- *Starting Time:* The starting time should comply with the one specified in the lamp data sheet and should not exceed 1.5 seconds
- *Run-up Time:* Should be stated by the manufacturer and should not be more than 90 seconds
- *Power Factor:* For lamps claiming to have "high power factor" and are equal to or less than 25 W, the power factor should not be less than 0.85 and for lamps greater than 25 W, it should comply with the standard IEC 61000-3-2. Lamps with low power factor, it should not be less than 0.5.
- *Lumen Maintenance:* The standard stated that 1000 hours lumen maintenance should not be less than 90% of the initial luminous flux and 2000 hours lumen maintenance should not be less than 88% of initial luminous flux
- *Lifetime:* It defined a lifetime of 6000 hours for CFLs
- *Audible Noise:* Ballast, if included must have sound rating of Class A or quieter
- Stabilization Time: The time to stabilize light output to 75% should not be less than 100 seconds
- *Fast Switching Life Evaluation:* The number of cycles in the rapid cycle test should not be less than the claimed lifetime in hours.
- *Luminous Efficacy*: This shall comply as shown in Appendix 1
- *Information on Packages:* The standard says that all lamps shall have this information clearly printed on their packages – lifetime in hours, energy label and comparison between CFL and ICLs (incandescent lamps).
- *Guarantee*: Furthermore, the standard defined 1year guarantee on lamp failure
- *Climatic Conditions:* Lamp should be suitable for use in tropical climate and should be able to withstand humidity of up to 95% and ambient temperature of up to 40 ^{0}C

[37] Standards Organization of Nigeria. FDNIS 747:2012 Self-ballasted Lamps for General Lighting Services – Performance Requirement, 2013

Minimum Energy Performance Standards for Refrigerating Appliances

The process to developed minimum energy performance standards for refrigerating appliances began during the GEF and UNDP supported Energy Efficiency Programme in Nigeria. The SON inaugurated the Technical Committee to review the draft standard. However, the standardization process extended beyond the life span of the GEF/UNDP project (2011-2015). The standardization process was concluded in 2017 with support from the Nigeria Energy Support Programme (NESP) funded by the GIZ and the European Union and gave birth to the Standard NIS 942:2017 - Minimum Energy Performance Standards (MEPS) and Labels for Refrigerators. Within the same period, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) facilitated the development of a regional MEPS for refrigerators which was adopted by ECOWAS member states. Each country is expected to domesticate the regional MEPS to become a national regulation.

The ECOWAS standard titled "ECOSTAND 071-1:2017 – Minimum Energy Performance Standard – Part 1: Refrigerating Appliances" has undergone the national standardization process to become a national standard thus assuming the status to the "Nigeria Industrial Standard (NIS) ECOSTAND 071-1:2017EE – Minimum Energy Performance Standard – Part 1: Refrigerating Appliances". This standard replaces the NIS 942:2017, which has become obsolete. The standard is identical to the ECOWAS standard; however, certain modifications were made to it due to national legal requirements. The notable modification is that refrigerating appliances of supply voltage of 230/415 V and ozone depleting potential (ODP) of zero are acceptable in Nigeria. Furthermore, the clause for manufacturers to affix energy label to refrigerating appliances was added to the standard.

The standard covers alternating-current (AC) powered refrigerating equipment of storage capacity of up to 1500 litres which are manufactured, assembled, imported or sold in any of the ECOWAS countries. The minimum energy performance of refrigerating appliances is indicated by the Energy Efficiency Index (EEI) which is defined as the ratio of the annual energy consumption (AEC) of product and a calculated standard annual energy consumption both in kWh/year. The lower the EEI, the more efficient the product. The standard defines the EEI for two climatic classes (Sub Tropical and Tropical) as shown in the Table 2.1 below. The standard prohibits the manufacturing and importation of any refrigeration equipment with EEI above 80.

Table 2.1: EEI for different climate class

	Energy Efficiency Index (EEI)	
	Climate Class ST	Climate Class T
5 Star (Most Efficient)	EEI < 30	EEI < 40
4 Star	30 ≤ EEI < 42	40 ≤ EEI < 55
3 Star	42 ≤ EEI < 55	55 ≤ EEI < 65
2 Star	55 ≤ EEI < 65	65 ≤ EEI < 75
1 Star	65 ≤ EEI < 80	75 ≤ EEI < 80

Sources: SON Gazette, NIS ECOSTAND 071-1:2017EE

The Standard clearly stated that the packaging and label affixed on refrigerating appliance shall provide accurate information on the product and its performance. The information shall be presented in English and will include the manufacturer, model number, type of refrigerator and the climate class[38].

[38] Standards Organization of Nigeria. Nigeria Industrial Standard (NIS) ECOSTAND 071-1:2017EE – Minimum Energy Performance Standard – Part 1: Refrigerating Appliances, 2017

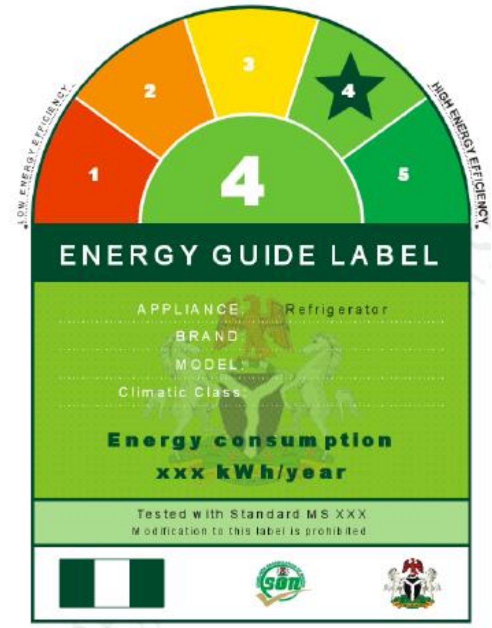

Fig. 2.1: Feature of energy label for refrigeration appliances
Source: SON Gazette, NIS ECOSTAND 071-1:2017EE

Minimum Energy Performance Standards for Air Conditioners

The NESP supported the national process to develop and adopt MEPS for air conditioning appliances in Nigeria. The process lasted from 2015 to 2017 and gave birth to the national standard "NIS 943:2017 – Minimum Energy Performance Standards and Labels for Air Conditioners". However, with development and adoption of a regional MEPS by ECOWAS countries, the Nigerian authority move swiftly to domesticate the regional MEPS and gave birth to national standard "NIS ECOSTAND 071-2:2017EE – Minimum Energy Performance Standards - Part 2: Air Conditioning Products". This new standard replaces the NIS 943:2017, which becomes technically obsolete.

The Standard covers the requirements for domestic and commercial air conditioners (up to 20 kW which could be portable, unitary, split or centralized air conditioning system) with single or double duct, mobile that are manufactured, assembled, imported or sold in any of the ECOWAS countries. Air conditioning systems that do not use alternating current or non-electric energy sources are excluded from this standard. The energy efficiency of air conditioning system is indicated by the Energy Efficiency Ratio (EER) which is the cooling capacity of the system (in kW) divided by the input power (also in kW). The standard stipulated that for air conditioning system of up to 20 kW must meet a minimum requirement of EER equal to 2.8.

The standard stated that air conditioners that will be sold in the Nigerian market must have energy label affixed on them. It provided a description of the energy label as shown in Fig. 2.2. The energy label present five different energy classes shown in Table 2.2 below, the highest being the most efficient. Air conditioning system with EER below the minimum value defined by this standard is prohibited from entering the Nigerian market. According to the standard, the energy label must contain the following information: appliance type, manufacturer, model number, energy consumption (in kWh/year), star rating, Nigerian coat of arm and the national flag[39].

[39] Standards Organization of Nigeria. NIS ECOSTAND 071-2:2017EE – Minimum Energy Performance Standards - Part 2: Air Conditioning Products, 2017.

Table 2.2: Air conditioners energy classes

Energy Class	Star Rating	EER
5	★★★★★	EER ≥ 5
4	★★★★	4.20 ≤ EER < 5
3	★★★	3.60 ≤ EER < 4.20
2	★★	3.20 ≤ EER < 3.60
1	★	2.80 ≤ EER < 3.20

Source: SON Gazette, NIS ECOSTAND 071-2:2017EE

Building Energy Efficiency Guidelines for Nigeria

The Building Energy Efficiency Guideline (BEEG) was developed by the Federal Ministry of Power, Works and Housing in partnership with the Nigeria Energy Support Programme (programme of the GIZ and the European Union). The aim of the BEEG is to provide practical advice to professionals on how to design, construct and operate more energy efficient buildings. The other objectives of the BEEG is to educate the public on energy efficiency measures and provides intended users with the information that will help them choose energy efficient buildings. The Guidelines is designed to help inform and create awareness on the state of energy consumption in the building sector and the potentials for improvement. It will help stakeholders to understand the importance of energy efficiency and the energy efficiency goals that should be set for Nigeria and show the ways energy efficiency can be implemented in the building sector.

The Guidelines is complemented by case studies where different building energy efficiency packages have been modified and compared to identify optimal solutions for Nigerian climatic conditions. Two climatic conditions were chosen for the solution, and these include the hot and dry climate of northern Nigeria and hot and humid climate of southern Nigeria. The BEEG focused on new buildings in the residential sector and office buildings. Existing buildings are excluded in these guidelines, however, many of the solutions proffer in this document are equally relevant to existing buildings. Cooking energy was not addressed in these guidelines as this is not related to building design.

The analysis performed for various case studies to develop the BEEG represent three scenarios. The first scenario is implementing basic energy efficiency measures including bioclimatic design best practices such as improved building orientation. The second being an enhanced scenario where highly efficient façade and mechanical system were added while the third scenario involve the addition of renewable energy system. The result showed that first scenario achieved energy consumption reduction of minimum 40% which increased to 75% against the business-as-usual buildings when improved envelop and efficient systems were included. The addition of photovoltaic system could contribute to the reduction of electricity generated from fossil fuel sources.

National Building Energy Efficiency Code

The National Building Energy Efficiency Code (BEEC) specifies the minimum energy efficiency requirement for new buildings to achieve reduction in energy use and consequently leading to reduction in the emission of greenhouse gases over the life of the building. The process to develop the BEEC was initiated by the Housing Sector of the Federal Ministry of Power, Works and Housing and supported by the Nigeria Energy Support Programme (NESP). The BEEC will complement the existing National Building Code, contribute to ensuring constant availability of electricity in the country and implement energy efficiency in the building sector in conformity with the overarching Energy Efficiency Policy. The BEEC was developed in three stages. First, was the development of the Building Energy Efficiency Guidelines to promote the construction of bioclimatic buildings considering the views of stakeholders. The second stage was to conduct Technical BEEC Study to identify minimum energy efficiency requirements and other elements of the BEEC also with stakeholders' views. Based on the BEEG and the Technical BEEC Study, a draft copy of the BEEC was developed and validated through stakeholders' review process and validation workshop.

The objectives of the BEEC are to set minimum energy efficiency requirements for buildings and to provide for their proper implementation, control and enforcement. The following elements were addressed in the BEEC and include:

- minimum energy efficiency requirements and verification methods;
- calculation methods and tools;
- building energy label and energy efficiency incentives;
- control and enforcement of the BEEC;
- qualification of experts;
- review and adaptation of the BEEC.

The requirement in the BEEC only applies to new buildings which falls under Group B (Business and Professional – spaces primarily used for office work) and Group R (Residential Buildings) in the National Building Code. The scope for buildings in the Group R Houses shall have a minimum threshold of 85m^2 gross floor area.

At the federal level, the provision of the BEEC apply directly to the public building of the Ministry responsible for the National Building Energy Efficiency Code. At the state and local government level, the BEEC shall be adopted by the states and local government in order to apply the provisions within their territories. By adopting the BEEC at the state and local government level, the state and local government authorities shall determine the competent institutions in charge of implementing the provisions of the BEEC in their respective territories. Furthermore, the adoption of the BEEC at the state and local government level can include adaptation to reflect the specific climatic conditions provided the adaptations are scientifically substantiated and shall not reduce the minimum requirements. As soon as the BEEC enters into force, it shall be voluntary for a period up to a maximum of two years to allow for an adoption and inception phase. At the end of two years after adoption, the competent authority shall then make the requirement of the BEEC mandatory[40].

Nigeria Cooling Action Plan

The National Cooling Action Plan (N-CAP) was developed through series of stakeholders' engagements and surveys by the Federal Ministry of Environment, through the National Ozone Office of the Ministry. The N-CAP was developed with technical support from an International Consultant, HEAT GmbH and the UNDP, and the process of developing the N-CAP received financial support from the Clean Cooling Collaborative (CCC) formally Kigali Cooling Efficiency Programme (K-CEP). The aims of the N-CAP is to mitigate the indirect greenhouse gas (GHG) emissions associated with electricity use for powering cooling equipment and direct GHG emissions and ozone-depleting substances (ODS) associated with the refrigerants used. The N-CAP identifies potential energy demand reduction, energy efficiency interventions, the transition from high to low GWP refrigerants, and proposes a timeline for the implementation of these actions in an integrated approach. It proposed the appropriate framework to enforce minimum energy performance standards (MEPS) and labelling scheme for RAC equipment, being one of the major contributors to carbon emissions and energy consumption. The specific objectives of the NCP include:

- Provide information on the current state of the market and projections of the potential future paths of energy demand and GHG emissions for the two RAC subsectors
- Identify key emission reduction and energy-saving potential, to guide in the strengthening or developing enabling policies and regulations, where necessary

[40] Federal Ministry of Power, Works and Housing. Building Energy Efficiency Code, 2016

- Provide recommendations and the background support for the development and implementation of mitigation measures, especially a MEPS and labelling scheme for the domestic refrigerators and Unitary Air Conditioners (UAC), including testing methods and metrics.
- Provide recommendations to support Nigeria's monitoring, verification and enforcement, (MVE) activities.
- Support the update of Nigeria's Nationally Determined Contribution based on the GHG projected emissions and mitigation measures defined and implemented in the two studied RAC subsectors.
- Provide financial and funding recommendations to support the market transformation towards higher energy efficient appliances and low GWP technologies[41].

[41] Nigeria Cooling Action Plan (2022). A policy document published by the Nigeria Federal Ministry of Environment with support from the UNDP and Clean Cooling Collaborative.

CHAPTER THREE

NIGERIA END-USE MONITORING STUDY

Introduction

This current Chapter will focus on the findings of the End-use Monitoring Study conducted by the Energy Commission of Nigeria, with support from the GEF and the UNDP. ENERTECH, a French company served as the technical partner in the study. The GEF-UNDP supported Energy Efficiency Programme was implemented between 2011 and 2015. The overall objective of the GEF-UNDP Energy Efficiency Programme was to improve the energy efficiency of end-use appliances used in Nigeria with the aim to reduce energy demand. The Energy Efficiency Programme had four main components – set minimum energy performance standards (MEPS) for end-use appliances (lighting, refrigeration and air conditioning appliances); establish testing centers to enforce energy efficiency standards; enhance the capacity of relevant stakeholders and create awareness on energy efficiency best practices and their importance; and support processes that will upscale the penetration of energy efficiency appliances. One of the approaches adopted during the implementation of the Project was the Survey Approach. This approach involves the use of metering equipment with data loggers to monitor the energy consumption of appliances at the household level. This data served as the baseline for evaluating the impact of the Energy Efficiency Programme[42].

Objective of the Nigeria End-use Monitoring Study

There were two primary objectives of the study. First, to monitor the actual level of total households' electricity usage and secondly, to assess the energy consumption of selected households' electrical appliances (refrigerators, air conditioners and lighting appliances). The results of the study served as tool to campaign among Nigerian policy makers and other stakeholders on the need to promote energy efficiency. Moreover, the study was designed to guide the development of MEPS for the set of appliances monitored during the study; before standards are set, it is imperative to monitor actual consumption of appliances, which in turn will guide the development of MEPS. The study provided information on the state and structure of the specific use of electricity in residential houses. Furthermore, it is expected to produce reference data that will allow researchers and organizations that work on the modelling and forecasting of electrical consumptions to base their works on reliable data. The Study was limited to the measurement of electrical energy.

Method of Study

Data collection was carried out across the six geopolitical zones of Nigeria: one city from each of the six geopolitical zones (Table 3.1). The cities selected for the survey are Lagos (South-west), Benin City (South-south), Enugu (South-east), Abuja (North-central), Bauchi (North-east) and Sokoto (North-west). These are cities where the Energy Commission of Nigeria had established research centers to promote research in the energy sector. From each of the cities, 35 households were monitored for a period of 30 days using data logger devices. In all, a total of 210 households were monitored across the six geopolitical zones, which lasted from March 2012 to March 2013. Furthermore, another 11 households were monitored for a period of one year (July 2013 to July 2014) in residential buildings in the Federal Capital Territory (FCT) to assess the relationship between seasonality and energy consumption of residential houses and appliances. The households monitored were randomly selected considering geographical and socio-economic criteria representing different types of Nigerian households. The households were selected to represent the

[42] ECN, GEF and UNDP. Nigeria End-Use Monitoring Study: A Survey of the Energy Consumption of Households and Appliances in Nigeria, 2014. A publication of the Energy Commission of Nigeria, the Global Environment Facility and the United Nations Development Programme.

different income level (high, medium and low income). Data analysis was carried out in ENERTECH office in France.

Table 3.1: Cities of data collection

	Geopolitical Zone	City
1	South-south	Benin City
2	South-west	Logos
3	South-east	Enugu
4	North-central	Abuja
5	North-west	Sokoto
6	North-east	Bauchi

Source: ECN, GEF and UNDP, 2014[43]

Energy Logger Devices

The logger devices which include the Lampmeters, Serial Wattmeters, Multivoies and Digital Thermometers were deployed to collected data during the study. These logger devices are described below:

Lampmeters: The lampmeter is an electronic recorder of a reduced size which is installed close to the lighting equipment without any connection to the electrical supply network. It has an optical sensor that detects the duration the lighting equipment is switched on. It is fast to install without interference with the electric circuit. The lampmeter is installed near the lamp to be measured and it is fixed in way that the sensor is directed towards the source of light. It has an LED lamp that flickers and indicates if the sensor is correctly positioned. The logger devices are entirely autonomous and can be left in a place for several months depending on the frequency of data collection. When the period of measurement is complete, the data is downloaded using the Oscar Software which transfers the data to a computer where they were analyzed.

Plate 3.1: Lamp meter installed near a compact fluorescent lamp
Source: ECN *et al*, 2014

In this study, lampmeters were used to measure the consumption of the different lighting appliances - incandescent bulbs, compact fluorescent lamps (CFLs) and others with constant power rating. The device

[43] The Tables and Figures presented in this Chapter were taken from the technical report published by the Energy Commission of Nigeria, the Global Environment Facility, and the UNDP, 2014 – Nigeria End-Use Monitoring Study: A Survey of the Energy Consumption of Households and Appliances in Nigeria.

measured the time during which the light sources were switched on and the power rating was measured separately during installation of the Lampmeters. From the measurement of the time and power rating of the lamps, it was easy to precisely determine the consumption of each lighting point. For halogen lamps, Wattmeters were used to measure the energy consumption since the power drawn from electricity source is not constant.

Serial Wattmeters: The Serial Wattmeter was developed by ENERTECH. It was designed to measure the active energy and voltage of single-phased appliances with power rating up to 2.6 kW. In this study, the energy consumptions of refrigeration appliances (fridges and freezers) were monitored using the Serial Wattmeters. The Serial Wattmeters were placed in series between the standard socket outlet (up to 230 V) and the plug of the appliance to be measured. Similar to the lampmeter, the Serial Wattmeter is entirely autonomous and can be left to collect data for several months. At the end of the measurement period, the stored data were read using the Oscar Software which transferred them to a computer for analysis.

Plate 3.2: A Serial Wattmeter
Source: ECN, GEF and UNDP, 2014

Multivoies System: The Multivoies System was developed by the French company by name OmégaWatt. The device is designed for the measurement of a large number of channels of power consumption and energies from electrical switchboard (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 Bluetooth. The modules are fitted with standard closed miniature current transformers (0-45 Amps). Some appliances such as air conditioning and lighting appliances were monitored directly from the switchboard of each house.

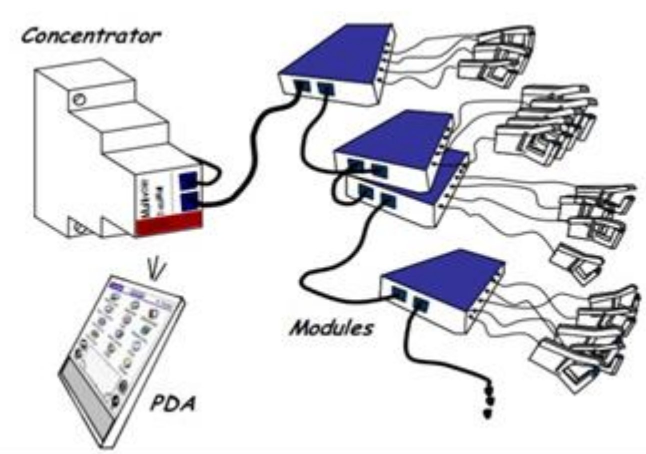

Fig. 3.1: Schematic representation of the Multivoies

Thermometers: The Thermometers used for the study were autonomous electronic data logger device of reduced size provided with a temperature sensor. They take measurements at regular interval and stores them at selected time on the average of several measurements (2 minutes interval between each measurement except when they are programmed to take measurement at an interval of 1 minute). The thermometers had broad range of measurements ranging from -50°C to 120°C.

Results of the Study

Indoor Temperature

The temperature data from the six geopolitical zones were not collected at the same time and as such the data could not be used to infer the relationship between seasonality and energy consumption. As discussed in the previous section, the impact of seasonality on energy consumption was inferred from the one-year monitoring of households in Abuja. This will be discussed in subsequent section. The study revealed that the average indoor temperature in Nigeria is 29.5^0 C. Fig. 3.2 shows the average daily indoor temperature curve for the six cities monitored during the study. The highest indoor temperature was recorded in Sokoto in Northern Nigeria and the lowest was recorded in Benin City. A temperature difference of of 6-8°C was recorded between Sokoto and Benin City.

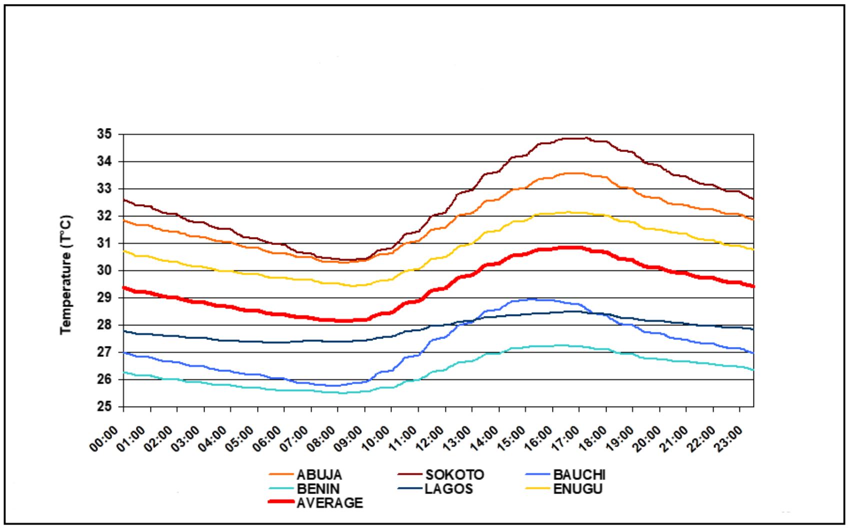

Fig. 3.2: Average daily indoor temperature curve of the sampled locations

The cumulative frequency curve of indoor temperature revealed that in Benin City, for 20% of the time, the temperature values were always higher than 27°C and 65% of the time higher than 26°C. In Sokoto, the indoor temperature value were higher than 34°C for 24% of the time and higher than 31°C for 80% of the time (Fig. 3.3).

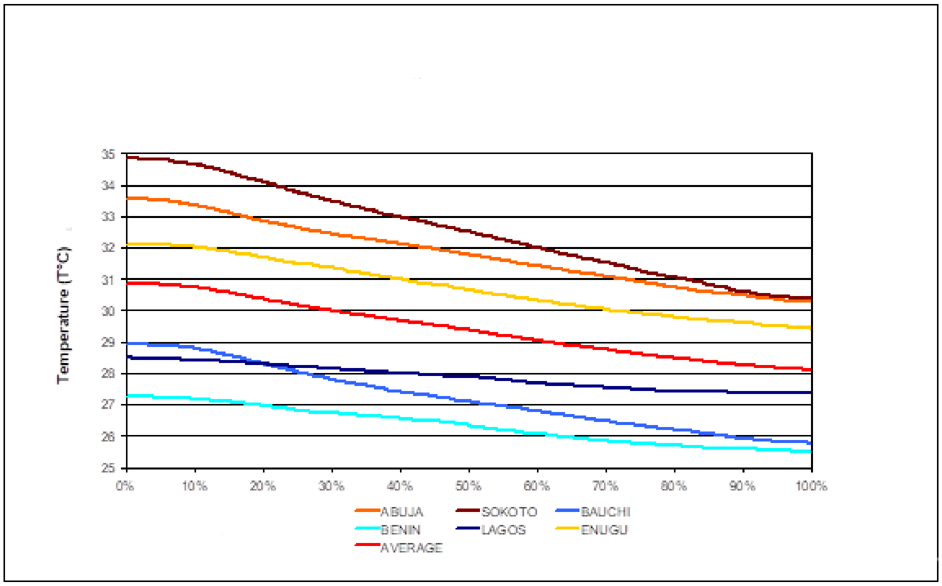

Fig. 3.3: Indoor temperature cumulative frequency curve

<u>Power Quality, Availability and Outages</u>

The electricity from the grid in Nigeria is unstable and the time consumers receive power supply from the national grid varies with the geographical location. With the use of the Multivoies System, it was possible to record the average voltage of the grid every ten minutes, hence know the periods electricity was available. The period that the voltage is greater than zero indicates the period that power was available. Similarly, for the period where the voltage is equal to zero implies that there was power outage. As shown in Fig. 3.4, the study revealed that on the average, the power outage periods is 45% of the time, while power was available for 55% of the time.

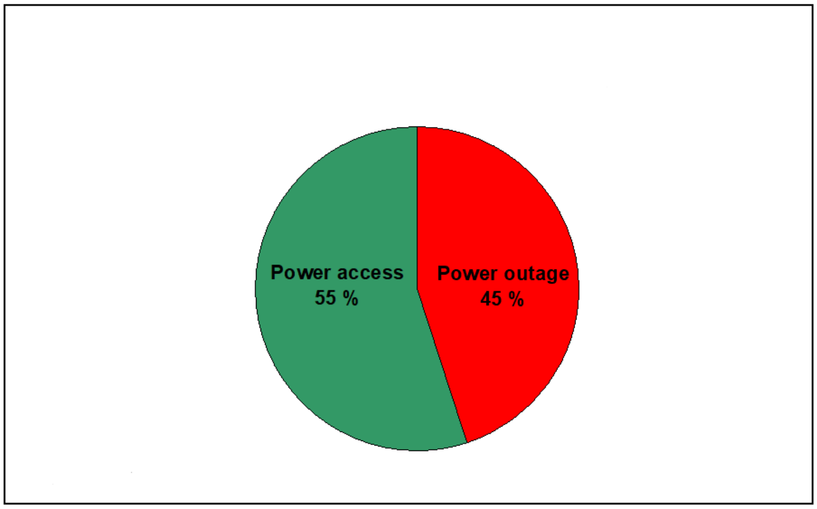

Fig. 3.4: Power availability and power outages
Source: ECN, GEF-UNDP, 2014

The power access and power outage ratio for each of the cities is shown in Fig. 3.5. On the average, the period power was available is longer in the cities in southern Nigeria. Sokoto and Bauch had the lowest duration of power supply, for each recorded 39% of monitoring time. The lowest period of power outage was recorded in Lagos (34%) while Bauchi and Sokoto had the highest (61%).

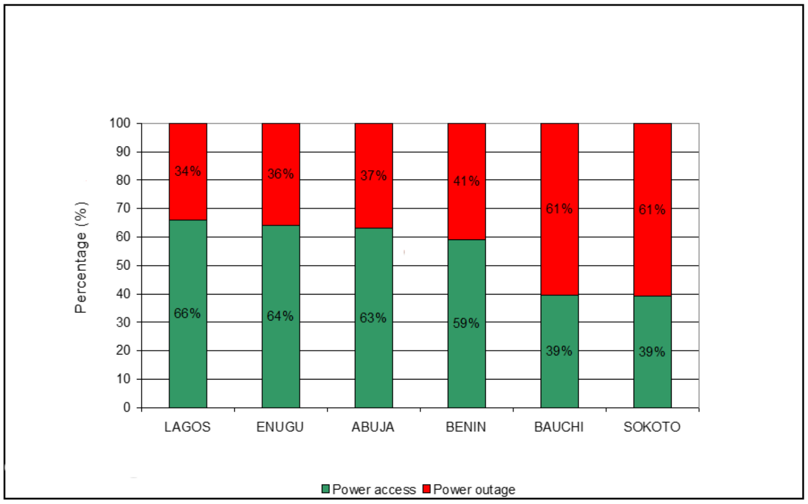

Fig. 3.5: Distribution of power access and power outage per zones

The power supply voltage recorded during the study ranges from between 160V to 240V with an average of 204V. The most stable voltage was recorded in Lagos, with an average value of 211V. In Lagos, the highest voltage of 228V was recorded in one of the households and the lowest voltage of 184V was recorded in another household. Benin City had the highest voltage variation. The average voltage for the six locations ranged from 201V to 211V.

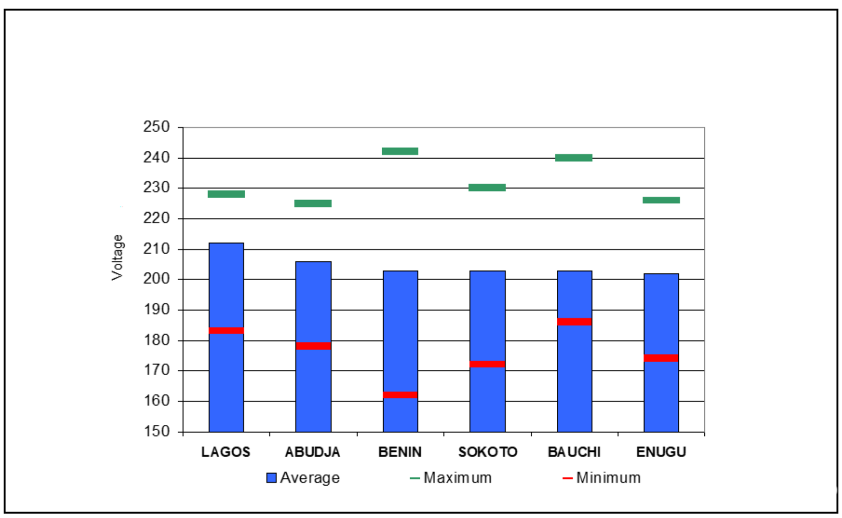

Fig. 3.6: Average and maximum voltage during power access

The duration of electricity supply to the households in a day varies and ranges from 2 hours per day to 24 hours per day with an average value of 13 hours per day as shown in Fig. 3.7.

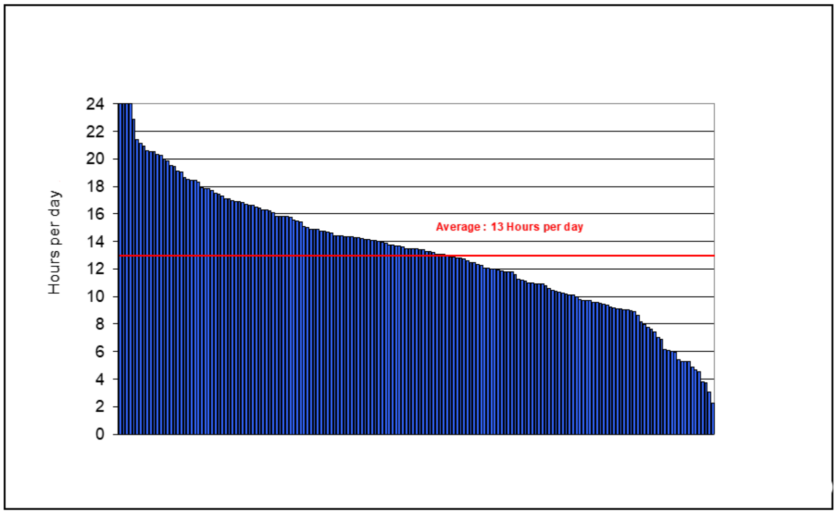

Fig. 3.7: Number of hours households get electricity per day

<u>Annual Electricity Consumption of Households</u>

The total electricity consumption of each household was monitored using the Multivoies Systems which were connected to the main switchboard. As shown in Fig. 3.8, the average electricity consumption was recorded as 3710 kWh/year. This value would have been higher if electricity supply was constant. With the current electricity price of N27/kWh, this figure suggests that on the average, Nigerian households residing in the urban areas spend about N100,170 ($546.50) for electricity per year.

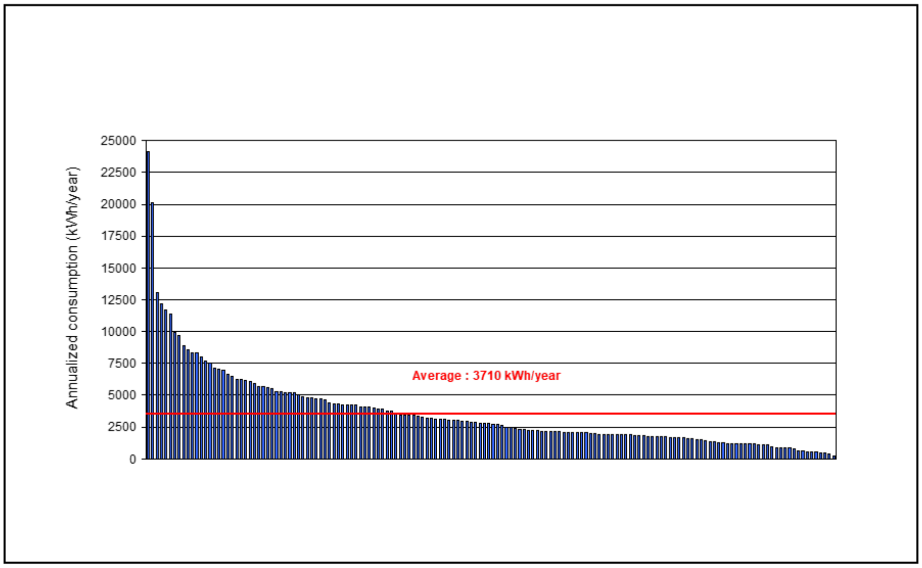

Fig. 3.8: Annual electricity consumption

Figure 3.9 shows the average and maximum values for the annual electricity consumption from each of the studied locations. The minimum annual electricity consumption was recorded in Bauchi while the highest was recorded in Lagos. There is a ratio of 2:5 of electricity consumption between Bauchi and Lagos. Furthermore, there is correlation between the average duration of power supply per day and the annual consumption. Lagos which had the highest duration of power supply per day was also the place that recorded the highest annual electricity consumption. Sokoto and Bauchi had the lowest duration of power supply per day and the lowest annual electricity consumptions.

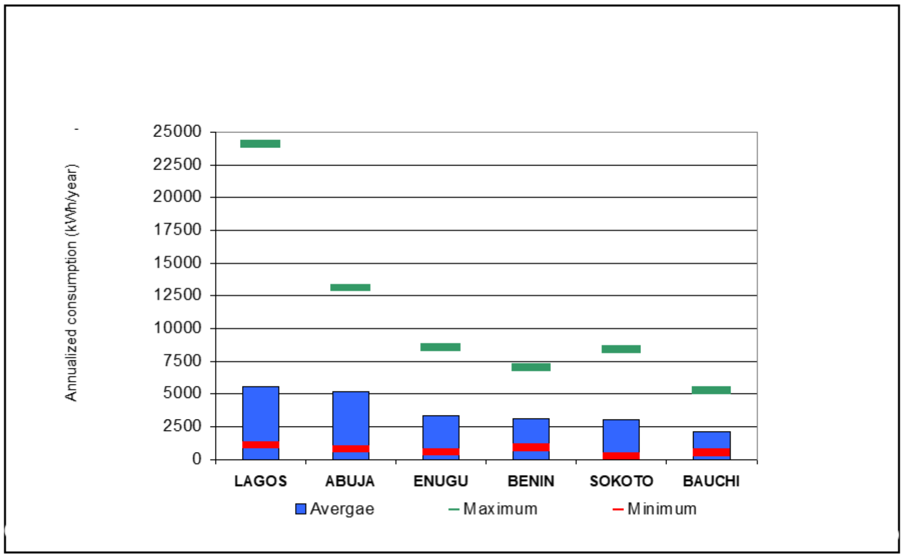

Fig. 3.9: Average and maximum annual electricity consumption

The load curve of the six cities are shown in Fig. 3.10. The curves for the six locations were different in terms of power demand and profile. For example, Benin City had two power demand peaks at approximately 800 W at 07:00 hour in the morning and 19:00 hour in the evening, while Lagos had only one peak in the evening but the energy demand in Lagos was always higher than that of Benin City. In all, the morning peaks were between 06:00 and 07:00 and the evening peaks were between 20:00 and 21:00.

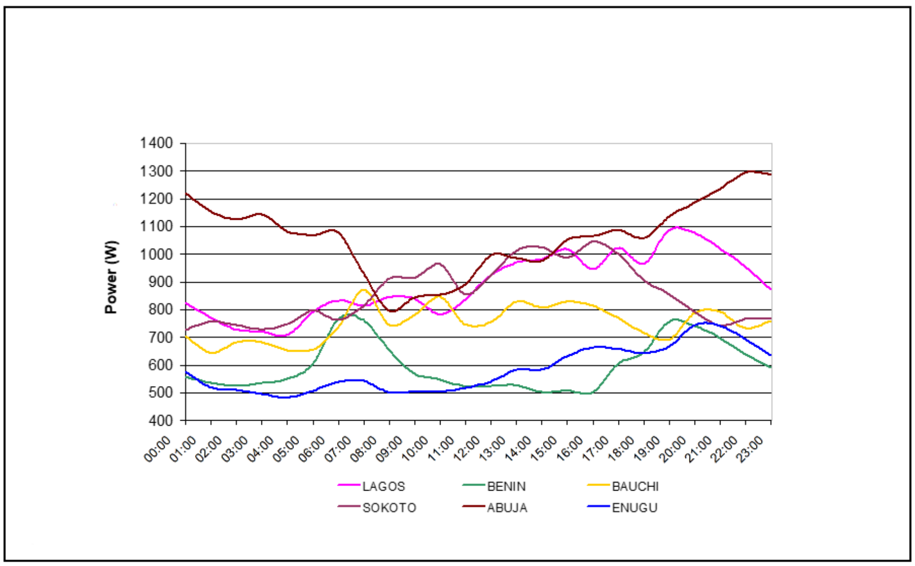

Fig. 3.10: Daily average load curve during power access per area

Energy Consumption of Cooling Appliances

Cooling appliances refers to refrigeration and air conditioning equipment. In countries located in the hot climate, cooling is a significant contributor to global GHG emissions, usually contributing between 5% and

15% of energy-related emissions[44]. Globally, in 2015, air conditioners accounted for approximately 20% of the residential electricity demand in 150 developing and emerging countries[45]. Residential refrigerators accounted for approximately 10 per cent of global electricity consumption in households. The number of refrigerators is expected to double to just under two billion in the next 15 years[46]. In the current study as shown in Figure 3.11, cooling appliances (refrigerators and air conditioners represent about 45% of total energy consumption in Abuja, in Benin City less than 40%, in Sokoto about 40%, in Enugu 40%, in Bauch about 30% and in Lagos about 30%. The part labeled unknown in Fig. 3.11 is the difference between the main consumption and the sum of all the monitored appliances, in other words it represents the appliances not monitored with the data logger devices[47].

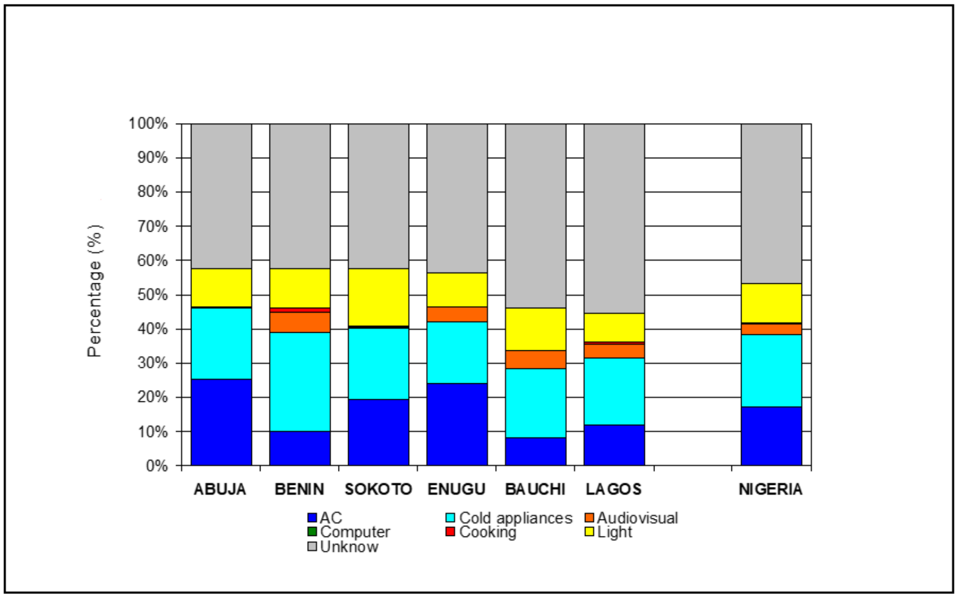

Fig. 3.11: Relative contribution from the different loads per zones

Figure 3.12 below shows the annual electricity consumption of air conditioners from all the households monitored in this study. With the epileptic power supply in Nigeria, on the average, air conditioners consume 828 kWh/year. When this value is compared with a similar study carried out in the French Guiana in Kourou, the average electricity consumption of air conditioner was 2314kWh/year. It should be noted that the Kourou's power grid is stable with constant electricity supply[48].

[44] International Energy Agency Report. The Future of Cooling, 2018

[45] National Ozone Office, Federal Ministry of Environment. Draft National Cooling Plan for Nigeria, 2021

[46] U4E Policy Guide Series (2017): Energy efficient and climate friendly air conditioners and refrigerators.

[47] ECN, GEF-UNDP. Nigeria End-use Monitoring Study 2014. A publication of the Energy Commission of Nigeria and the GEF-UNDP.

[48] Information on the French Guiana in Kourou study was provided by ENERTECH, www.enertech.fr

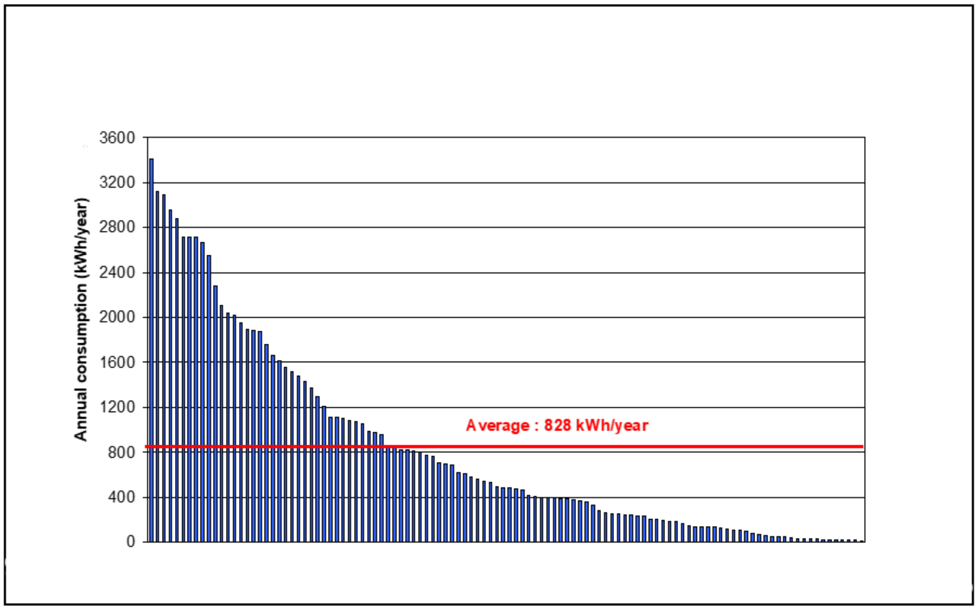

Fig. 3.12: Annual electricity consumption of air conditioners

The energy consumptions of fridges per household ranged from less than 100 kWh/year to 1000 kWh/year with an average value of 425 kWh/year (Fig. 3.13). In a similar study carried out in France in 2007, the average energy consumption of fridges was recorded as 253 kWh/year and in England in 2010, an average value of 162 kWh/year[49]. The factors responsible for the differences in energy consumption from country to country is not clear. However, the indoor temperature of households and the frequent power outages might have contributed to the high energy consumption in Nigeria. The other factors that may contribute to the high energy consumption of fridges in Nigeria are the amount of food stored in them and the energy efficiency level of the fridges.

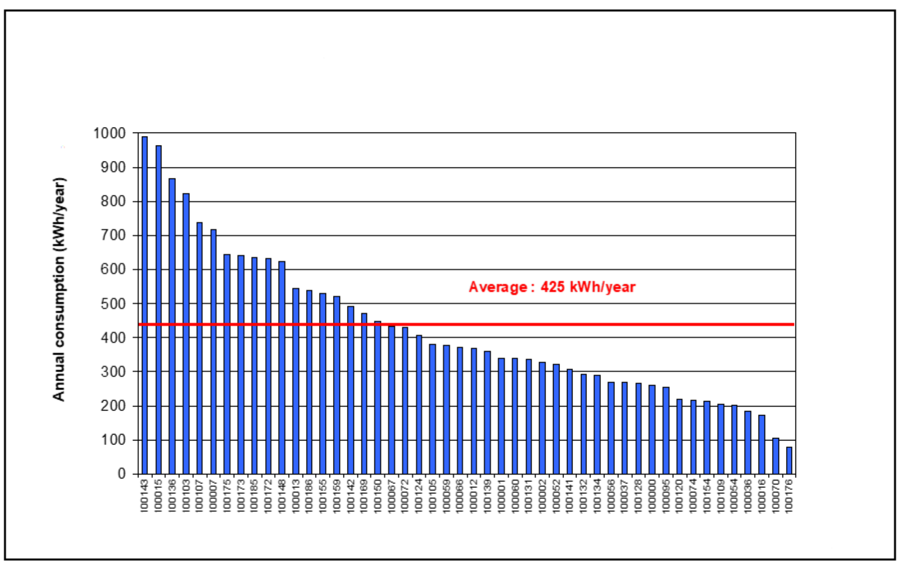

Fig. 3.13 : Annual consumption of fridges

[49] The data on the average electricity consumption of fridges in France and England was provided by ENERTECH, France, www.enertech.fr

The volumes of the individual cold appliances were recorded at the time the data logger devices were installed on them. There was no visible correlation between the volume of the fridges and their energy consumption. The functioning rate of fridges during the period power was available ranged from about 20% to 100% with an average value of 73%. This value was quite high for this type of equipment. This was as a result of the frequent power outages leading to long compressor cycles.

Figure 3.14 shows the annual electricity consumption of freezers. This graph shows the values for all the households during the study. The energy consumptions per household ranged from less than 30 kWh/year to 1650 kWh/year. The average value of 635 kWh/year recorded in this study was higher than the value of 556 kWh/year recorded in a similar study in France in 2007 and higher than the 327 kWh/year recorded in England in 2010. In Sweden, the energy consumption of freezers ranged from 326 kWh/year to 585 kWh/year[50]. It is not clear at this stage the factors responsible for the variation in annual energy consumption in the different countries. However, the indoor temperature of the households and frequent power outage may play an important role in the high energy consumption in Nigeria.

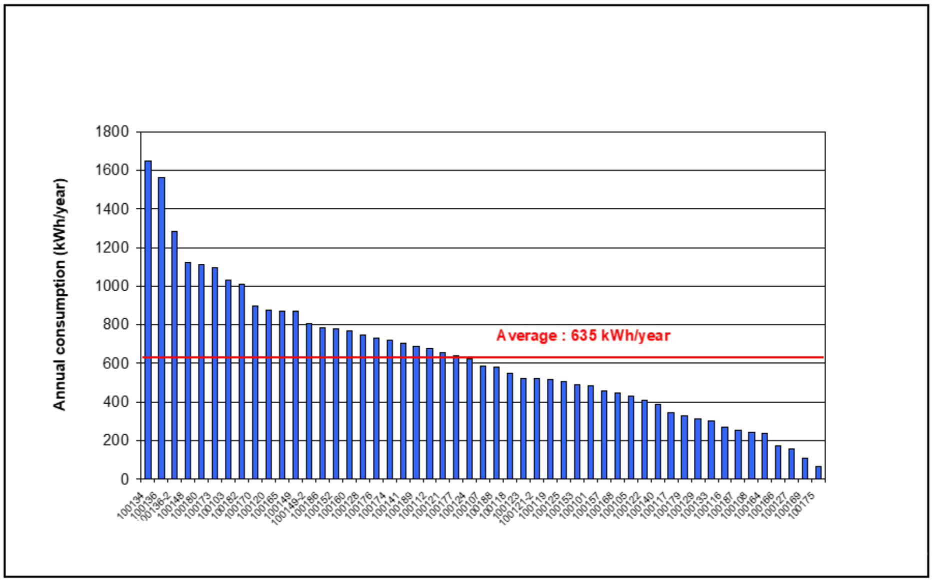

Fig. 3.14: Annual electricity consumption of freezers

The functioning rates of freezers during the period of power supply ranged from 28% to 100% and with an average value of 78%. Similar to the functioning rate of fridges, this value was very high for this type of equipment. This may be as result of the frequent power outages that leads to very long compressor cycles. The study established the fact that there was no definite correlation between the annual electricity consumption of freezers and the duration of power availability. The most consuming freezers were the ones having constant electricity supply.

The graph below (Fig. 3.15) shows the annual electricity consumption for fridge-freezers. The energy consumption value for each household ranged from less than 100 kWh/year to 2000 kWh/year. The average value was recorded as 496 kWh/year. When compared to the studies carried out in other countries, this value was higher than the one recorded in France in 2007, which was 460 kWh/year. The value recorded in Nigeria was also higher than 427 kWh/year recorded in England in 2010. In Sweden, for the SWE400 Project, the average energy consumption of fridge-freezers ranged from 413 kWh/year to 525 kWh/year[51].

[50] Data on average electricity consumption of freezers from France, England and Sweden was provided by ENERTECH, France, www.enertech.fr

[51] Data from France, England and Sweden was provided by ENERTECH, France, www.enertech.fr.

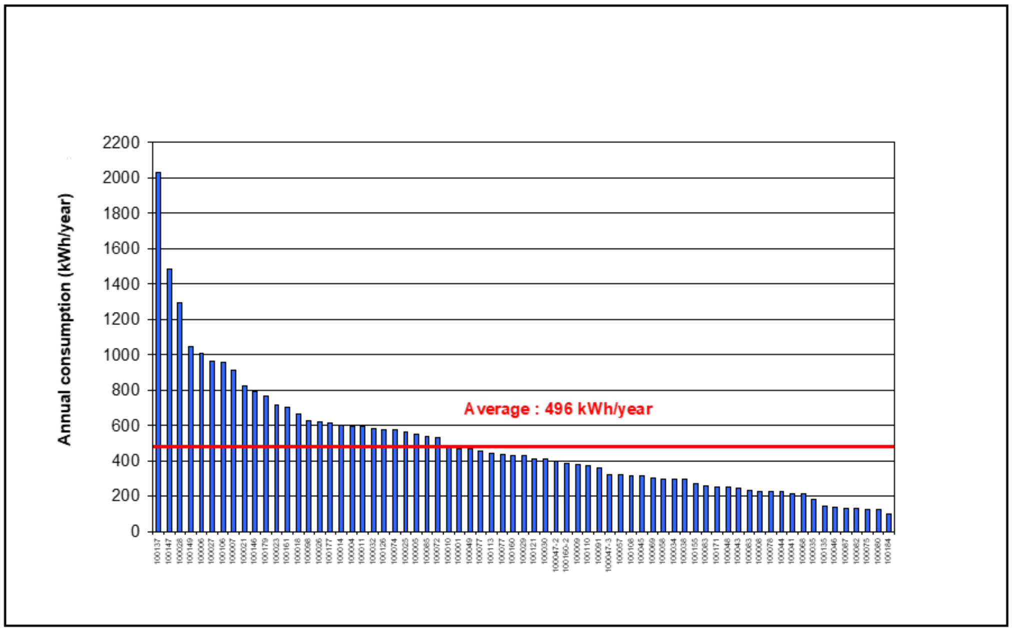

Fig. 3.15: Annual energy consumption of fridge-freezers

The functioning rates of fridge-freezers had values that ranged from 31% to 100% and the average value of 82%. Again the high functioning rates may be due to frequent power outages that leads to very long compressor cycles. The energy consumption of chest freezers ranged from less than 75 kWh/year to 1400 kWh/year, with an average value of 572 kWh/year (Fig. 3.16). This value was higher than the 460 kWh/year found in France in a similar study in 2007 and 362 kWh/year found in England in 2010. In Sweden, the average consumption was 242kWh/year[52].

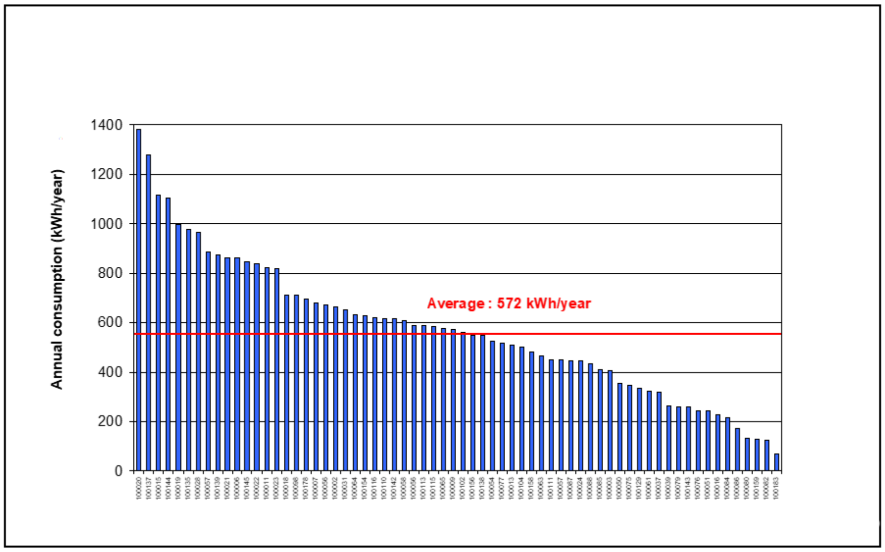

Fig. 3.16: Annual energy consumption of chest freezers

The functioning rate of chest freezer ranged from 30% to 100% with an average value of 79%. The study established a correction between the annual electricity consumption of chest freezers and power availability. As the number of hours electricity was made available increases, the energy consumption also increases.

[52] Data from France, England and Sweden was provided by ENERTECH, France, www.enertech.fr

Annual Electricity Consumption of Lighting Appliances

In Abuja and Sokoto, most of the energy consumed by lighting appliances was monitored from the main switchboard using the Multivoie System. There was a limitation to this approach. It was common to find several appliances connected to one single breaker inside the switchboard. This type of distribution system complicates the electricity measurements and the identification of the specific lines connected to each lighting point from the switchboard. In order to overcome this problem, Lampmeters were deployed to monitor the energy consumption of lighting appliances. But this solution encountered another limitation; the field staff were not always given full access to every room in the houses especially in the Northern part of the country and therefore it was not possible to monitor all the lighting points. Figure 3.17 shows the power rating of each lighting equipment monitored during the study. The average power rating of all the lighting appliances was 37W. This value is lower than the average power rating recorded in the studies carried out in Sweden (38W), England (41W) and France (56W)[53].

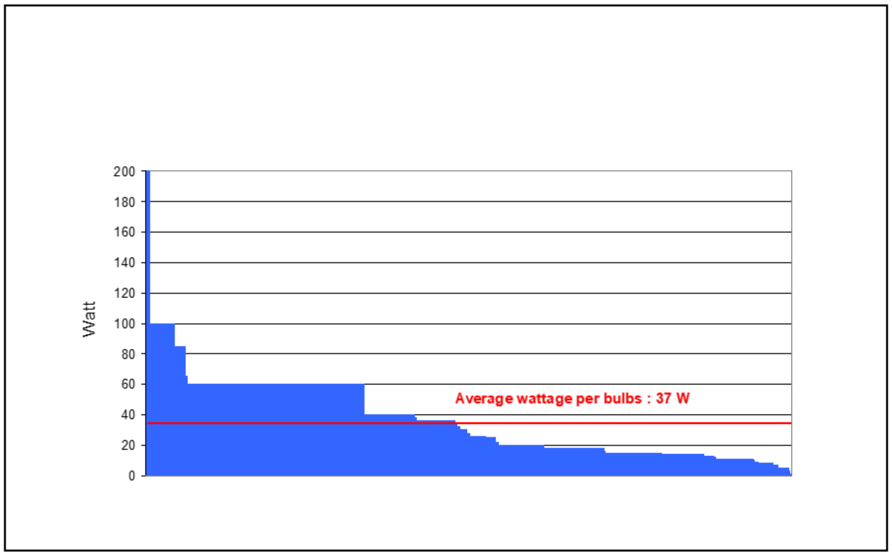

Fig. 3.17: Installed wattage per light bulb

The lighting appliances monitored include incandescent lamps (ICLs), linear fluorescent lamps, compact fluorescent lamps (CFLs), light emitting diodes (LEDs) and halogen spotlight. Figure 3.18 shows the percentage of the quantity of each type of light bulb. Over half of the light bulbs were CFLs followed by the ICLs. These two types together represented more than 90% of the total light bulbs.

[53] Data provided by ENERTECH, France, www.enertech.fr

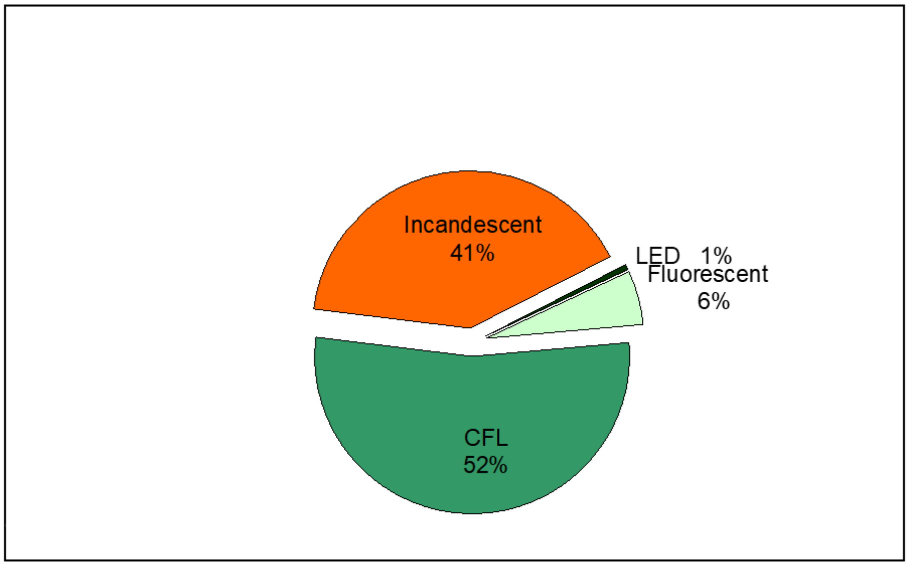

Fig. 3.18: Types of light bulbs

Over 60% of the linear fluorescent lamps monitored during the study were rated 36 W while about 14% of them were rated 18 W. Only about 8% of the linear fluorescent lamps were rated 40 W. The CFLs rated 15 W recorded the highest representing over 16% of the total number of CFLs. Those rated 14W made up 12% of the total. About 3% of the CFLs were rated 85W. About 68% of the ICLs monitored in the study were rated 60W and this was followed by ICLs rated 40W which made up 16% of the total ICLs. The annual energy consumption of lighting appliances per household ranged from 25 kWh/year to 3500 kWh/year with an average of 454 kWh/year (Fig. 3.19). Compared to similar studies done in other countries, this value is higher than the values recorded in France (354 kWh/year) and lower than the value recorded in the United Kingdom (537 kWh/year)[54].

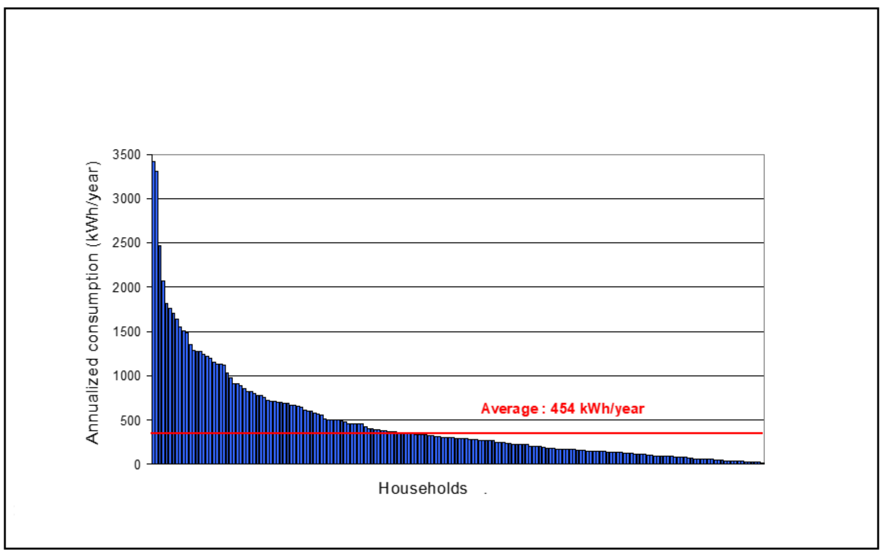

Fig. 3.19: Annual energy consumption of lighting appliances per households

The daily average load curve were calculated during the monitoring period. The values for ploting this graph were recorded during the period electricity was available. There were two main peaks, one in the morning

[54] Data from France and United Kingdom provided by ENERTECH, www.enertech.fr

at 06:00 and the highest one in the evening between 20:00 – 21:00. It was clear that the light consumption during the night remained at a significant level.

Conclusion

The study had shown that the refrigerating appliances in Nigeria consume more energy compared to those in England and France (Table 3.2). Several reasons may be responsible for the higher energy consumption of appliances in Nigeria. Nigeria falls under the tropical region with higher ambient temperature when compared to France and England. Secondly, the frequent power outages in Nigeria will result in longer compressor cycle. It is likely that the cooling appliances in Nigeria are not as efficient as the ones in England and France. As at the time of the study, Nigeria was yet to develop minimum energy performance standards (MEPS) for cooling appliances.

Table 3.2: Electricity consumption of refrigerating appliances

	Annual Energy Consumption (kWh/year)			
	Fridge	Fridge-freezer	Freezer	Chest Freezer
France 2007	253	460	556	460
England 2010	162	427	327	362
Nigeria 2014	**425**	**496**	**635**	**572**

The introduction of MEPS in the cooling sector is expected to move the efficiency level of RAC appliances higher and will be comparable with appliances in other countries already implementing MEPS. This will lead to significant energy savings and reduction in the emission of GHGs. The study has provided sufficient evidence to justify the need to improve the energy efficiency of RAC products in Nigeria.

CHAPTER FOUR

NIGERIA APPLIANCE INVENTORY STUDY

Introduction

There appears to be few available reports on the installed stock of appliances in Nigeria. There are two studies that are easily accessible, one of them is the Nigerian Appliance Inventory Study, which is one of the studies initiated under the Energy Efficiency Programme.[55] The second study was embarked upon by the Nigeria Energy Support Programme (NESP), a project implemented by the GIZ and supported by the GIZ and the European Union[56]. The UNDP-GEF supported study focused on three sets of appliances – lighting, refrigerators, and air conditioners, while the GIZ-implemented project focused on air conditioners. A pre-condition for a meaningful implementation of minimum energy performance standards (MEPS) is an inventory of appliances. The two studies provided information on the estimated stock of theses appliances and their associated energy consumption.

Objective of Study

The objective of the study was to make an inventory of lighting appliances, air conditioners and refrigerators and use the outcome to quantify energy demand and consumption.

Method of Study

The ability to estimate the installed stock of the appliances under consideration was an important element of these studies, which in turn will form the basis for the estimation of their energy demand. By installed stock, it refers to the number of appliances in use at the time of the study. In the UNDP-GEF supported project, several approaches were adopted to ensure that the data collected were reliable. The first approach was the top/down data gathering which involves collecting import data from responsible institutions and local manufacturers. The Nigeria Customs Service (NCS) ought to have been the best single source of data for the study. This organization is the chief steward of the Nigeria's international trade. It is the agency responsible for the control of the importation and exportation of goods and services. The NCS keep records of imports of the appliances under study.

The NCS started computerizing its import entries in 2003 when the Maxtech Data Extractor Software was installed for use in selected ports. This was upgraded about two years later to cover all ports with the installation of the Automated System for Customs Data (ASYCUDA). The ASYCUDA system has been described as a very reliable source of import data. The data from the ASYCUDA platform could be more reliable than the ones obtained from the importers, being more comprehensive in content and scope. The first set of data acquired from the NCS during the study could not be used because the imports were reported by weight (in kilograms), which is the default import format. However, the NCS was able to bring out the imports of the targeted appliances by quantities, which also had some challenges. The quantities of appliance imports came under different packaging forms and needed to go through some transformations for it to be used for the purpose of the study. Every stage of the needed transformation tends to reduce the reliability of the final data.

As a result of this limitations from the data produced through the NCS ASYCUDA System, there was need to turn to another source of data at the import level. This source is the United Nations Commodity Trade Statistics Database (UN Comtrade). The UN Comtrade was established in the early 1960s. Since then, the database has been the source of trade information to policy makers, the business community, research

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[55] Nigeria Appliance Inventory Study: An Inventory of Lighting Appliances, Air Conditioners and Refrigerators in Nigeria, 2015. A publication of Energy Commission of Nigeria, Federal Ministry of Environment, the United Nations Development Programme and the Global Environment Facility.

[56] Nigeria Energy Support Programme. Baseline Assessment of Air Conditioners in Nigeria, 2015. A report of the Nigeria Energy Support Programme implemented by GIZ

institutions and the general public all over the world. The database stores standardized, official, annual trade statistics reported by countries and shows the flows of international products. Its coverage is estimated to reach up to 99 percent of world commodity trade. For this study, the UN ComTrade data format was adjudged better, needing little or no transformation as was the case with the local custom data. However, it also has some limitations. Since trade transactions recorded are those reported by different countries, there was also data gaps when countries failed to provide report for any product or in a particular year. This was the case for some of the targeted appliances under study. UN ComTrade report had missing data for some years that are of interest to this study. Consequently, there was need to complement the NCS data with the UN ComTrade data.

Another important source of data were the local manufacturers of these appliances. There are no manufacturers of lighting appliances in Nigeria as the country solely depended on imported lighting products. There were local manufacturers of air conditioners as well as manufacturers of fridges and freezers. Most of them were located in Lagos and Oyo State, south-west geopolitical zone of Nigeria. These local companies provided the yearly production figures of these appliances, with exception of one of them.

The second approach to data collection was the bottom-up approach. The bottom-up data gathering involves acquiring quantitative data from sales or end users' sources. Sales data was acquired from a company called GFK. GFK was founded in 1934 as an institutional market research organization. The company is present in over 100 countries of the world, and it attempts to answer questions on how consumers experience brands and what they think about them. In Nigeria, GFK covered product such as mobile phones, televisions, DVDs, refrigerators, air-conditioners, washing machines, deep freezers and free-standing cookers. The company's survey covered Lagos, Abuja and Kano with plans to expand to Kaduna, Ibadan, Onitsha, Aba, Port Harcourt and Benin City. For this study, data available for air conditioners only covers 2010 while data available for fridges and freezers cover 2010 and 2011. The data from GFK gives good information on appliance prices and the energy efficiency ratings. It also provides information on the annual energy consumption of these appliances. The major limitation to this data source relates to the number of years for which data is available. In addition, the number of cities covered are also limited and the number of retails shops used as points of survey are very few. As a result of this, the GFK data could not be used as a major data source for the current study.

Results of Study

Inventory of Lighting Appliances

Lighting appliances were classified into five groups – incandescent lamps (ICLs), tungsten halogen, linear fluorescent lamps (LFLs), compact fluorescent lamps (CFLs), and high intensity discharge (HID) lamps. Lighting data was obtained from only two sources - Nigeria Custom Services and the UN Commodity Trade Statistics Database. The imports of lighting appliances are shown in Table 4.1. It should be noted that the 2012 data entries for all sectors came from The Nigerian Customs ASYCUDA system as well as most of the data entries for LFLs and HID. All the other entries came from the UN ComTrade database. The 2012 import figures cover only from January to September.

Table 4.1: Stock of lighting appliances from 2006 to 2012

	ICLs	Tungsten Halogen	LFLs	CFLs	HID	Total
2006	22,305,008	179,132	41,948	1,532,783	69,862	**24,128,733**
2007	43,577,494	113,629	37,448	2,400,260	101,497	**46,230,328**
2008	15,825,270	279,543	187,631	5,419,917	483,740	**22,196,101**
2009	111,271,218	514,461	115,024	9,310,718	367,224	**121,578,645**

2010	154,667,493	134,838,803	202,715	4,532,277	587,123	**294,828,411**
2011	18,850,356	1,246,189	66,976	7,074,054	4,492,113	**31,729,688**
2012	2,358,612	156,965	51,931	1,230,416	1,370,243	**5,168,167**
Total	**368,855,451**	**137,328,722**	**703,673**	**31,500,425**	**7,471,802**	**545,860,073**

Source: ECN *et al*, 2015[54]

Over 500 million lighting appliances were imported into Nigeria between 2006 and 2012. The year 2010 recorded the highest number of imported lighting appliances (294,828,411), followed by the year 2009 (121,578,645). The total number of installed stocks increased from 2006 with a peak in 2010 and declined from 2011 with the lowest stock recorded in the year 2012. The reason for the decline is unclear. ICLs had the largest share of the total stocks of lighting products for each of the years of study. In aggregated values, ICLs constituted approximately 68% of the total imported lighting appliances for the 7 years period, followed by Tungsten Halogen representing 25% of the total lamps. From the study, ICLs is the dominant lighting products in the Nigerian market within the period of the study.

According to the UNEP Enlighten Programme[57], the use of lighting appliances in Nigeria cuts across three main sectors – residential, commercial/industrial and outdoor (street lighting). Residential lighting appliances give visibility and illumination in residential buildings, these are mainly incandescent lamps, tungsten halogen, linear fluorescent lamps and compact fluorescent lamps. Commercial/industrial lighting products include those used in commercial and industrial building and encompass all the lamp technology types under consideration in the study. Outdoor lighting products consist of street lighting equipment, such as floodlights, beacon lights and security lights, and they are generally used to light up streets, illuminate outdoor playing fields, positioned at road intersections to aid navigation and placed at critical points for security reasons.

The distribution of lamps by sector is shown in Table 4.2; the percentage distribution was adopted from the UNEP's 2010 Nigeria's Country Lighting Assessment report. From Table 4.2, ICLs were the dominant lighting products in residential areas, while LFLs were the dominant ones in commercial/industrial sector. HID were mostly used for outdoor lighting.

Table 4.2: Distribution of lighting appliances by sector

	ICLs	Tungsten Halogen	LFLs	CFLs	HID	Total
Residential	141,923,619	10,917,201	81,879,011	60,044,608	0	**294,764,439**
Commercial/ Industrial	10,917,201	43,66,880	147,382,220	32,751,604	5,458,600	**200,876,506**
Outdoor	0	1,091,720	27,293,004	10,917,201	10,917,201	**50,219,126**
Total	**152,840,820**	**16,375,802**	**256,554,234**	**103,713,413**	**16,375,802**	**545,860,073**

Source: ECN *et al*, 2015

The basic data in Table 4.1 above could not be used to estimate the energy demand resulting from the use of the lamps. The life span of the different types of lamps varies and the life spans of some of them such as the ICLs and the CFLs are less than 7 years. Fig. 4.1 shows the average life span of the different lamp types in the sector under consideration. Thus, many of these lamps would have gone out of use over the years depending on their lifetimes. It was necessary for the basic import entries to be transformed into estimates of installed lamp stocks, which needs the application of a modelling tool to do this. With reference to the operating hours and lifetime of lamps, the installed stock of lamps as of 2012 was predicted using a time-series stock modeling tool bases on Gaussian.

[57] UNEP enlighten. Country Lighting Assessment – Nigeria 2010

Using the raw data on the different types of lamps imported between 2006 and 2012, and based on some assumptions, the model tries to predict the number of the different lamp types in operation over time by using lamp average life span by sector and lamps operating hours. The lamps average life span by sector and type was adopted from UNEP's Country Lighting Assessments report (Fig. 4.1). The daily operating hours for the different sectors was derived based on the local experiences of indigenous electrical engineers, giving the operating time in residential buildings to be 6 hours, commercial/industrial to be 12 hours and outdoor to be 9 hours. The predicted installed lamps stock by the end of 2012 is shown in Table 4.3 below.

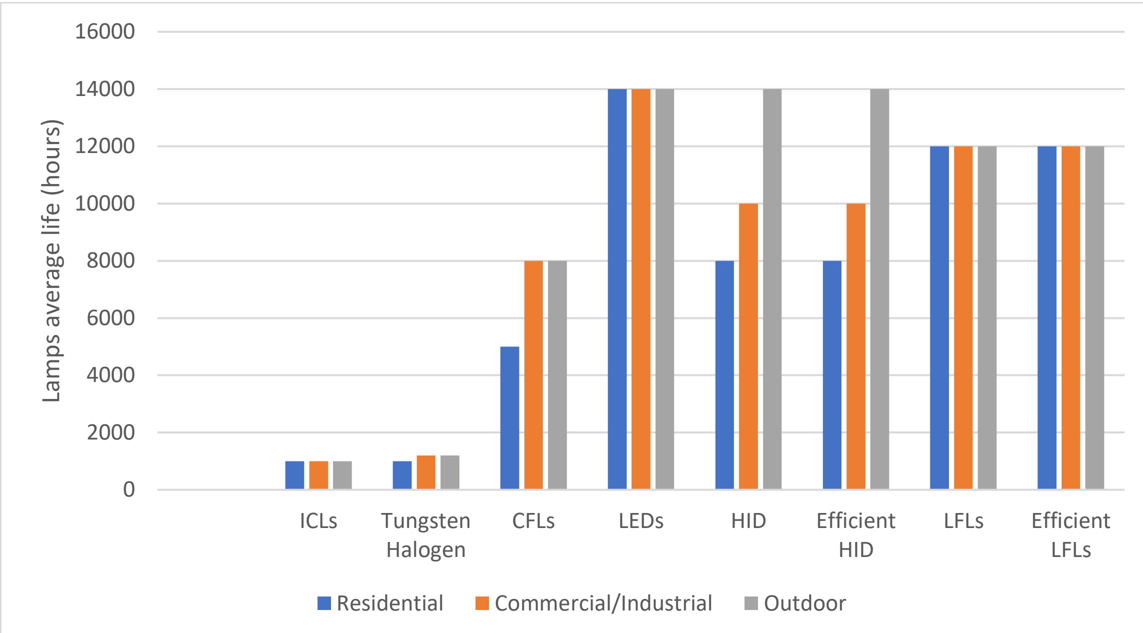


Fig. 4.1: Lamps average life by sector and type (Source: UNEP Country Lighting Assessments, 2010)

Table 4.3: Predicted installed lamps stock by the end of 2012

	ICLs	Tungsten Halogen	LFLs	CFLs	HID	Total
Residential	1,095,070	52,322	205,213	6,119,826	0	7,472,431
Commercial/Industrial	42,118	20,929	155,648	2,622,464	2,051,973	4,893,132
Outdoor	0	5,232	43,393	1,112,696	4,705,715	5,867,036
Total	**1,137,188**	**78,483**	**404,254**	**9,854,986**	**6,757,688**	**18,232,599**

Source: ECN *et al*, 2015

As shown in Table 4.3, the output of the modeling put the total installed lighting stock at the end of 2012 to be over 18.2 million lamps. This value was less than the total installed lamps reported in the Country Lighting Assessment (CLA) Report (UNEP, 2010) which puts the value of total installed lamps to be about 40 million lamps. The disparity could be as a result of the based data used for analysis in the CLA and this study; the CLA relied on different sources which may be more robust than the raw data used for this study. Despite the disparity, a close examination of Table 4.3 shows some interesting trends. Over half of the total installed stock of lamps in all sectors were CFLs. ICLs accounted for less than 10% of the total installed stock of lamps in all sectors.

Air Conditioners

Unlike the lighting appliances, some brands of air conditioners were manufactured in Nigeria. The current study recorded five companies manufacturing air conditioners in the Country and they include Dajcom, Norman, Nigeria Engineering Works (NEW), Grand and HPZ (Thermocool). The report of the Nigeria Energy Support Programme (NESP) in 2015[58] revealed that there were five different types of air conditioners commonly found in Nigeria. They are described below:

Window Unit: This type of air conditioner is installed sitting on a window or an opening of the wall of a building, with the control panel facing the inside of the building. Interior air is cooled as a fan blows it over the evaporator. On the exterior, the air is heated as a second fan blows it over the condenser. In this process, heat is drawn from the room and discharged to the environment. The compressor and the heat exchanger are located in the same unit.

Split Systems: The Mini-split Unit is designed to allow flexibility in the installation. Similar to the Window Unit, it is made to cool a single room or space. For this type of air conditioners, the compressor and heat exchanger unit can be located further away from the inside unit. The inside and outside units are connected with insulated metallic ducts. The Mini-Split Systems are much more efficient than the Window Units; they are however more expensive than Window Units.

Mobile Units: This is a single unit which contains both the evaporator and condenser. The system is connected to the outside via flexible ducts. It can be moved inside the conditioned space.

Packaged Terminal Air Conditioners (PTAC): These types of air conditioning systems are usually installed in commercial buildings. They have two separate parts; the evaporator and the compressor are usually located inside the same housing. PTAC systems are connected with the conditioned space through ducts.

Central Systems: These are large scale systems for large buildings, with many internal units connected to a single external unit.

Brands of Air Conditioners in Nigeria

There are different brands of air conditioners in the Nigeria market. Although, there is a ban on the importation of secondhand air conditioners by the government, the study revealed that many air conditioners were still imported into Nigeria. The new air conditioner brands are shown in Table 4.4. Most the new air conditioner brands are imported into Nigeria while some are locally manufactured. The secondhand air conditioner brands are shown in Table 4.5. There were 21 brands of new air conditioners and 26 brands of secondhand air conditioners. The new air conditioners were imported from Japan, China, Europe, Malaysia, Philippines and Dubai while the secondhand air conditioners were imported from Italy, Hong Kong, South Korea, Singapore, Japan and Germany[59].

Table 4.4: Brands of new air conditioners in Nigeria

Brand New Air Conditioner	**Country of Importation**	**Comment**
Samsung	Europe, China, Malaysia	The assembled brand new products and the brand new types imported into the country, are designed
Haier		
Panasonic		
Chigo		
Hisense		

[58] NESP 2015. Baseline Assessment of Air Conditioners in Nigeria. A publication of the Nigeria Energy Support Programeme, a project of the GIZ and European Union

[59] NESP. Baseline Assessment of Air Conditioners in Nigeria, 2015. A publication of the Nigeria Energy Support Programme and the Nigeria Federal Ministry of Power.

Scanfrost	Philippines, Dubaï, Japan	for the Nigerian environment
Midea		
Newclime		
Airflow		
Sharp		
General		
LG		
Amaco		
Polystar		
Bluegate		
Bruhm		
Westpoint		
Beko		
Kenstar		
Daikin		
Carrier	USA	

Sources: NESP, 2015[55]

Table 4.5: Brands of secondhand air conditioners in Nigeria

Second Hand (Fairly Used) Air Conditioner	**Country of Importation**	**Comments**
Goldstar	Italy, HongKong, Korea, Singapore, Japan Germany	The second hand air conditioners were designed for the original country of use, before their importation into the country
Itaclima		
Sanyo		
Corona		
Olimpia		
Panasonic		
LG		
Queen		
Hitachi		
Hisense		
Sharp		
Mitsubishi		
Delonghi		
Technopoint		
Fortress		
Hansys		
National		
Artel		
Amcor		
Dimplex		
Siesta		
Samsung		
Fujitsu		
Whisen		
Kosner		
Aurora		

Sources: NESP, 2015

Stock of Air Conditioners in Nigeria

From the NESP report, unlike lighting appliances, some brands of the air conditioners were manufactured in Nigeria. There were five companies manufacturing air conditioners in the Country and they were Dajcom, Norman, Nigeria Engineering Works (NEW), Grand and HPZ (Thermocool). Table 4.6 shows the base data for air conditioners imported into Nigeria between 2006 and 2014.

Table 4.6: Air conditioners import from 2006 to 2014

Year	Domestic	Commercial	Industrial	Total
2006	19,615	4,061	847	24,523
2007	287,212	1,162,202	580,892	2,030,306
2008	312,227	355,495	207,520	875,242
2009	148,868	3,498,258	1,606,992	5,254,118
2010	5,548,865	380,144	130,284	6,059,293
2011	2,000,883	592,410	109,406	2,702,699
2012	648,388	8,331	15,293	672,012
2013	865,553	243,121	101,223	1,209,897
2014	923,191	254,231	122,435	1,299,857
Total	**10,754,802**	**6,498,253**	**2,874,892**	**20,127,947**

Source: NCS (2006-2014); ComTrade (2007-2011); NESP, 2015

The highest number of air conditioners imported into Nigeria were recorded in the year 2010 (6,059,293), closely followed by the year 2009 (5,254,118). About 54% of the total imported air conditioners were targeted at the Domestic Sector, while 32% at the Commercial Sector and 14% at the Industrial Sector. The total number of air conditioners imported between 2006 and 2014 shows increasing trend and peaked in 2010 before declining with lowest number being recorded in the year 2012. The based data also revealed that the demand for air conditioners was highest in the domestic sector followed by the commercial sector. The low demand in the industrial sector may be as a result of the low industrial activities in Nigeria. Between 2006 and 2014, the total number of locally manufactured air conditioners was 3,855,404 of which 89% of them were manufactured for the Domestic Sector, while 11% was manufactured for the Commercial Sector (Table 4.7). No air conditioner was manufactured for the Industrial Sector within the period of the study.

Table 4.7: Air conditioners manufactured locally from 2006 to 2014

Year	Domestic	Commercial	Industrial	Total
2006	232,922	20,839	-	253,761
2007	319,588	31,647	-	351,235
2008	175,155	19,841	-	194,996
2009	271,072	43,174	-	314,246
2010	367,246	49,312	-	416,558
2011	513,227	64,343	-	577,570
2012	393,278	53,520	-	446,798
2013	552,600	67,800	-	620,400
2014	620,000	59,840	-	679,840
Total	3,445,088	410,316	-	3,855,404

Source: NESP, 2015

As shown in Fig. 4.2, the total number of imported domestic air conditioners show increasing trend between 2006 and 2014. However, for imported commercial and industrial air conditioners, their trend is decreasing during the years data was collected. For locally manufactured air conditioners, both domestic and commercial air conditioners show increasing trend for the nine-years period (Fig 4.3).

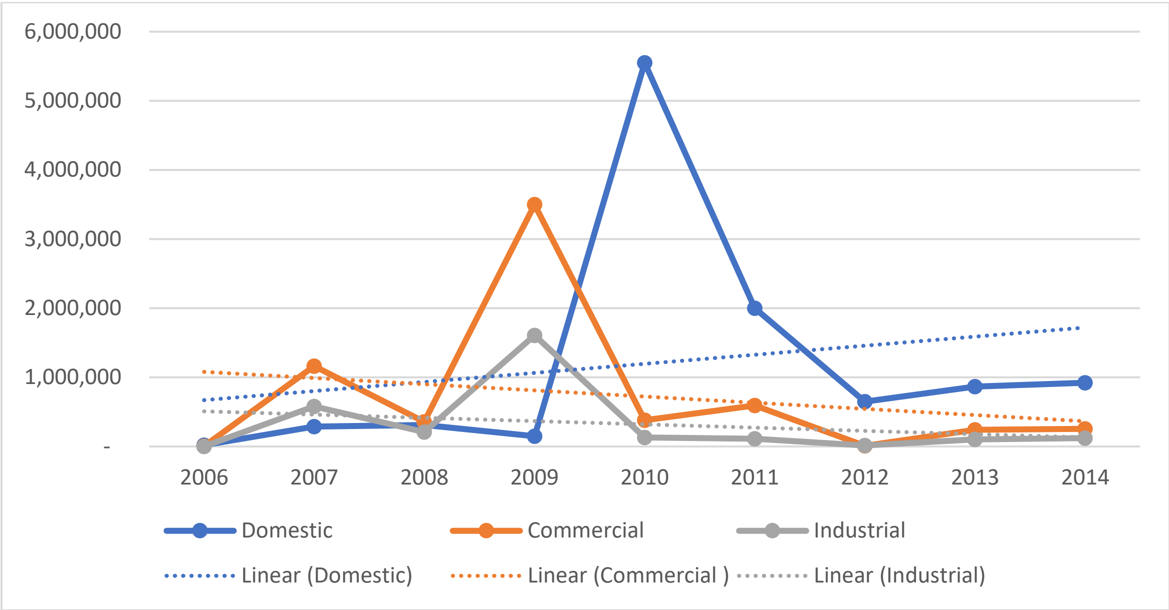


Fig. 4.2: Trends of imported air conditioners in Nigeria between 2006 and 2014

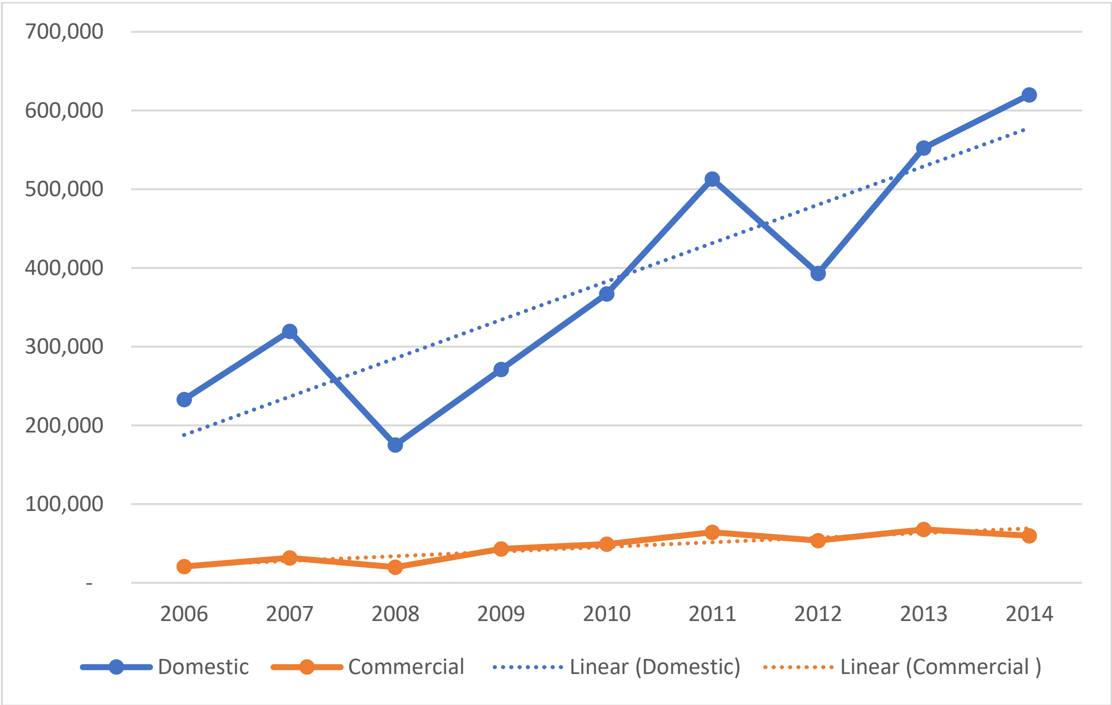


Fig. 4.3: Trends of locally manufactured air conditioners between 2006 and 2014

Installed Stock of Refrigerating Appliances

The study to estimate the installed stock of refrigerating equipment (fridges, freezers, fridge-freezers) was embarked upon by the GEF-UNDP supported Energy Efficiency Programme. The data collection covered from 2006 to 2012, which falls within the life span of the Project. The study relied on three sources that provided the base data for refrigerating appliances. They are the Nigeria Customs Service, UN ComTrade and local manufacturers. The imports data for the year 2012 did not capture the last three months of the year. Within the study period, the larger percentage of refrigerators in Nigeria were imported into country. Only about 1% of the total refrigerating appliance was manufactured locally. Three companies were involved in the local manufacturing of fridges and freezers, and they are Dajcom, Nigeria Engineering Works (NEW), and HPZ. Table 4.8 shows the number of refrigerating equipment imported into Nigeria from 2006 to 2012.

Table 4.8: Imported refrigeration appliances 2006-2012

Year	**Fridges**	**Fridge/Freezers**	**Freezers**	**Total**
2006	53,478	148,632	78,759	280,869
2007	132,529	90,126	1,856,989	2,079,644
2008	86,450	84,604	15,9927	330,981
2009	76,493	106,590	3,812,599	3,995,682
2010	65,554,007	25,150,879	70,161,513	160,866,399
2011	19,416,516	22,054,931	29,888,889	71,360,336
2012	307,971	292,793	304,882	905,646
Total	**85,627,444**	**47,928,555**	**106,263,558**	**239,819,557**

Source: ECN *et al*, 2015

Over 239.8 million refrigerators were imported into Nigeria within the study period and the year 2010 recorded the highest number of imports totaling 160,866,399 refrigerators and this was followed by the year 2011 recording 71,360,336 refrigerators. There was a sharp decline in the number of imported refrigerators between 2011 and 2012. The reason for this decline is unclear. However, the base data shows an increasing trend from 2006 to 2012 (Fig. 4.4)

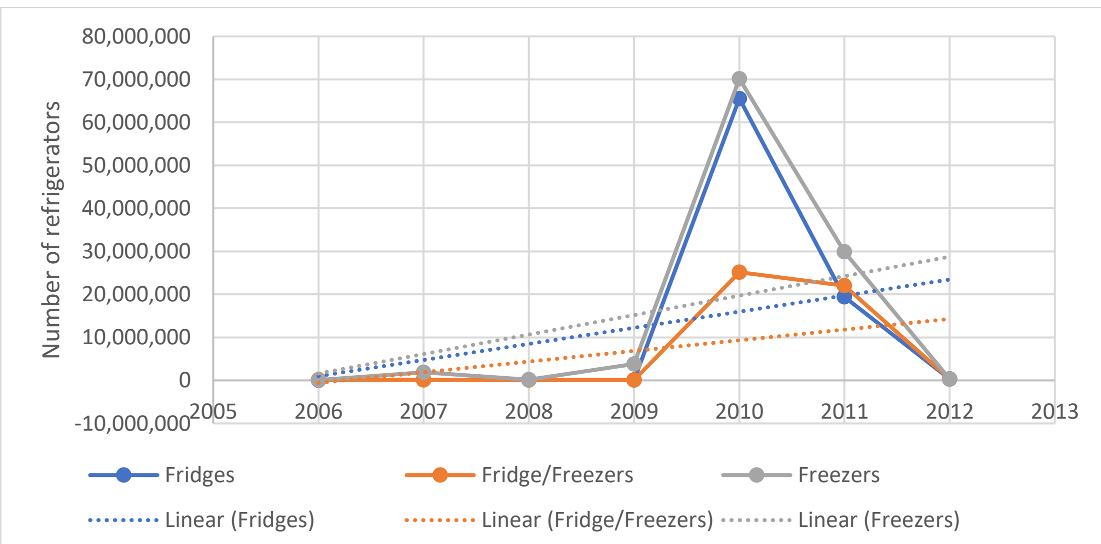


Fig. 4.4: Trends in the number of imported refrigerators

Table 4.9 shows the number of locally manufactured refrigeration appliances within the study period. For both imported and locally manufacture products, freezers were the dominant type of refrigerators representing 78.8% of the total number of refrigerators manufactured locally and 44% of the total number of imported refrigerators.

Table 4.9: Locally manufactured refrigerators 2006-2012

Years	**Fridges**	**Fridge/Freezers**	**Freezers**	**Total**
2006	4,000	25,758	140,412	**170,170**
2007	4,000	46,252	251,682	**301,934**
2008	2,000	32,471	161,983	**196,454**
2009	4,000	59,857	331,708	**395,565**
2010	4,000	52,323	322,012	**378,335**
2011	4,000	173,432	420,176	**597,608**
2012	4,000	121,046	372,578	**497,624**
Total	**26,000**	**511,139**	**2,000,551**	**2,537,690**

Source: ECN *et al,* 2015

As shown in Fig. 4.5, the base data for the locally manufactured products revealed an increasing trend within the study period.

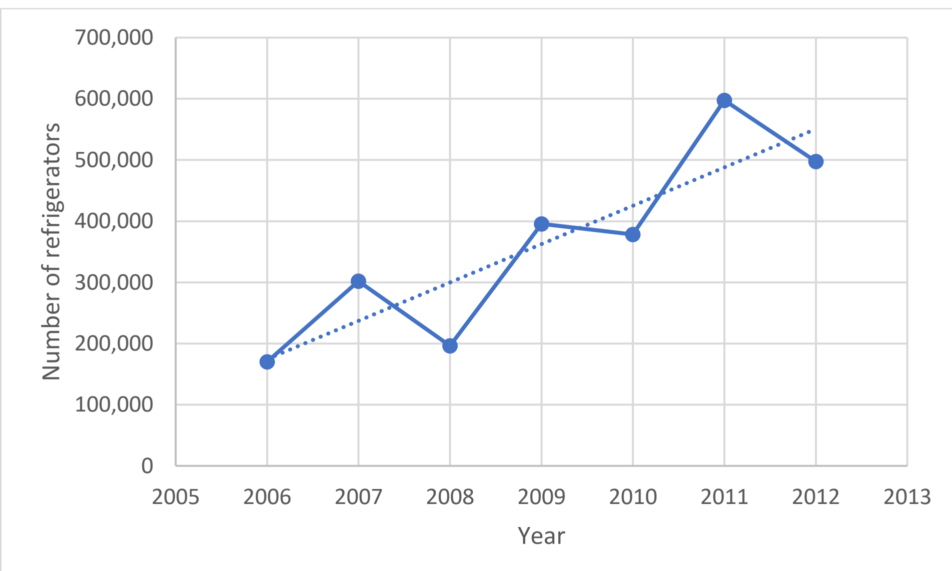


Fig. 4.5: Trend in the number of locally manufactured refrigerators between 2006 and 2012

Lighting Appliances Energy Demand

Nigeria operates a 220V along the distribution grid. According to the report by UNEP en-lighten Programme (2010) on Nigeria, the power ratings of lighting appliances varies and ranges from 6W to 100W as shown in Table 4.10. Lighting products used for outdoor lighting had higher power ratings compared to lighting products used in residential and commercial sectors. The HID lamps type, which exerted a higher energy demand are mainly used for outdoor purposes. The lamps wattages and the installed stock of lamps is needed to calculate the energy consumption of lighting appliances.

Table 4.10: Lamps energy ratings by sector and type

	Residential	Commercial/ Industrial	Outdoor
ICLs	40	50	60
Tungsten Halogen	35	42	50
CFLs	8	12	14
LEDs	6	8	12
HID	40	90	100
Efficient HID	32	70	80
LFLs	40	48	52
Efficient LFLs	30	38	40

Source: UNEP en.lighten CLA (2010)[46]

In order to calculate the energy demand from lighting sources, the power ratings in watts of the different lamp types were used in combination with the installed stocks of lamps. In addition to these parameters, some assumptions had to be made. The energy demand in kilowatt hour (kWh) was calculated using the following formula:

$$E = PT$$

Where:

E = Energy Demand (kWh)

P = Electrical Power (Watts)

T= Time (hours)

The yearly energy consumption of each light bulb was calculated using the formula:

$$Yearly\ energy\ consumption\ = P \times 24 \times 365 \times de - rating\ factor$$

The de-rating factor is defined as deductions made in relation to the number of hours in the day and numbers of days in the year the lamp is expected to be switched on based on where they are deployed, either in the residential, commercial/industrial or outdoor. A de-rating factor of 0.5 (denoting 50% usage) has been applied to both residential and outdoor. For an industrial/commercial setting, it is assumed that lamps are switched on for up to 12-15 hours for which a de-rating factor of 0.6 has been applied. A further de-rating factor of 0.7 was applied on the assumption that 104 days out of the 365 days in a year will account for work free weekends. Based on the above assumption and from the lamp estimation, the energy demands for the different types of lamps are shown in Table 4.11 in gigawatt hour (GWh).

Table 4.11: Estimated energy demand of different types of lamps in GWh

	ICLs	**Tungsten Halogen**	**LFLs**	**CFLs**	**HID**	**Total**
Residential	191.86	8.02	35.95	214.44	0.00	450.27
Commercial/Industrial	7.75	3.23	27.49	115.78	679.47	833.72

Outdoor	0.00	1.15	9.88	68.23	2061.10	2140.57
Total (GWh)	**199.60**	**12.40**	**73.32**	**398.45**	**2740.57**	**3,424.35**

Source: ECN *et al*, 2015

It is estimated that the lighting sources under consideration placed a total of 3,424.35 GWh on the Nigeria power grid in 2012. Outdoor lighting sources placed the highest demand with 2140.57 GWh followed by commercial/industrial sector with 833.72 GWh and then the residential sector 450.27 GWh. HID placed the highest energy demand on the power grid representing 80% of the total energy demand, this was followed by CFLs representing 12% of the total demand.

Energy Efficient Lamps Deployment Scenario

This section examined the impact of replacing the base lamps with energy efficient ones. To do this, the estimated installed stocks as of 2012 shown in Table 4.3 are replaced with efficient lamps using the percentage shown in Table 4.12 below. The Table was adopted from the UNEP en.lighten Initiative. It shows the one-for-one lamp technology substitution for each lamp in the existing installed stock and each energy efficient lamp that would replace it. Under the efficiency scenario, each lamp listed in the top row of Table 4.12 is replaced by a more energy efficient lamp of the type listed in the left columns according to the percentages shown in the columns. For example, 80% of the existing tungsten halogen lamps are replaced with CFLs and 10% with LED lamps.

Table 4.12: Assumptions for lamp technology substitutions

		ICLs	**Tungsten Halogen**	**CFLs**	**LEDs**	**HID**	**LFLs**
Replacement Lamps (% of Total)	**ICLs**	10%					
	Tungsten Halogen		10%				
	CFLs	85%	80%	90%			
	LEDs	5%	10%	10%	100%		
	Efficient HID					100%	
	Efficient LFLs						100%

Source: UNEP en.lighten Initiative (2010)

The application of the assumptions of lamp technologies shown in Table 4.12 on the install stocks as shown in Table 4.3 resulted in the values shown in Table 4.13 below.

Table 4.13: Efficient lamps substitution

	ICLs	Tungsten Halogen	CFLs	LEDs	HID	LFLs	Total
ICLs	113,719	-	-	-	-	-	113,719
Tungsten Halogen	-	7,848	-	-	-	-	7,848
CFLs	966,610	62,786	8,869,487	-	-	-	9,898,883
LEDs	56,859	7,848	985,499	-	-	-	1,050,207
Efficient HID	-	-	-	-	6,757,688	-	6,757,688
Efficient LFLs	-	-	-	-	-	404,254	404,254
Total	**1,137,188**	**78,483**	**9,854,986**	**-**	**6,757,688**	**404,254**	**18,232,599**

Source: ECN *et al*, 2015

This was further applied to estimate the assumed stock of efficient lamps by sector and lamp technology type. This is shown in Table 4.14 below

Table 4.14: Efficient lamps substitution stock by sector and type

	ICLs	Tungsten Halogen	CFLs	LEDs	Efficient HID	Efficient LFLs	Total
Residential	474,048	36,465	6,527,270	802,234	-	2,005,586	9,845,602
Commercial/ Industrial	36,465	14,586	1,309,101	244,317	182,326	4,922,802	6,709,597
Outdoor	-	3,647	331,833	65,637	364,652	911,630	1,677,399
Total							**18,232,599**

Source: ECN *et al*, 2015

By applying the same assumptions to calculating energy demand for the values in Table 4.14, the energy demand output based on efficient lamps scenario is shown in Table 4.15.

Table 4.15: Energy demand based on efficient lamp scenario

	ICLs	Tungsten Halogen	CFLs	LED	Efficient HID	Efficient LFLs	Total
Residential	83.05	6	228.71	21	0	264	601.99
Commercial/Industrial	6.71	2	58	7	47	688	809.16
Outdoor	0	1	20	3	128	159.72	312.08
Total (GWh)	**89.76**	**9**	**306.86**	**32**	**174.73**	**1,112**	**1723.23**

Source: ECN *et al*, 2015

As shown in Table 4.15 above, the installed stock of energy efficiency lamps under efficient lamps placement scenario would place a total of 1723.23 GWh on the Nigeria power grid. In terms of sector energy demand after transition to energy efficient lamps, commercial/industrial sources would now place the highest demand with 809.16 GWh followed by residential with 601.99 GWh and outdoor with 312.09 GWh. As earlier estimated, without transition to the use of energy efficient lamps, the energy demand was estimated as 3,424.35 GWh. With transition to energy efficient lamps, the energy demand would be reduced drastically to 1,723.25 GWh. This gives a total energy savings of about 1,701.10 GWh in annual electricity consumption from lighting sources. This translates to a savings of about 49.6% of the total demand from lighting equipment.

Air Conditioning Appliances Energy Demand

The energy demand for air conditioners as of 2012 was estimated using the base data. To do this, several assumptions were made. The average power rating of domestic, commercial and industrial air conditioners was taken as 1.5kW/Unit, 4.7kW/Unit and 18.7kW/Unit respectively. These estimates were made based on the experiences of local electrical engineers working with these appliances in the field. It was assumed that the residential apartments are unoccupied for 8-10 hours a day and air conditioners are not used during this period. As a result, a de-rating factor of 0.6 was applied to calculate the energy demand for residential sector. In a commercial setting, it was assumed that air conditioners are switched on during office and business hours. Thus, a de-rating factor of 0.6 was applied. Furthermore, on the assumption that many offices are closed during weekend, that is 104 days out of the 365 days, a further de-rating factor of 0.7 was applied. In the industrial sector, it was assumed that work go on virtually every day and industries are only shut down for maintenance. Air conditioners work for 80% of the time, hence, a de-rating factor of 0.8 was applied. Applying the above assumptions, air conditioner base energy demand output is shown in Table 4.16.

Table 4.16: Air conditioners energy demand by sector

	Domestic	Commercial	Industrial	**Total**
2006	1,991.00	430,576.78	110,999.01	2,532.58
2007	4,784.01	20,644.32	76,125.66	101,554.00
2008	3,842.52	6,490.40	27,195.41	37,528.33
2009	3,310.81	61,239.29	210,595.66	275,145.76
2010	283,162.62	7,426.26	17,073.67	307,662.54
2011	256,341.24	11,356.73	14,337.61	282,035.59
2012	8,212.49	1,069.54	2,004.14	11,286.18
Total (GWh)	**561,644.70**	**108,657.12**	**347,443.16**	**1,017,744.97**

Source: ECN *et al*, 2015

As shown in Table 4.16, air conditioning appliances placed a total energy demand of 1,017,744.97 GWh on the Nigeria power grid. Domestic air conditioners placed the highest energy demand representing 55% of the total energy demand. This was followed by the industrial air conditioners representing 34% of the total.

Refrigeration Appliances Energy Demand

The energy demand of refrigerating appliances was calculated on the assumption that the average power rating of fridges, fridge-freezers and freezers were 100W/Unit, 150W/Unit and 200W/Unit respectively. Since refrigerating equipment are always switched on wherever they are being use, no de-rating factor was applied for calculating their energy demand. The energy demands of refrigerating appliances by type are shown in Table 4.17.

Table 4.17: Estimated energy demand of refrigerating appliances

	Fridges	Fridge/Freezers	Freezers	Total
2006	46.85	195.30	137.99	380.13
2007	116.10	118.43	3,253.44	3,487.97
2008	75.73	111.17	280.19	467.09
2009	67.01	140.06	6,679.67	6,886.740
2010	57,425.31	33,048.26	122,922.97	213,396.54
2011	17,008.87	28,980.18	52,365.33	98,354.38
2012	269.78	384.73	534.15	1,188.67
Total (GWh)	**75,009.64**	**62,978.12**	**186,173.75**	**324,161.52**

Source: ECN *et al*, 2015

As seen in Table 4.17, refrigeration appliance placed a total energy demand of 324,161.52 GWh on the power grid. Freezers place the highest demand with 58% of total demand and followed by fridges with 23% and fridge/freezers with 19% of the total energy demand.

Costs and Benefits of Appliance Energy Standards

The Policy Analysis Modeling System (PAMS), an analytical tool developed by CLASP was used to evaluate the cost and benefit of appliance standards and labeling programme. PAMS is a spreadsheet tool developed to provide an estimate of costs and benefits of appliance efficiency standards and labeling programmes. The tool provides both a consumer-oriented analysis and a national cost-benefit analysis. The tool uses a bottom-up approach by using the technical specifications of products to estimate the increased cost to the consumer resulting from the use of energy-saving devices. The tool requires little input data, making it ideal for developing countries where dearth of information exist. PAMS can also estimate the carbon emissions and mitigation resulting from the implementation of energy efficiency standard programme. It calculates the Life Cycle Cost (LCC), the National Energy Savings (NES) and the Net Present Value (NPV). To run PAMS analysis for Nigeria, several assumptions were made.

Benefits of Implementing Refrigerator MEPS

To run the PAMS analysis to model the impacts of MEPS for refrigerators in Nigeria, the following economic parameters were used for the analysis; consumer discount rate of 12.6%, national discount rate of 10% and income growth of 1.4%. The consumer discount rate was interpolated from the known value of another country. The marginal price of residential electricity as at the time of the study was N12.00/kWh and going by the prevailing exchange rate was equal to $0.075/kWh. The heat rate was found to be 2.0, indicating a significant fraction of hydroelectric or other renewable generation. The amount of renewable electricity production also has a direct influence on the carbon emission factor of 0.372 kg of CO_2 per kWh. Transmission and distribution losses are 10% of production. About 50% of Nigerians households use commercial electricity. The result of the analysis for refrigerator is shown in Table 4.18.

Table 4.18: Unit benefit of using energy efficient refrigerator

	Base Case		Standard Case
Purchase Price	$500		$620
UEC in kWh/year	1,314		930
Electricity Bill	$98.55		$69.75
Life Cycle Cost (LCC)	$1,152		$1,081
Efficiency Improvement		41%	
Payback Time (years)		4.17	
Lifetime (Years)		15	
LCC Savings		$71	

Source: ECN *et al*, 2015

The baseline model refrigerator used for the analysis is estimated to cost $500 and consume 1314 kWh per year. The standard case refrigerator would raise the efficiency of the baseline model by 4%. The most cost-effective way to achieve this improvement is to increase the efficiency of the compressor moderately and add insulation to the door panel. The implementation of these high efficiency options increases the price of the refrigerator by 24% ($120). On the other hand, annual consumption goes down to 930kWh per year, a decrease of nearly 384 kWh per year. Correspondingly, the customer's annual electric bill contribution from the refrigerator decreases by about $29. Over the 15 years appliance lifetime, each household that purchases a refrigerator after standards are implemented will save about 5760 kWh per year. The LCC savings is $71 over the life of the refrigerator.

The national level savings and benefits were also evaluated. In the standards scenario, every appliance that is purchased after the standards implementation date saves energy relative to the base case. National impacts therefore depend on the expected number of sales over the forecast period. It is anticipated that there will be increase in importation/production of refrigerators, but we chose to increase available data by 5% annually. Table 4.19 shows the national benefits of implementing energy efficient standard for refrigerators.

Table 4.19: National benefit of using energy efficient refrigerator

NATIONAL LEVEL RESULTS		
Discounted at 10% to year 2013 (millions $US)		
Total Electricity Cost Savings through 2030 (millions $US)		1051.10
Total Incremental Equipment Cost through 2030 (millions $US)		591.30
Net Present Benefit (millions $US)		459.80
Benefit/Cost Ratio		1.78
Site Energy Savings in	2010 (GWh)	0
	2020 (GWh)	1209
	2030 (GWh)	4411
Site Energy Savings through	2010 (GWh)	0
	2020 (GWh)	3527
	2030 (GWh)	32589
Source Energy Savings through	2010 (Mtoe)	0.00
	2020 (Mtoe)	0.674
	2030 (Mtoe)	6.228
CO2 Emissions Mitigation through	2010 (MT)	0.00
	2020 (MT)	1.46
	2030 (MT)	13.47

Source: ECN *et al*, 2015

For each year in the forecast, the appliance stock is calculated from previous sales and the appliance survival probability. Total electricity savings is given by the stock multiplied by the annual savings of each unit, equal to about 1051 kWh as shown in Table 4.19. National operating cost savings are then calculated by multiplying the total electricity savings by the electricity price per kWh. Likewise, national equipment costs are the incremental per unit cost ($120) multiplied by unit sales. Future savings and costs are discounted by the National Discount Rate, which is 10% by default. A summary of costs and savings is given in Table 4.19, taken from the summary page of the PAMS spreadsheet. In this example, total discounted electricity cost savings through 2030 are 1051 million Dollars (US), while discounted incremental equipment costs for the same period are 591 million Dollars implying a net present benefit of 460 million Dollars from the program. A positive net savings is to be expected since the cost benefit was shown to be favorable in the unit case.

Benefits of Implementing Air Conditioner MEPS

To analyze the benefits of implementing air conditioner MEPS, the economic and energy sector parameters remain the same for the country as used of for the analysis of refrigerator MEPS above. The benefits for unit air conditioner are shown in Table 4.20 below.

Table 4.20: *Unit benefits of implementing air conditioner MEPS*

	Base Case		Standard Case
EER (SI)	2.48		2.90
Purchase Price	$548		$581
AEC in kWh/year	7,884		6,734
Electric Bill	$591.30		$505.03
Life Cycle Cost	$4460		$3,922
Efficiency Improvement		17%	
Payback Time (years)		0.39	
Lifetime (Years)		15	
LCC Savings		$537	

Source: ECN *et al*, 2015

The base case air conditioners model is estimated to cost $548 and consumes 7884 kWh per year. The model adopted by the standard would raise the efficiency of the baseline model by 17%. Technically, the most cost-effective way to achieve this efficiency improvement is to add evaporator/condenser enhanced fins. Implementation of these efficiency options increases the price of the air conditioner by $33 (6%). On the other hand, annual consumption goes down to 6734 kWh per year, a decrease of nearly 1150 kWh per year. The consumer's annual electric bill contribution from the air conditioner decreases by about $86. Over the 15 years appliance lifetime, each household that purchases that model of air conditioners after standards are implemented would save about 17250 kWh. Life cycle cost savings considers that operating cost savings in the second year are valued 8% less than those in the first year. For this example, LCC savings is $537 over the life of the air conditioner. The national level benefit is shown in Table 4.21 below.

Table 4.21: National benefits of air conditioner MEPS

NATIONAL LEVEL RESULTS		
Discounted at 10% to year 2005 (millions $US)		
Total Electricity Cost Savings through 2030		1384.30
Total Incremental Equipment Cost through 2030		69.30
Net Present Benefit		1315.00

Benefit/Cost Ratio		19.97
Site Energy Savings in	2010 (GWh)	0
	2020 (GWh)	3864
	2030 (GWh)	8272
Site Energy Savings through	2010 (GWh)	0
	2020 (GWh)	19962
	2030 (GWh)	83568
Source Energy Savings through	2010 (Mtoe)	0.00
	2020 (Mtoe)	3.82
	2030 (Mtoe)	15.97
CO2 Emissions Mitigation through	2010 (MT)	0.00
	2020 (MT)	8.25
	2030 (MT)	34.54

Source: ECN *et al*, 2015

The total electricity saved is estimated to be 8272 GWh at the cost of 1384 million Dollars. Total CO_2 Emission mitigation through 2030 will be 34.54 metric tons.

Estimated Benefits of Energy Efficiency on Lighting

With the introduction of the lighting MEPS, Table 4.22 shows the estimation of financial gain by the government using the difference between the projected figures of different types of lighting types before the introduction of the policy and after the introduction of the policy.

Table 4.22: Estimated gains of implementing lighting MEPS

	Lighting 1 (millions)	Lighting 2 (millions)	Energy 1 (MW)	Energy 2 (MW)
ICLs	74.8	27.4	4491.4	1643.3
Tungsten Halogen	4.6	2.2	192.2	93.9
LFLs	3.5	3.5	180.2	138.6
CFLs	41.9	41.2	755.0	576.4
HID	43.7	82.2	4366.4	5753.4
TOTAL	**168.5**	**156.5**	**9985.2**	**8205.6**

Source: ECN *et al*, 2015

In Table 4.22, the first column (Lighting 1) represents the estimated numbers of lighting products that are in use from 2006 to 2030 while the second column (Lighting 2) is the projected figures for the same period if there is a ban on importation of incandescent lamps. An estimated peak load of about 2 GW is expected to be save during the period with a total cost of about 150 million Dollars.

Conclusion

The development and enforcement of MEPS for the appliances considered in this study is worthwhile for Nigeria. This has been rightly demonstrated by the result of this study. The implemented MEPS for home appliances like the ones examined in the current study have the potential to conserve and thereby save energy and contribute towards solving the current energy crisis in the country. In addition, this will help in reducing the amount of CO_2 emission from energy generation. Furthermore, this will contribute significantly to achieving the country's target in the NDC. They can also provide direct economic benefits to consumers. The analysis undertaken using the PAMS tool is a good step in the right direction. Efforts should continue to be made to build on this foundation. The customized model for the estimation of installed stocks of lighting appliances developed under the study is an asset and could be a bedrock for further developments on lighting appliances installed stocks predictive model. The assumptions could be expanded, contracted and modified with the aim of extending and improving its use.

The major challenge in the study was getting quality and reliable base data. The current study relied mainly on import data from both local and international sources, and this is limited in some ways. It is also important to have a good idea of the placement of the appliances and their distribution pattern between rural and urban areas.   This calls for the need to improve on the record keeping mechanism in both public and private institutions. The NCS data source should not be abandoned. For the future, it may be necessary to begin to engage the NCS to discuss with them the data needs of the energy sector. In this way the NCS may be able to retrieve data from the ASYCUDA system in the format attuned to the energy related programmes. This will go a long way in improving future studies outputs. However, government is encouraged not to wait for all the information to come in before acting. The results of this study already support the need for immediate action because of the benefits to be derived from such.

CHAPTER FIVE

NIGERIA LIGHTING COMPLIANCE STUDY

One of the key challenges witnessed during the earlier efforts to promote the use of energy efficient lighting products in Nigeria was the presence of substandard lighting products in the market. Many stakeholders complained that the energy saving lamps, mostly CFLs found in the market do not last as long as the expected life span. There were several reports of cases where CFLs do not last as long as 6 months; the expected lifespan of a standard CFL is 6000 hours to 15,000 hours (that is at 8 hours per day will be 2-5 years)[60]. As a result, many stakeholders are discouraged using these products. If this problem is not addressed, it will greatly hinder all efforts to promote the use of energy efficient lighting products.

The process to develop MEPS for lighting products was concluded in 2013 and the MEPS was officially launched the same year by the Standard Organization of Nigeria (SON). With the development of the minimum energy performance standard (MEPS) for CFLs and the installation of light testing analyzing machines in the SON and the National Centre for Energy Efficiency and Conservation (NCEEC), SON and other stakeholders are set to fully regulate the lighting appliance market. The need to build confidence in stakeholders in Nigeria to use energy saving bulbs is critical to transform the market. It is imperative for the relevant authorities in Nigeria such as the SON and the Federal Competition and Consumer Protection Commission (FCCPC) to be properly informed of the lighting products that meet the newly set standard so that they can advise consumer appropriately.

The lighting compliance study was conducted with the objectives to collect baseline information that will form the bases for monitoring and measuring success when the lighting market is fully regulated; to identify CFLs and other energy efficient lamp in the Nigerian market that do meet the newly approved lighting standards; and to make available adequate data to the relevant agencies of government to properly inform consumers on the lighting products that meets the Nigerian standard[61].

Data Collection and Analysis

To ensure that the different types of CFLs were captured during data collection, samples were collected from February to September 2013 in cities where the two major ports in Nigeria are located – Lagos (Lagos State) and Port Harcourt (River State) and in cities where the major markets in Nigeria are located – Aba (Abia State), Onitsha and Awka (Anambra State), Kano City (Kano State) and the Federal Capital Territory, Abuja (Fig. 5.1). As at the time of data collection, the Federal Government of Nigeria declared state of emergency in Borno State and as a result, it was impractical to collect data from Maiduguri, the state capital, and a major commercial hub in north-east Nigeria. The light bulbs were taken to the laboratory of the National Centre for Energy Efficiency and Conservation (NCEEC), located in University of Lagos. Samples were collected both from the open market and organized grocery market.

[60] US Food and Drug Administration (FDA). Compact Fluorescent Lamps – Facts Sheets/FAQ, 2017. Compact Fluorescent Lamps (CFLs) – Fact Sheet/FAQ | FDA

[61] Uyigue, E., Yapp, J., Lebot, B. and Odele, M. (2015). Nigerian Lighting Compliance Study. Paper presented during the 8th International Conference on Energy Efficiency in Domestic Appliances and Lighting (EEDAL), Luzerce-Horw, Switzerland 26 – 28 August, 2015. Pages 1257 – 1267. https://ec.europa.eu/jrc/en/publication/proceedings-8th-international-conference-energy-efficiency-domesticappliances-and-lighting

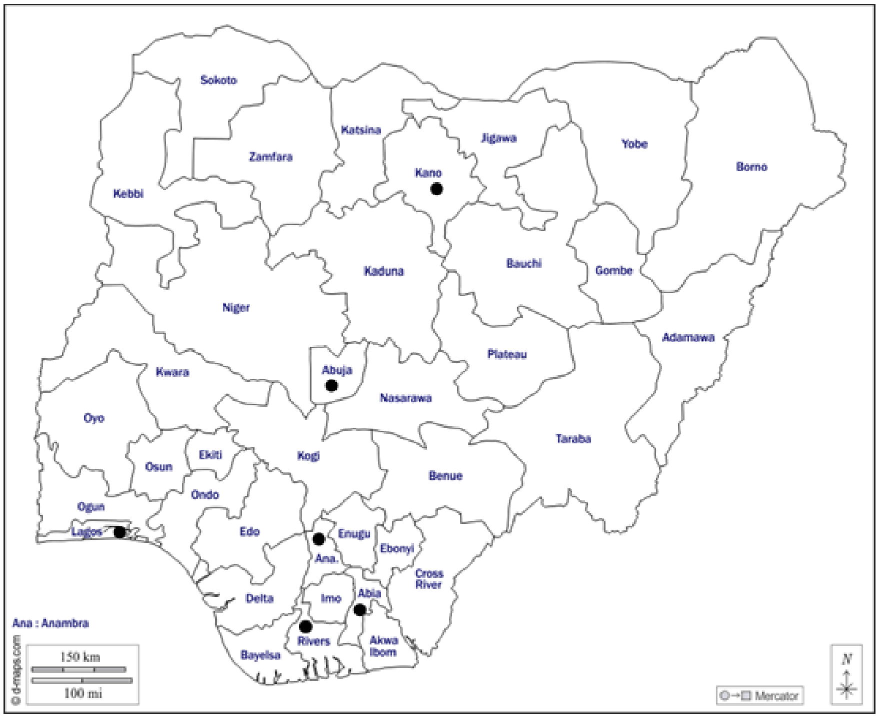


Fig. 5.1: Map showing cities of data collection[62]

At the point of collection, the samples of light bulbs were properly labeled, that is the date, price and place of collection were immediately inscribed on them. A total of 1500 samples were collected. Table 5.1 below shows the sample distribution. The highest number of samples were collected from Abuja (392) followed by Lagos (302) and then Anambra (263). The samples were sent to the laboratory of the National Centre for Energy Efficiency and Conservation, University of Lagos for further analysis. The lamps were tested according to IEC 60969 standard testing procedures.

Table 5.1: Sample size distribution

Location	Number of Samples	Percentage
Port Harcourt	117	7.8
Kano	190	12.7
Abuja	392	26.1
Anambra	263	17.5
Aba	236	15.7
Lagos	302	20.1
Total	**1500**	**100.0**

Source: Uyigue, et al, 2015

Visual check was conducted on the pack of every lamp. The following parameters in Table 5.2 are required on the pack of every lamp sample according to IEC 60969. A form is allocated to each lamp for recording the parameters available on each pack for comparison with IEC 60969 requirements.

[62] https://d-maps.com/continent.php?num_con=80&lang=en

Table 5.2: IEC 60969 marking requirements

Parameter (Rated)	Product	Product Packaging	Product datasheet or leaflet
Initial luminous flux of the lamp (lumens)	-	X	X
Beam angle (degrees) and centre beam intensity (candela) for reflector lamps	-	X	X
Initial efficacy (lumens/Watt)	-	-	X
Correlated color temperature (kelvin)	X	X	X
Color rendering index	-	X	X
Chromaticity coordinates	-	-	X
Median lamp life (hours)	-	X	X
Lumen maintenance (%) including operating hours at which lumen maintenance value(s) are claimed	-	-	X
Switching withstand (number of cycles)	-	-	X
Special operating requirements (dimming, orientation and restricted operating temperature range)	-	X	X
Starting time (seconds)	-	-	X
Low temperature starting time (seconds) and temperature if lower than -10°C	-	-	X
Run-up time (seconds)	-	X	X
Displacement factor	-	-	X
Distortion factor	-	-	X

As specified in the Nigerian lighting standard - NIS 747:2012: Self-ballasted lamps for general lighting services – Performance Requirements, the lamps were pre-conditioned by operating them at controlled conditions for 100 hours using the DJ4000 Aging–life Tester. On completing the aging test, the lamps were immediately transferred to the YF-1000 analysis machine. Each bulb is fixed to a lamp holder in the 1.5 m Integrating Sphere within 2-3 minutes after the aging test. It is allowed to stabilize for 20 minutes in the sphere. The results of the different parameters were read from a computer connected to the entire unit of the YF-1000 machine. For all the parameters tested in this study, the power supplied to the testing unit is alternating current (AC) from the electricity grid which is measured and regulated by the PF9811 Digital Power Meter. For each sample, the following parameters were tested:

- Color parameters - render index, color temperature (K) and purity
- Photo parameters – flux and efficacy
- Electrical parameters - voltage range, current range, wattage and power factor

Results of Study

Markets and Brand Names: In the context of this study, the open market is defined as a cluster of shops in a particular location selling a particular product or variety of products. The number of shops could range from as few as two to reach several hundreds. In many cases, in an open market, there may be sections of the market devoted to the sales of one kind of product. A good example of an open market is the popular Alaba International Market in Lagos State. While the organized markets are large departmental shops where different kinds of goods are sold. In the organized market, there are usually sections of the shop dedicated to one kind of product. Examples of organized market are departmental shop such as Shoprite. A total of 83% of the samples were collected in the open market while 12% were collected in the organized market. In many large cities, individual shop operating in the open market are larger in number compared to the departmental stores.

The study revealed that there were 206 different brand names inscribed on CFLs in the market, indicating that there are 206 companies manufacturing CFLs and imported them to Nigeria. As noted in Chapter Four, Nigeria depends solely on the importation of lighting products. The presence of numerous brands of CFLs in the market suggests that Nigerian businessmen rely on offshore companies for the manufacturing of these products and brand them with their given names before importing them into Nigeria. These businessmen are not original equipment manufacturers (OEMs) but depend on a third part company to do the manufacturing. One of the key challenges with this structure of manufacturing is that these products are hardly manufactured to any standard, whether national or international standards. Products also manufactured under this kind of arrangement may lack after-sales services and warrantees.

Aging Test: As mentioned earlier, many of the CFLs in the market do not meet the expected life span. The operational lifespan of CFLs is about 6000 – 15,000 hours. Many consumers complained that their CFLs last for few months. This was a huge disincentive to the use of energy saving bulbs. The aging test was carried out to determine the actual lifetime of lighting products. Out of the 1500 samples collected during the period of the study, a total of 237 (representing 15.8 % of the total sample sized) failed the 100-hour aging test while 1263 (84.2%) were fit enough to proceed to the parameters test. The result of this test suggests that the samples that failed the aging would burn out in less than one month.

Countries of Origin: Every manufacturer of lighting equipment is expected to declare the countries where these products were manufactured. The countries of origin of 334 (22.3%) of the samples collected are unknown, that is the manufacturers did not declare the countries of origin either on the pack or on the products. Majority of samples originated from China (72.6%), followed by the United Kingdom (1.6%) and Vietnam (1.2%) as shown in Table 5.3. The inscription on one of the samples showed that it was manufactured in Nigeria. This declaration is false as there is no lighting equipment manufacturing capacity in Nigeria.

Table 5.3: Countries of origin of light bulbs

Country	Number	Percentage
China	1089	72.6
Hungary	14	0.9
United Kingdom	24	1.6
Vietnam	18	1.2
Japan	7	0.5
Netherland	4	0.3
Nigeria	1	0.1
Poland	1	0.1
Germany	6	0.4
Malaysia	1	0.1
Canada	1	0.1
Unknown Origin	334	22.3
Total	**1500**	**100**

Prices of Products: Price is an important economic factor which has strong influence on consumer behavior. The lower the price of any commodity, the more affordable and the higher the demand for the product. The study revealed that the prices of these products vary and the samples with lower prices were more in number. As shown in Fig. 5.2, the prices of most of the products, about 70% range from ₦100 to N 500 while 19.6% of the products are sold for between N 500 to N 1000, 1.7 % is sold from N 1501 to N 2000 and less than 1% is sold for over ₦2500. From Fig. 5.2, we see a decreasing trend, that is the higher the price, the less the number of products. This suggests that the products with lower prices were more in number in the market. There is an established relationship between standard and price; in many cases, it is a direct relationship, that is the higher standard will attract higher price. The prevailing cost of good quality CFL as at the time of this study was about ₦600 and above.

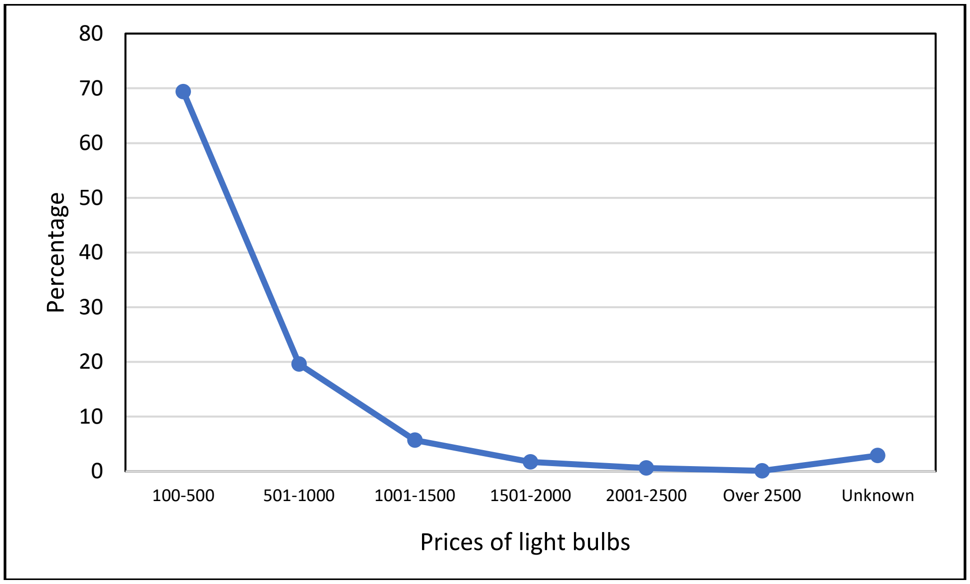


Fig. 5.2: Trend in the prices of CFLs in the Nigerian market

Types of Bases: From the study, the CFLs in the market have three major types of base – Edison Screw base with the larger diameter (E27), the Edison Screw with smaller diameter (E14) and the Bayonet Cap (B22). The CFLs with E27 base recorded the highest number representing 59.6% of the total, followed by the ones with the B22 base which accounted for 37.5% and the ones with E14 base accounted for only 2.9% of the samples (Fig. 5.3).

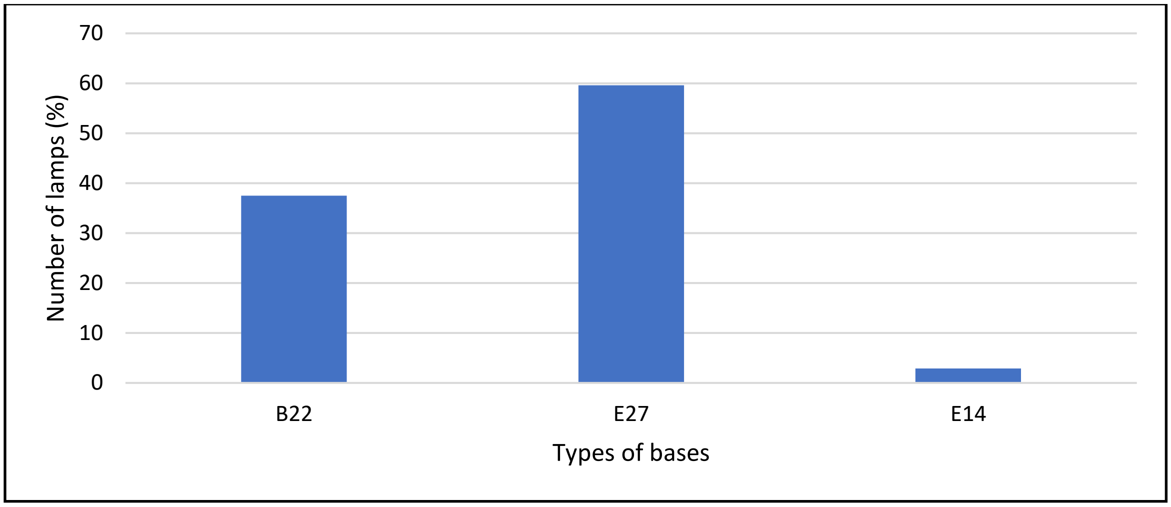


Fig. 5.3: Types of bases

Rated Voltage: According to the Nigerian Industrial Standard (NIS747:2012), the rated voltage is defined as the voltage or voltage range inscribed on the lamp or its pack, while the test voltage is the voltage at which test was carried out on the lamp. The rated voltage was inscribed on over 99% of the total lamps collected. During the test procedures, a total of 85% of the lamps operated efficiently within a voltage range of 100V to 250V. Although Nigeria low voltage (LV) grid operates at 220 V, many end-users experience voltage quite lower than 220V. In other instances, some consumers receive electricity at voltages higher than 220V. As a result of this, it is important for lighting equipment sold in the Nigerian market to operate within wide range of voltage. It is encouraging to know that most of the CFLs collected in this study operated with a wide voltage range. As already discussed in Chapter Two, the Nigerian energy performance standard approved by the authorities in 2013 (NIS 747:2012) stipulated an operating voltage of between 100V to 240V for self-ballasted lamps.

Power Factor: The power factor of an electrical system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit. An appliance with a low power factor draws more current than the one with a higher power factor for the same amount of useful power transferred. A total of 94 % of the manufacturers of the samples collected in the study did not inscribe the power factor of their lamps either on the pack or on the products. When the power factors of the products were measured using the light analyzing machine, 83% of the products had power factor of less than 0.85. As noted earlier, about 16% of the samples did not pass the 100-hour aging test and as such they could not be subjected to the parameter test. Therefore, only 1% of the samples had power factor from 0.85 and above. The lighting standard discussed in (NIS 747:2012) clearly stipulated that lamp rated 25W and below should have a power factor of 0.85 and above and lamp greater than 25 W should comply with the IEC 61000 – 3-2.

***Power Rating*:** The rated wattage is the power rating in Watts (W) inscribed on the lamp and/or on the package. The Nigerian standards requires manufacturers of light bulbs to inscribe the power rating of their products either on the pack or on the product. Many of the manufacturers inscribed the power rating on the pack and some on the products. From the study, 90.5% of the samples had the power ratings inscribed on the products. A total of 87% of the samples had the power rating inscribed on the pack. When the power ratings of the bulbs were measured in the laboratory, the measured power ratings of 83.3% of the light bulbs were below 60W. The newly lighting MEPS (NIS 747:2012) has stipulated that the rated power of tubular fluorescent and other gas discharged lamps should not exceed 60W. It was also observed that in many cases, there were differences between the declared values on the pack or product and the measured values.

***Luminous Efficacy*:** The luminous efficacy of a light bulb is the ratio of the luminous flux to the power rating. It is a measure of the efficiency at which the lamp provides visible light from the energy input. Manufacturers of 95% of the samples did not declare the luminous efficacy on the products or packs. Only 5% of them declared their luminous efficacy. When the luminous efficacies of the lamps were measured, the luminous efficacy of 58.6% of the samples was less than 45 Lumen/W while the efficacies of 25.5 % of the samples were equal to and greater than 45 Lumen/W.

Starting Time: The starting time is the time needed, after the supply voltage is switched on, for the lamp to start fully and remain alight. Manufacturers of 94% of the samples did not declare the starting time of their products. After subjecting them to the test procedures, it was found that 85% of the samples conforms with the Nigerian standard (NIS 747:2012). The lighting standard stipulated that the starting time shall conforms with the values indicated by the manufacturers and the starting times should not exceed 1.5 seconds.

Discussion and Conclusion

The current study was conducted before the Nigerian Lighting Standard (NIS 747:2012) became enforceable. Therefore, the outcome of the study reflects the Nigerian market before the lighting standard implementation. The data from the study becomes the benchmark for measuring the impacts of the standard on the market after a period of implementing the standard. When measuring the impact of any standard after implementing it for certain period, which could be up to 5 years or more, it is logical to compare the metrics with a baseline. This study provides such baseline information. It is recommended that a similar study be conducted 5-10 years after implementing the standard to determine the extent of compliances to the standard.

Furthermore, the outcome of this study will be relevant to enforcement agencies such as the Standards Organization of Nigeria (SON) and the Federal Competition and Consumer Protection Commission (FCCPC). Consumers need to be adequately informed of the quality of lighting products in the market. Agencies such as the SON will also require the information in this study to further refine and enhance their surveillance activities. Public agencies and non-governmental organizations that are willing to create awareness on the quality of lighting products in the market will also find the information in this study resourceful.

The current study revealed that there are 206 different brands of compact fluorescent lamps in the Nigerian market and yet none of these products are manufactured in Nigeria. From the previous study conducted under the Nigeria Energy Efficiency Programme, it was revealed that the Nigerian market depends solely on the importation of light bulbs; as at the time of this study, there is no manufacturing facility for CFLs in Nigeria. Further investigation revealed that many of the CFLs are manufactured offshore and branded by Nigerian businessmen and not the original manufacturing companies. This implies that many of the CFLs in the market are branded by the individual importers. At the early stage of the Nigeria Energy Efficiency Programme, during consultations with stakeholders, it was gathered that some Nigerian businessmen go to countries in Asia to buy substandard products and bring them into the Nigerian market[63].

Approximately 16 % of the total samples collected during the current study did not pass the 100-hour aging test. This implies that this set of light bulbs will burn out within 30 days if used for an average of 5 hours a day. This has been a major barrier to the energy efficiency campaign in Nigeria. At the early stage of the Nigeria Energy Efficiency Programme, many stakeholders complained that the energy saving bulbs in the market do not last as long as the stipulated time. A good CFL is expected to last for up to 6000 hours. As a result of this anomaly, many Nigerians do not have faith in the use of energy saving lamps. Many of them will prefer to continue using the incandescent light bulbs instead of buying energy efficient bulbs. The result

[63] Global Environment Facility (GEF). Promoting Energy Efficiency in Residential and Public Sector in Nigeria, 2011. The project document of GEF-funded full-sized project in Nigeria.

of the aging test already suggests that up to 16 % of the CFLs in the market are substandard. The newly approved standard in Nigeria stipulated that CFLs should last for a minimum of 6000 hours (approximately 3 years at 5 hours of use per day).

Over 70% of the samples collected during the current study originated from China. The countries of origin of some of the products were unknown (22.3 %). The study revealed that less than 5 % of the products were manufactured in other countries outside China. This concurs with the previous finding during the development phase of the Nigeria Energy Efficiency Programme, that many Nigerians businessmen go to China to manufacture CFLs using price as major consideration for the quality. In a situation where the capacity to enforce national and international regulations is weak, it is inevitable that manufacturers supplying the Nigerian market will manufacture to their own specification irrespective of the quality. This barrier is being addressed with the new regulation (NIS 747:2012)). The Nigerian standard has clearly stated that the country of origin of lighting products should be inscribed on the product or on the pack.

Price is a strong economic factor influencing the demand for goods and services. In the current study, it has been revealed that the prices of over 70% of the products fall between N100 and N500. Price is a parameter to determine the quality of products. From the interaction with manufacturers of lighting products, it was revealed that the higher the quality of light bulbs, the higher the prices of these products. For example, the cost of a good CFL that meets the required standard set by the Nigerian authority will not be less than N600. The result from the current study suggests that the products that cost below N600 are most likely to be substandard.

Many Nigerians, an estimated 83 million people live below the poverty line of $2 per day[64] and as such price will be an important factor that informs their decision to purchase lighting products. Many may not be able to afford the upfront cost of energy efficient lighting appliances which are sometime higher than the cost of less efficient ones. This may be one of the reasons why many Nigerians go for low-cost goods. Using the life cycle cost (LCC) analysis, energy saving light bulbs are less expensive than the inefficient ones. The proliferation of imported low-cost and substandard appliances may hinder the use of efficient appliances. The reason is that these products have lower upfront cost compared to the high-quality and efficient ones and they are easily available in the market. Because of the price factor, the high-quality efficient lighting products may be unable to compete with the substandard ones in the market. The current study has shown that the Nigerian market is flooded with all kinds of substandard lighting appliances. Many consumers will prefer low-cost lamps not minding the long-term benefit of using efficiency lamps.

The types of market where these products are purchased also have a lot to do with the quality of the products. In the current study, 83% of the products were collected from the open market. Most of the products that do not meet the Nigerian standards were collected in the open market. The current study has shown that good quality lighting products are most likely to be found in the organized grocery shops. In the current study, the lamps with the E27 base were the most abundant accounting for 59.6% of the samples. Most of the products operated within a voltage range of 100-250 V. From the visual checks on the packs of the samples, many of the products did not meet the newly developed standard for lighting products in Nigeria. It is required for manufacturers supplying the Nigerian market to inscribe the values of the electrical parameters on the packs or on the products. The study revealed that 95% of the samples do not have the values of the luminous efficacy inscribed on the product or on the pack. Similarly, the value of the power factors is not inscribed on 94% of the samples. From the Nigerian standard (NIS 747:2012))., these products have deviated from the standard requirements for lighting products.

Check-testing has been carried out in many developed countries, for instance, it has been done in Australia since 1991[65]. In Nigeria, in addition to check-testing, it is important for the Nigerian authority to create a platform where they can interact periodically with importers and manufacturers of lighting products. There

[64] World Bank. Nigeria releases new report on poverty and inequality in country, 2020. https://www.worldbank.org/en/programs/lsms/brief/nigeria-releases-new-report-on-poverty-and-inequality-in-country

[65] Grubbert, M. (2001). Monitoring and enforcement in Australia: Standards, MEPS and Labelling. Presented at Lessons Learnt in Asia: Regional Symposium on Energy Efficiency Standard and Labelling, UN Conference Centre, Bankok, Thailand, CLASP and UNF. 29-31 May 2001.

is need to inform importers and manufacturers about the newly approved lighting standard. The Nigerian authority should also invest in awareness creation, to let the Nigerian populace know of the economic benefits of purchasing good and quality lighting products. When this is combined with the check-testing, it will speed up the process of eliminating substandard lighting products from Nigeria.

CHAPTER SIX

DESIGN OF APPLIANCE ENERGY LABEL

Introduction

As already explained in Chapter One of this book, energy efficiency labels are integral components of energy efficiency standards. They are placed on manufactured products to describe product's energy performance in terms of energy use, efficiency, or energy cost. Moreover, they serve as instruments to create consumers' awareness by convincing them to buy more efficient appliances. Since consumers are final users of appliances, their needs and perceptions are crucial inputs in designing an effective and comprehensive energy label. The Nigerian minimum energy performance standard for lighting (NIS747:2012), described in Chapter Two) has prescribed that energy labels should be placed on the packages of each lamp sold in the market. As a result of this, it became mandatory for the Nigerian authority to design an energy label. An effective energy label will require inputs from the targeted stakeholders, which in this case are majorly consumers of these products.

Consequently, under the Nigeria Energy Efficiency Programme funded by the GEF and the UNDP and executed by the Energy Commission of Nigeria, a survey was inaugurated to capture the opinions and needs of stakeholders and incorporate them into the design of energy labels. This was done through market research that sought stakeholders' opinions. The overall objective of the study is to design an energy label that will be appropriate and easy to understand by stakeholders in Nigeria. Specifically, the study was carried out to understand consumer's interpretation of the elements in predesigned energy labels and establish their overall interpretation of each label. The study also helped to understand the cause of difficulties consumers may have had in understanding each of the predesigned labels. Several consultations were carried out during the study serving as platform to listen to consumers and other stakeholders to get their opinions on the purpose of developing energy label. It serves as a tool to consider the needs of stakeholders, particularly their needs of getting quick and reliable information about the energy efficiency of various appliances in an easily understandable and simple manner.

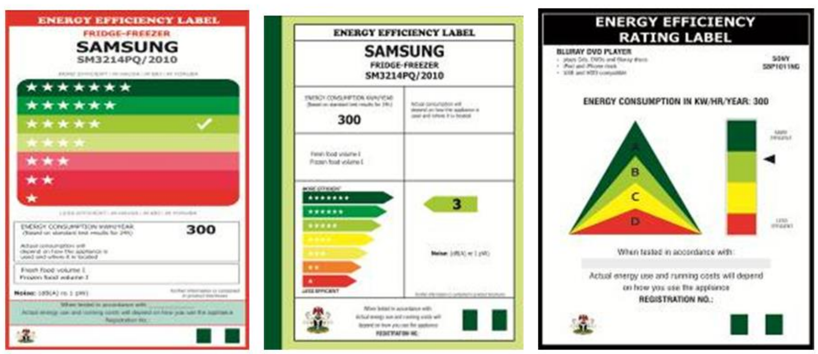
Method of Data Collection and Analysis

Data was collected using questionnaires, focused group discussions, interviews with key informants and review of existing documents from relevant agencies and academic institutions. Respondents included end-users of electrical appliances in semi-urban and urban areas, electrical and electronic dealers in major commercial hubs and grocery shops. The stakeholders' engagement was structured to ensure that all sectors of the electricity end-users were captured. Using energy labels from other countries as reference, nine (9) trial labels were predesigned for the purpose of this study. The trial labels were given numbers 1 to 9 (Fig. 6.1, Fig 6.2, and Fig 6.3) so that information gathered from respondents can be analyzed statistically. They were printed and laminated and were placed before respondents during the survey. The predesigned labels were further categorized as Type A – Comparative Label, Type B – Informative Label and Type C – Endorsement Label. Respondents were then asked to rate the features of each label in a questionnaire.

Questionnaires were administered to the respondents along with predesigned labels. The questionnaire consisted of three main sections. The first section requires the respondents to provide information on their location and personal information such as gender, age, income and occupation. The second section focused on the level of awareness of respondent on the concept of energy labels and energy efficiency. The last section asked questions on the predesigned labels, questions regarding their contents and acceptance. Before the actual survey, a pilot test was carried out in selected shops and residents. The pre-survey exercise helped to identify some gaps in the questionnaire. Through the pilot test, it was ascertained whether the questionnaire was too long or too short, as well as the time it will take an enumerator to complete a questionnaire[66].

1 2 3

Fig. 6.1: Predesigned labels numbers 1-3[67]



4 5 6

Fig. 6.2: Predesigned labels numbers 4-6

7 8 9

Fig. 6.3: Predesigned labels numbers 7-9

Source: Nigeria Energy Efficiency Programme, 2014

[66] UNDP 2015. Strategies for Enforcing Energy Standards and Labeling Scheme in Nigeria. A publication of the United Nations Development Programme, December 2015.

[67] The figures in this Chapters were taken from the report - Strategies for Enforcing Energy Standards and Labeling Scheme in Nigeria. A publication of the United Nations Development Programme 2015.

The survey was carried out in Lagos and the Federal Capital Territory. The respondents were drawn from peri-urban and urban areas in the two cities. In Lagos, the questionnaires were administered in Alaba International Market, one of the major markets where electrical and electronic products are sold and taken to other parts of the country. A total of 63 interviews were conducted– 36 from Lagos and 27 from Abuja. Interviews were also conducted among retailers of electrical products. All the consumers who took part in the research were screened to ensure that they were potential appliance purchasers. Based on the opinion of the respondents, it was practicable to select the best label design.

Results of Study

Sex and Age: Out of the 63 respondents, 84% were male and 16% were female. It was observed that the ages of 89% of respondents range from 23 years to 55 years while 11% were 60-70 years old. Among the respondents, 42% were wholesalers and retailers of electrical and electronic equipment while 58% were end-users of these appliances. The consumers were easier to approach than the retailers and wholesalers.

Ability to Comprehend Energy Labels: When respondents were asked to identify the appliances that are most and least energy efficient using any of the predesigned labels, about 90% of them were able to correctly identify the most and least energy efficient models. The occupation of respondents tends to have a strong influence on their ability to comprehend the labels. The study revealed that people dealing with electrical appliances exhibited more understanding than the users. For example, the dealers in Alaba International Market exhibited more level of understanding of energy labels than other respondents. The share of respondents who were able to correctly identify both the most efficient and least efficient models is shown in Table 6.1.

Table 6.1: Share of respondents that correctly identify energy efficiency models

Label Number	Respondents (%)
1, 2 and 3	90
4	50
5 and 6	70
7	46
8 and 9	66

Source: Nigeria Energy Efficiency Programme, 2014

Overall, the ability to comprehend Label 1 and 3 (Fig. 6.1) by respondents was significantly higher than Label 4 (Fig. 6.2), while the ability to comprehend Label 2 was slightly higher than Label 3. About 70% of people could understand the contents of these labels without having seen them.

Familiarity with the Concept of Energy Labels: As shown in Fig. 6.4, respondents in Alaba International Market were more familiar with the concept of energy label. A total of 94% of respondents in Alaba International Market were familiar with the concept. This was followed by respondents in Festac Town in Lagos, where 70% of respondents were familiar with the concept. In Abuja, only 63% of respondents were familiar with the concept of energy labels. Similarly, respondents were also asked to define the term "Energy Label". A total of 92% of respondents in Alaba International Market were able to define it correctly. In Festac Town, 90% of respondents defined the term correctly while in Abuja 89% of respondents correctly defined the term. On average, 90% agreed that the government should introduce energy label.

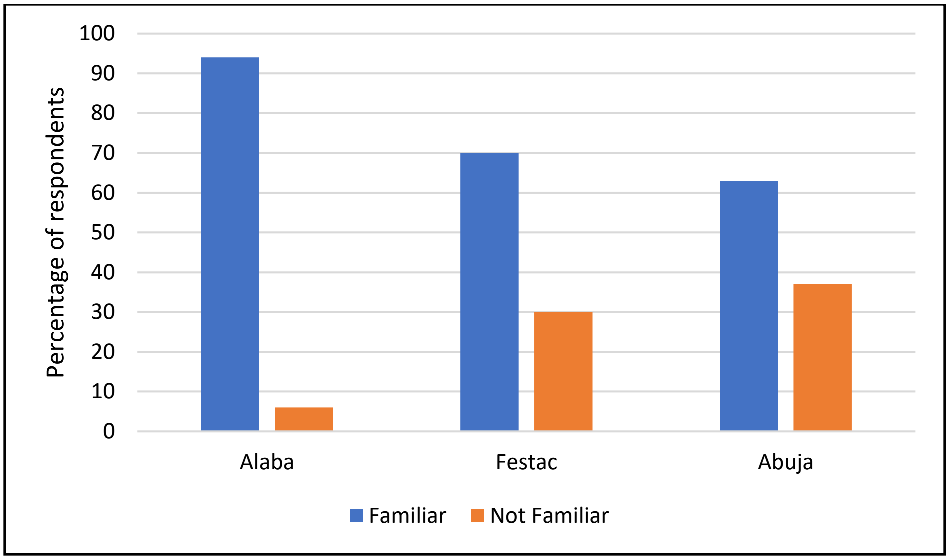


Fig. 6.4: Familiarization with energy labels

Energy Consumption and Choice of Appliances: When purchasing appliances, there are several factors considered by end-users. In this study, respondents were asked if they consider the appliance's energy consumption when purchasing one. In Alaba International Market, 85% of the respondents claimed that they consider the energy consumption of appliances when making their choices, while 70% in Festac Town responded in affirmative and 85% in Abuja (Fig. 6.5).

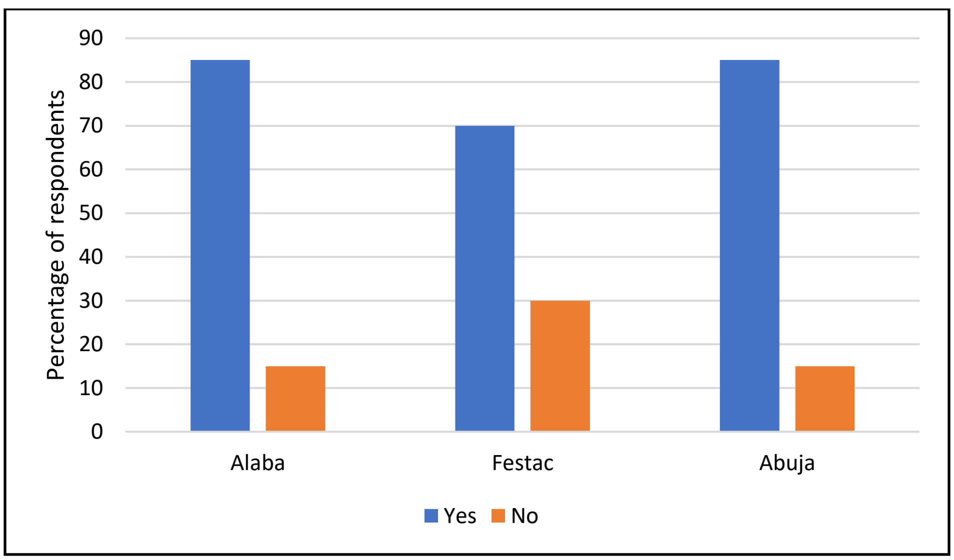


Fig. 6.5: Energy consumption and choice of appliances

Consistent Label Design Among Products: In many countries, label designs are the same for different types of products. For example, the label design to provide information on lighting products is the same design for refrigeration appliances. The slight changes are specific information about the type of product. In this study, respondents were asked if they will prefer the use of the same label design for all products in the market or use different label design for different products. In Alaba International Market, 92% of respondents agreed on the use of the same label design for all types of appliances, in Festac Town 80% and in Abuja, 100% of respondents. The study revealed that while the details on energy labels for different products may differ slightly, it is important to keep a consistent labeling style and format among the product types. In this way, consumers can use the understanding of one type of label to evaluate other products.

Endorsement or Comparative Label: As discussed in Chapter One, there are two categories of labels. – Endorsement and Comparative Labels. Endorsement Labels inform the consumers that the products meet certain required standard while comparative label allows consumers to make comparison and choose among the same type of products, the one that is more efficient. In this study, more of the respondents prefer the Comparative Label. As shown in Fig. 6.6, 50% of respondents in Alaba International Market prefer the use of Comparative Label. In Festac Town, 80% of respondents prefer the Comparative Label while in Abuja, 70% prefer the Comparative Label. On average, 67% of the total respondents preferred comparative label while 33% preferred Endorsement Label.

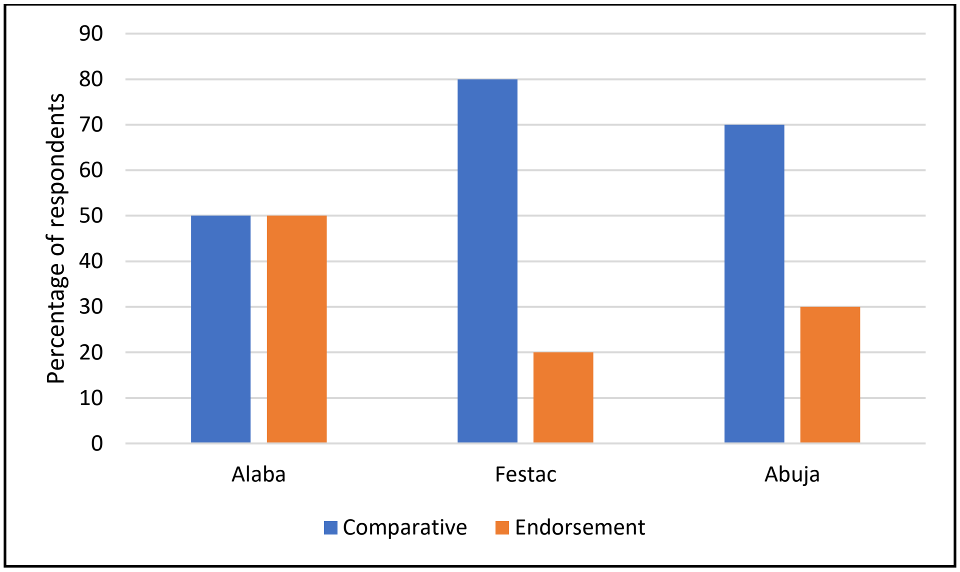


Fig. 6.6: Stakeholders preference for comparative and endorsement labels
Source: Nigeria Energy Efficiency Programme, 2014

Attractiveness and Simplicity: In respect of the attractiveness of the predesigned labels, most respondents (66%) were on the opinion that Label Number 1 (L-1) as shown in Fig 6.1 was attractive, followed by L-8 (Fig 6.3) with 43% of respondents saying that it was attractive. L-1 was the most attractive followed by L-8 and L-3 (Fig. 6.7).

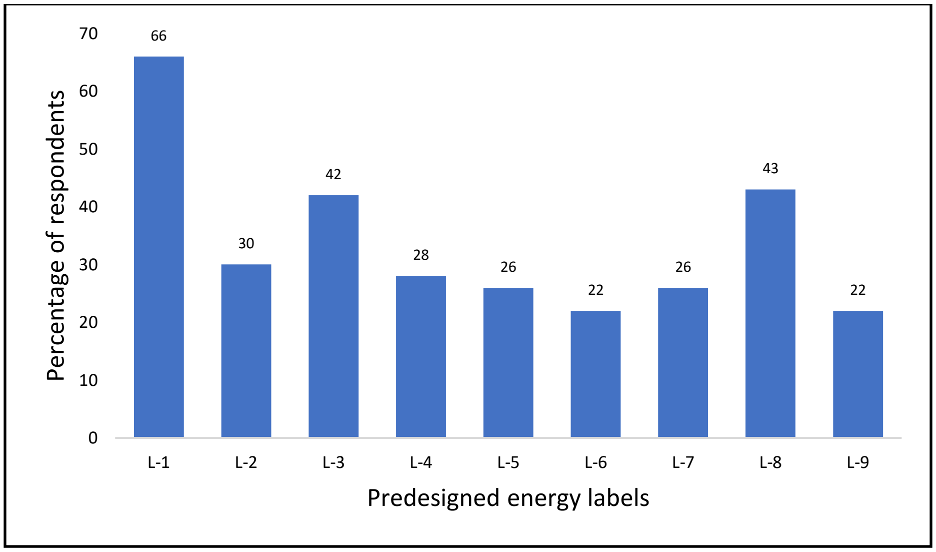


Fig. 6.7: Attractiveness of predesigned labels

The simplicity of label design is a function of how consumers can easily understand the label. In this study, 27% of respondents agreed that L-1 was simple to understand, 18% agreed that L-3 was simple to understand and 14% agreed that L-8 was simple to understand (Fig. 6.8). From these responses, the study showed that L-1 design is the simplest to understand.

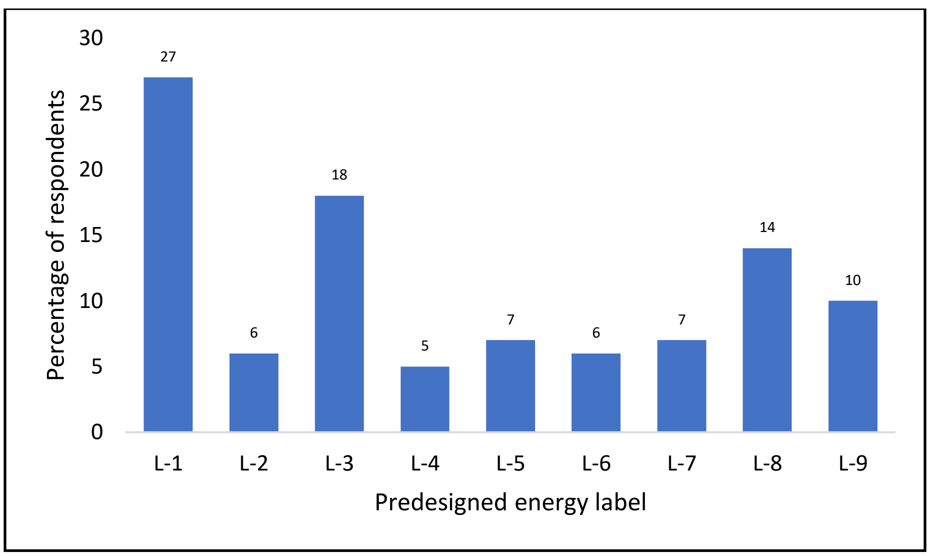


Fig. 6.8: Simplicity of predesigned label

Understanding the Unit of Energy: In Nigeria, electricity is sold in kilowatt hour (kWh) by the electricity distribution companies. Thus, the kWh is the common unit of electrical energy. However, not many Nigerian stakeholders are familiar with the kWh. Since the energy label will inform consumers of the energy consumption of appliances, it is important to determine how much consumers understand the unit of energy. In this study, the respondents were asked how much they understand the term 'kWh'. In Alaba International Market, 77% of respondents affirmed that they understand the kWh, 50% in Festac Town and 74% in Abuja

(Fig 6.9). Many consumers seem to be familiar with the term “Unit” to refer to how much energy they buy from the utilities instead of the kWh. The study shows that 65% respondents agreed that the terms “kWh” and “Unit” are the same.

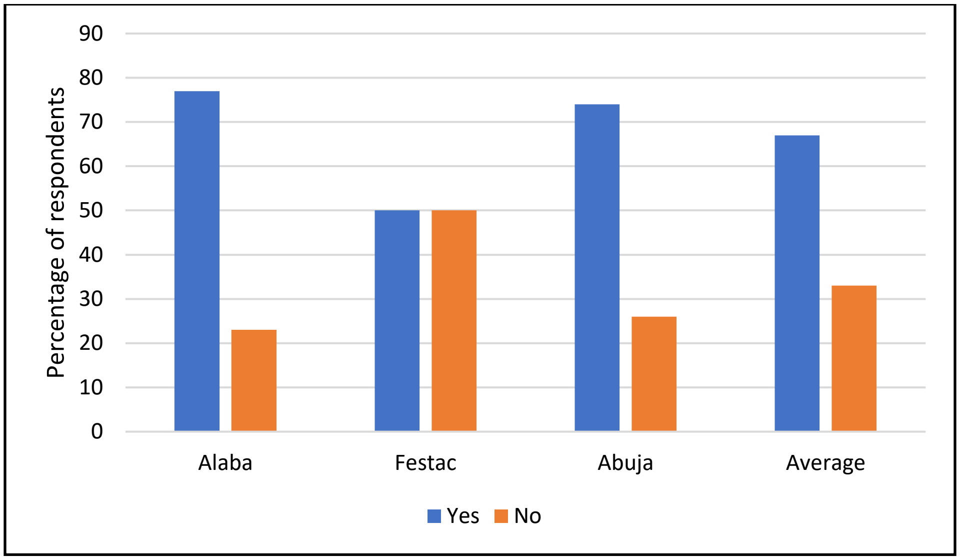


Fig. 6.9: Respondents’ understanding of the term “kWh”

Energy Labels and Consumers Informed Decisions: Most respondents agreed that energy labels will help them to make purchase decision. In Alaba International Market, 92% of respondents affirmed that energy labels will help them to make decision before paying for any appliance, 90% in Festac Town and 100% in Abuja. Similarly, in Alaba International Market, 96% of respondents agreed with the proposition that manufacturers should affix energy labels to appliances. In Festac Town and Abuja, 90% and 100% respectively are in support of the proposition. On average, 90% of respondents agreed they will read labels before buying any appliance, while 10% respondents said they may not necessarily read the label.

Enough Information on the Labels: When the nine predesigned labels were presented to respondents to determine whether the labels provided enough information that could guide the customers before buying any appliances, more respondents identified L-1, L-2, L-9 and L-3 (Fig. 6.10) as labels that provided sufficient information on appliances. On the other hand, other respondents were on the opinion that L-5, L-6 and L-7 did not provide enough information. Most of respondents agreed that they will buy appliances that have the energy label rather than those without labels. Those that agreed to buy appliances with energy label represent 92%, 100% and 96% respondents in Alaba, Festac Town and Abuja respectively. A total of 69%, 90% and 96% of respondents in Alaba, Festac Town and Abuja respectively agreed that the Federal Government should make the enforcement of energy label mandatory.

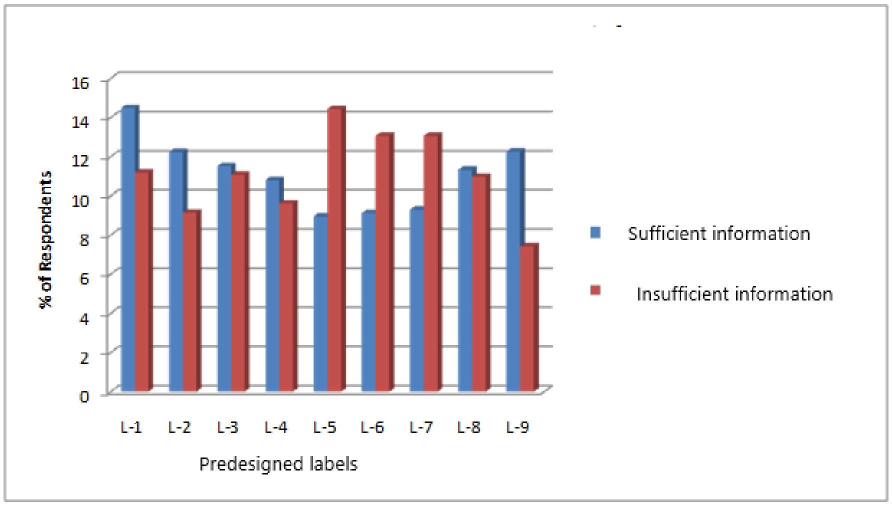


Fig. 6.10: Quality of information on predesigned energy labels

Information on the Energy Label: The contents of energy label are important to both the manufacturers, wholesalers, distributors and the consumers. On the part of the manufacturers, there may be limit on the information they can provide on any equipment. On the side of the consumers, they have their expectations on the kind of information that the energy labels should provide. In this study, 64% respondents are on the opinion that the price of appliances should not be included in the energy label while 36% respondents agreed that price should be included. Similarly, 78% of respondents agreed that the size or capacity of appliances should be included as part of the information provided by appliance energy label. Furthermore, 82% of respondents want the brand of any product to be included as part of the information in the energy label. In respect of the color of an appliance, only 53% of respondents agreed that the color of an appliance should be indicated by the energy label (Fig. 6.11).

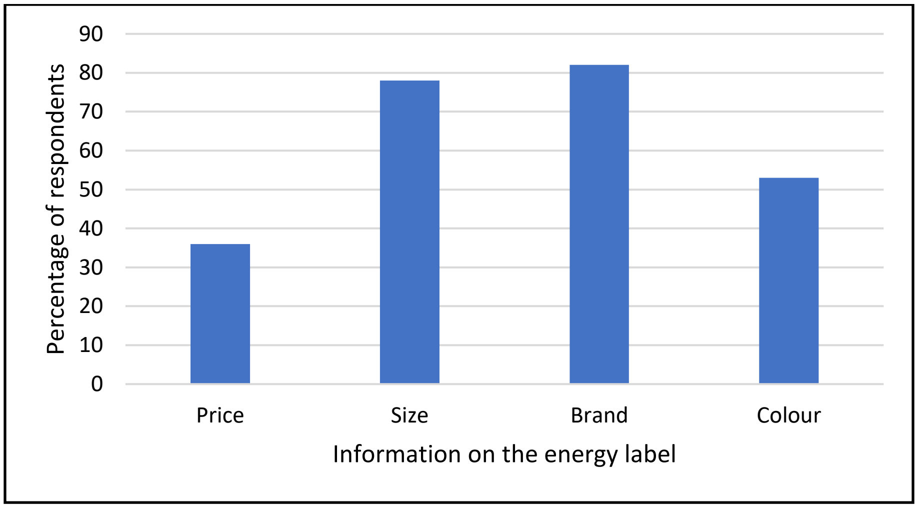


Fig. 6.11: Preference of information provided by the energy label

There are various ways you can rank the efficiency of appliances when designing energy label. Some energy labels use letters, some numbers and some other use stars. When respondents were asked what they will prefer to rank the efficiency of appliances, 34% of respondents prefer the use of numbers, while 28% prefer the use of stars, 25% of respondents prefer the use of alphabets and 13% the use of percentage (Fig. 6.12). It is clear from Figure 6.12 that more respondents will prefer the use of numbers and stars to indicate the energy efficiency of appliances. Premised on this, it is proposed that a new dial label be designed that uses numbers and stars, like the Indian energy label.

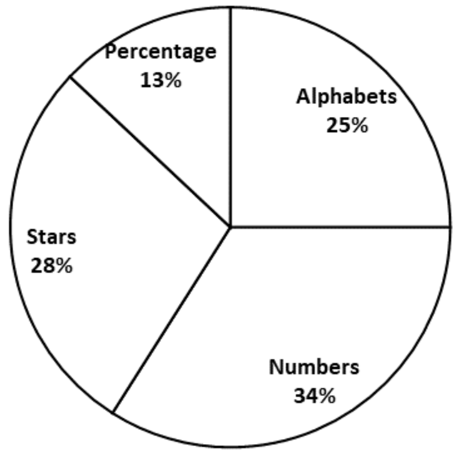


Fig. 6.12: Ways to indicate the energy efficiency of appliances

About 90% of respondents agreed that the sizes of the predesigned labels were appropriate. In respect of the unit of energy, approximately 49% of respondents prefer the use of the "kWh/day" as the unit of energy, 39% prefer "kWh/month" and 12% prefer "kWh/year". The study further tested stakeholders understanding of the use of star to rank the efficiency of appliances. The study revealed that 67% of respondents were able to understand the use of star to rank the efficiency of appliances. The predesigned labels using star to rank the efficiency of appliances were misunderstood by some consumers mainly because consumers struggled to know whether the efficiency ranking was determined by the number of stars with a shaded background or by the number without a shaded background. Another confusion that arose is that some consumers thought that the stars indicated that the label was a quality one. Therefore, the study will propose another design that uses numbers inside the stars and interpreted as the more stars the less energy consumption.

Study Results

The findings of this study are highlighted in this session. Since end-users of appliances are the targeted stakeholders, an effective energy label should be designed through consumer-based market research. This has been achieved in this study. The study revealed that the concept of energy efficiency was not well understood or associated with appliances. Retailers and end-users of appliances seemed to be familiar with the concept of energy labels, however, awareness campaigns to help the Nigerian populace to better understanding this concept is imperative. The study has shown that the approval rating for the concept of energy labeling was high with 70% of respondents affirming that they would make use of the label and another 79% were in support of the entire concept of energy labeling. Manufacturers were in favor of compulsory energy labelling programme as they felt it would provide equal basis for competition.

The study has shown that labels designs that present the efficiency of appliances on a comparative scale are more easily understood and motivating than those that present only technical information (Endorsement Labels). Consumers, even those that have never been exposed to the use of energy labels, generally think that comparative energy label would aid purchase decision making. Moreover, labels which present comparative efficiency via discrete categories such as stars, letters or numbers are generally more preferred and seem to be more effective than those which use a continuous scale. In part, this is because they are easier to remember when shopping for an appliance. In addition, the thresholds used in these labels can be highly motivating for both manufacturers and retailers.

Furthermore, consumers appeared to have a clear understanding of the letter “A” or the number “1” to denotes the most energy efficient appliance (for labels using letters or numbers). Most consumers found label designs with more than five efficiency categories confusing. Labels designs using letters to indicate the efficiency of appliances had the highest consumers’ rating in terms of the ability to comprehend information on the labels. Label designs using stars to indicate efficiency of appliances were more likely to be misunderstood than those using letters or numbers with some consumers believing more stars meant more energy consumption. The energy consumption value was an important parameter and most consumers wanted it emphasized over other product information. Consumers expressed a strong preference for monthly or daily energy consumption values over the annual energy consumption values used in all the predesigned labels. The use of relatively large and bold characters or numbers was preferred to smaller ones.

The study also revealed that consumers preferred less technical terms such as “power” or “current” to describe electricity. They also tend to prefer the use of “units per day” or “units per month” to the use of “kWh per day” or “kWh per month” to represent the quantity of electricity. There can be strong implication with colors and therefore it is helpful to exploit these to make the label more readily understandable and appealing. Consumers appeared to have a strong sense of the meaning of the different colors. Red was clearly associated with high energy consumption, green and blue with environmentally friendly/low energy consumption. Thus, designs using a green to red color progression were strongly preferred to those without them. In addition, green and blue emerged as the lead colors for the label background.

The survey revealed that the predesigned label L-1 was the most attractive label, followed by L-3, L-8 and L-2. Similarly, the least attractive was L-9, L-5 and L-6. Furthermore, the survey revealed clearly that L-1 was the simplest to understand, followed by L-3, L-8 L-9 and L-2. Overloading the label with excessive or poorly organized information is distracting and limits the ability to comprehend the label as well as engagement with the label. Appropriate choice of fonts is helpful to make labels clearer to consumers. Each label design may have some limitations. For example, a small portion of end-users concluded that less stars mean more efficiency. These potential problems of misunderstanding information on energy label can and should be addressed over time through public education and awareness campaigns.

The adoption of a well-known energy label design, even if it is successfully applied elsewhere, cannot be assumed to be effective in a new location and hence this should, as a minimum, be confirmed through research before considering its adoption. A multi-phased approach where the questions addressed became progressively narrower until finally a design emerged was seen as the best approach. The most appropriate design will depend upon local and cultural factors and should be assessed by multi-method research. Often these cannot be foretold even by local policymakers as they lie outside of their expertise. In this study, most consumers found designs with more than five efficiency categories confusing. The results of the retailer and manufacturer interviews were very consistent.

Recommendations and Conclusions

Government endorsement of label will enhance its credibility. Proposed energy labels should be tested for effectiveness with key stakeholders (most importantly consumers) prior to adoption. Labels that do not undertake such evaluation is at risk of losing consumers’ confidence. Thus, the effectiveness of the proposed designs from this study should be further tested and if necessary, amendments should be made, especially in areas where the research demonstrates some significant weaknesses. Similarly, an existing design should not be modified without testing the effectiveness of the proposed change. Failure to follow these prescriptions may pose serious risk to the integrity of the labelling programme and could risk minimizing the energy saving and market transformation impact of the labelling scheme.

Based on the information gathered from the study, two types of label designs were proposed for the Nigerian market. As shown in Fig. 6.13 and 6.14, they are a Dial Label and Bar Label. The Dial Label (Fig. 6.13) is the modifications of the predesigned label L-1, L-2 and L-3 (Fig. 6.1) and uses stars and numbers to rank the efficiency of appliances; the numbers are inscribed inside the stars. The more stars the higher the efficiency of the appliances. For example, the appliance with 4 stars is more efficient than appliance with 3 stars. The design also provided information on the model number, brand, energy consumption in kWh/month and type of appliance.

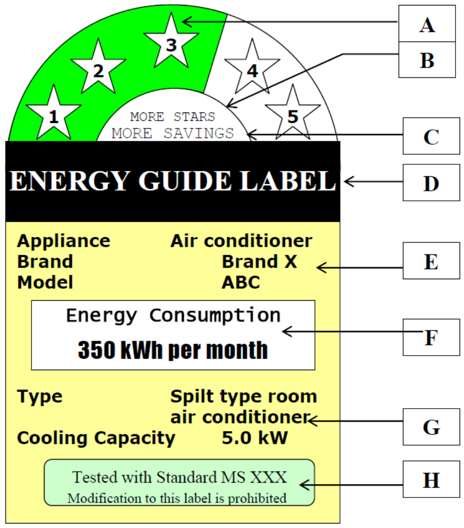


Fig. 6.13: Proposed energy label design

A – Star ranking indicating the energy efficiency level
B – Interpretation of the ranking (Star ranking)
C – Further interpretation of the ranking (energy savings)
D – General label description
E – Type of appliance and brand name
F – Value of energy consumption
G – Power rating
H – SON registration number

From the Fig. 6.14, the proposed Bar Label was selected from the predesigned labels L-4 and L-5 (Fig. 6.2). In this design, appliances are ranked into one of 7 bars graded from A to G. The length of the bars increases successively from A to G. The respective length of the bars is intended to show that A means lower consumption (shorter) while G means higher consumption (longer). Similarly, the G bar is colored bright red while A bar is colored deep green, while the other bars are colored in progression between the two ends.

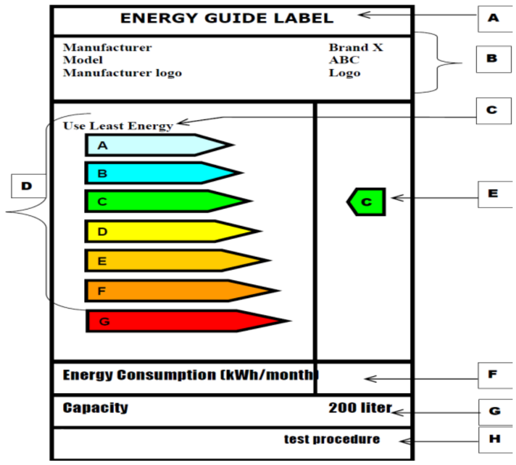


Fig. 6.14: Proposed bar label design

This survey reflected the opinions of stakeholders in the design of appliance energy labels for Nigeria. The study has shown that stakeholders preferred energy label with clear, graphical, simple, and detailed properties. Labels that meet these features will attract people and guaranty the successful implementation of energy efficiency standards and labeling programme in Nigeria[68].

[68] Nigeria Energy Efficiency Programme (2014). Consumer market survey towards the design of energy label for electrical appliances in Nigeria. A report of the Nigeria Energy Efficiency Programme executed by the Energy Commission of Nigeria and supported by the Global Environment Facility and the United Nations Development Programme

CHAPTER SEVEN

ENERGY EFFICIENCY CAPACITY DEVELOPMENT

Introduction

The United Nations (UN) defined capacity building as the process of developing and strengthening the skills, instincts, abilities, processes, and resources that organizations and communities need to survive, adapt, and thrive in a fast-changing world. The Sustainable Development Goal (SDG) 17 of the UN set targets for capacity building, which includes increasing technology and innovation in least developed countries and improving data collection and monitoring for the achievement of the SDGs[69]. The goal of capacity building is to enhance the ability of organization and communities to evaluate and address the crucial questions related to policy choices and modes of implementation among development options[70]. Capacity development was one of the components of the various initiatives to promote energy efficiency in Nigeria.

The success and sustainability of any standard and labeling programme are hinged upon the capacity of the stakeholders that will be involved in developing and enforcing the standards. In the case of implementing energy standards and labeling scheme, the most critical stakeholders are the public actors, that is the ministries, departments and agencies (MDAs) saddled with the responsibilities of implementing these standards. The GEF and UNDP supported energy efficiency programme placed priority on building the capacity of public institutions relevant to developing and implementing energy efficiency standards. Similarly, the Nigeria Energy Support Programme (NESP) of the GIZ and EU also placed emphasis on building the capacity of public institutions. The power to regulate the quality of products entering the Nigerian market lies in the hands of public officers. This session will discuss the capacity development activities that has been embarked upon in the energy efficiency sub-sector.

Capacity to Conduct Energy Research

The process of developing energy efficiency standards, especially for electrical appliances will require an empirical approach. For example, as discussed in Chapter 1, there is need to create a balance between technical possibility and economic viability when setting standards. When standards become too high, this attracts higher cost of the products and consequently may reduce the affordability. Before standards are set for any product, it is important to understand the energy efficiency status of the existing products in the market. The outcome of this type of survey can help the policy makers to accurately decide the MEPS values for the targeted products. The early part of the Nigeria Energy Efficiency Programme was devoted to building the capacity of the Energy Commission of Nigeria (ECN) and the National Centre for Energy Efficiency and Conservation (NCEEC) to conduct research in the energy sector that will guide the formulation of energy efficiency policies and regulations.

The ECN was a suitable choice for such capacity building. First, the agency is saddled with the national responsibility of conducting strategic planning on energy issues, to introduce new energy resources and ensure efficient utilization of energy resources. Secondly, the ECN served as the executing agency for the Energy Efficiency Programme supported by the GEF and the UNDP. For the sustainability of the Programme, building the capacity of the ECN was a necessity. Thirdly, the ECN established the National Centre for Energy Efficiency and Conservation (NCEEC) in 2008 to address issues around energy efficiency and conservation. The NCEEC is charged with the mandate of organizing and conducting research and development in energy efficiency and conservation. The Centre is located in the University of Lagos, Southwest Nigeria

[69] https://www.un.org/en/academic-impact/capacity-building
[70] UNCED, 1992. Capacity Building - Agenda 21's definition

The GEF-UNDP supported Energy Efficiency Programme entered into partnership with a French company by name ENERTECH to supply energy logger equipment. Engineers from the ECN and the NCEEC were trained by ENERTECH on the way to use the logger devices for data collection and carry out analysis of the data. ENERTECH was chosen because of its experience in carrying out end-use monitoring campaign in different countries. These devices include the Multivoies Systems, Serial Wattmeters, Lampmeters and Digital Thermeters. As discused in Chapter Three, the Nigeria appliance end-use monitoring study was carried out using these logger devices. Four engineers (two from ECN and two from the NCEEC) were trained by ENERTECH in France on the use and installation of these metering devices. This on-the-job practical training took place directly in households, after a short theoretical course.

Plate 7.1: Nigerian engineers receiving training in France

Light Testing Equipment

For effective enforcement of any standard, it is important to accompany the implementation process with the required capacity and training. When energy standards are approved and become enforceable, the products entering the market or manufactured within the country will have to conform with the new standards. The agencies responsible for the enforcement of the standards will require trained personnel and equipment to test the conformity of products before they are allowed to enter the country. The lighting MEPS (NIS747:2012) was approved by the government in 2013. The enforcement of this standard will be impracticable without the testing equipment to verify conformity of products.

With financial support from the GEF and the UNDP, a complete set of light testing analysis machine was donated to the Standards Organization of Nigeria (SON). Another set of the same equipment was given to the National Centre for Energy Efficiency and Conservation (NCEEC). The testing equipment is expected to enhance the ability of SON to enforce the newly approved lighting standard and regulate the Nigerian lighting market. The testing equipment in NCEEC will complement the laboratory in SON and at the same time will serve as platform to strengthen research in energy efficiency. The two sets of testing equipment were manufactured by a company called Everfine. As part of the purchase delivery agreement, EverFine deployed one of their engineers to install the equipment in Lagos. One set of the testing equipment contains the following pieces:

- General Standard Lamp
- Aging-life Tester

- Type Alternating Current Power Supply
- Voltage Dips and Interruptions Generator
- Electrical Fast Transient Generator
- Surge Generator
- High Accuracy Array Spectroradiometer
- Digital Torque Meter
- Digital Power Meter
- Rapid Recording Photometer
- 1.5m Integrating Sphere
- Digital CC & CV DC Power Meter
- Cabinet

Plate 7.2: A set of light analyzing equipment
Source: UNDP, 2015

Environmentally Controlled Room for Testing Refrigerators

The success of any standard and labeling programme depends to a large extent on the ability to carry out verification testing and surveillance. The capacity to test the efficiency of refrigerators will add immense value to the refrigerator standard and labeling programme. One of the outputs of the GEF-UNDP supported Energy Efficiency Programme was to assist the Government of Nigeria set up internationally accredited testing facility for refrigerators. The Programme procured and installed an Environmental Controlled Chamber (ECC) with six refrigerator testing stations in the Standards Organization of Nigeria (SON). The ECC will allow SON to:

- Test refrigerators and freezers for compliance before they are allowed to enter the Nigerian market

- Conduct random testing of refrigerators and freezers available in the market and report on non-compliance based on Nigeria refrigeration standard

- Provide important baseline data as part of the monitoring and evaluation (M&E) programme to study the impact of the Energy Efficiency Programme by tracking on the energy consumption trend of the appliances prior and after the Programme

- Inform and educate the public on the energy performance of the various refrigerator models to help with purchasing and decision-making process

- Use the data for public awareness campaign

Plate 7.3: Environmentally Controlled Chamber

The ECC is constructed to a high standard with high quality pre-molded and modular panels. Each panel is made to allow passage through a normal doorway. The design allows for future expansion and easy disassembling for possible relocation. The chamber is made with all necessary controls, circulation systems and all required mechanical and electrical equipment (Table 7.1). The chamber has the capacity to test six (6) refrigerators simultaneously. The key features of the ECC are described as follows:

Table 7.1: Dimension and key features of the ECC

Exterior Dimensions	**Length = 5.39m; Width = 4.78m; Height = 3.51m**
Design temperatures and tolerances	15.6^0C to 37.8^0C (±0.2)
Design relative humidity and tolerances	30 to 90 (±0.2). Limited by 4.4^0C low 35^0C high
Control panels	3 phase, 380V/70 Amps
Room condensing unit	3 Phase, 380V/30 Amp
Compression capacity	9 Hp
Equipment load	2000 BTU to 30,000 BTU

Control Panel Enclosure: All operating controls, instrumentation, functional switches, and control systems are located at a single control panel center mounted at operator eye level. Operating modes and functions are clearly indicated by pilot lights and legibly identified by engraved nameplates. The recessed control-panel section of the enclosure is located for easy opening by authorized maintenance personnel.

Plate 7.4: Training session for Nigerian engineers at TESCOR premises, USA
Source: UNDP, 2015

Main Temperature Control: This is an electronic controller which utilizes a precision platinum resistance thermometer (thermocouple) for sensing temperature. Automatic reset and rate functions are incorporated to compensate for error due to load variations. Operating temperature is adjustable and set by means of the pushbuttons on the face of the controller. Both set point temperature and actual temperature are displayed on a large, bright, digital LED read out screen. The system is capable of setting and reading temperatures to readable accuracy of one-tenth of a degree Celsius or Fahrenheit.

***Temperature Alarms*: ** In addition to the main temperature control system described above, an over and under temperature alarm system was provided on the control panel (Temperature Safety Limit Alarm). This alarm system is completely independent of the main controller and will activate in the event the room temperature control point deviates out of tolerance in either direction. The system contains separate high and low alarm set points and the dials are calibrated directly in degrees Celsius or Fahrenheit with 1° divisions. The alarm system is adjustable over the full range of the room. If an alarm is activated, an audible alarm will sound, and the operator will acknowledge a “High Temperature” or “Low Temperature” indicator by pressing a reset button. If the high alarm is activated, power to the room heaters will automatically be cut off from the conditioned space.

Data Acquisition System: The data from the six (6) stations are collected and analyzed by a Data Acquisition Unit (DAU).

The ECC was procured with support from the GEF and the UNDP from a United States of America (USA) base company, TESCOR. Seven Nigerian officials selected from the SON, ECN and NCEEC were sent to TESCOR company in the USA where they were trained on various aspects of the ECC. They were trained on different components of the testing Chamber – Testing Room, Electrical Panels, Compressor Chamber, Monitoring Panel, and the Data Acquisition System. Overall, the training focused on the following areas: basic set up of the ECC; hardware components and their operation and maintenance; software and data management system; and general troubleshooting[71].

[71] Inspection and training report on Environmentally Controlled Room for six stations refrigerator testing. An unpublished report under the GEF-UNDP supported Energy Efficiency Programme, 11-17 June 2014.

Capacity Building of Top Government Officials

Many development projects and programmes sometimes focus on developing the capacity of technical staff and engineers and in many cases neglects the Chief Executive Officers of these institutions. The GEF-UNDP supported Energy Efficiency Programme took a different approach. While building the capacity of field staff and engineers, it is equally important to build the capacity of the Chief Executive Officers of these agencies. The Chief Executive Officers of these agencies are the decision makers. For these important players in the energy sector to fully understand the energy efficiency concept, dynamics, and potentials for socio-economic development, it is important to build their capacity. This is also critical for sustainability of the energy efficiency initiatives.

Accordingly, the Chief Executive Officers of public agencies relevant to the implementation of the energy standards and labeling programme in Nigeria were invited to participate in an Energy Efficiency Training Tour to two Europeans countries - Belgium and France. The institutions invited to participate in the Tour included the Energy Commission of Nigeria (ECN), National Centre for Energy Efficiency and Conservation (NCEEC), Rural Electrification Agency (REA), Federal Ministry of Power (FMP), Federal Ministry of Environment (FME), Nigeria Custom Service (NCS), National Universities Commission (NUC) and one representative of the civil society group active in the energy sector – the Community Research and Development Centre (CREDC).

During the tour, participants were exposed to comprehensive and practical training on different aspects of energy efficiency. The training tour provided the platform for the participants to learn from the success stories in other parts of the world. Field visits were made to lamps recycling plants and e-waste collection point. The objectives of the Energy Efficiency Training Tour were:

- provide on-the-site and practical energy efficiency training for executive officers of the relevant institutions
- to provide the platform for these institutions to interact with stakeholders in developed economy and learn from their success stories
- to establish the bases for the continuity of the energy efficiency initiative in the relevant agencies and organizations
- to strengthen synergy among these agencies for the purpose of promoting energy efficiency in Nigeria.

During the Tour, the Nigeria delegation were privileged to be tutored by personnel of the following organizations:

- Schneider Electric
- French Environment and Energy Agency (ADEME)
- Energy Directorate of the European Commission
- Recylum, France
- Swedish Energy Agency
- Global Off Grid Lighting Association
- UNEP En.lighten Initiative
- NegaWatt

<u>Schneider Electric:</u> Members of the Nigerian delegation were trained by staff of Schneider Electric in the company's headquarters in Paris. The training focused on technical solutions to improve energy efficiency in residential buildings, industries, water supply systems and other facilities where energy is consumed. The delegates were also given the overview of the European Commission (EC) Directives on Energy Efficiency which is the driving force for all the technical and policy innovations in the European Union (EU) territory. The Nigerian delegates were taken round the International Customer Lounge of Schneider Electric to see the practical demonstration of some technical solutions to promote energy efficiency in buildings and industries.

Plate 7.5: *Nigerian Delegation with Staff of Schneider Electric*
Source: UNDP, 2015

French Environment and Energy Management Agency: Nigerian delegates visited the office of the French Environment and Energy Management Agency (ADEME) where they were received by the officials of ADEME. In a round-table interaction with the officials of ADEME, members of the Nigerian delegation understudy the French Energy Efficiency and Renewable Energy Policy. The Nigerian delegates were made to understand that the French government has put in place national policy, strategies, and programmes to implement the EU Directives to reduce greenhouse gas emission by 20%, increase energy efficiency by 20% and increase the share of renewable energy in the energy mix by 20% by the year 2020.

According to the officials of ADEME, in response to the EU Directives, the French government has set a target to increase the energy efficiency of different products by 19.7% to 21.4% by year 2020. Similarly, the Nigerian delegates were taught that the French government has set targets and plans to reduce energy consumption of existing buildings by introducing standards and labels, developing building codes (to achieve zero energy consumption in buildings), and to introduce tax credit for energy efficient buildings (in the form of zero interest loan).

Nigerian officials also learnt that the strategies employed by the French Government to promote energy efficiency include making it obligatory for energy suppliers to promote energy efficiency, support research and development on energy efficiency in building and smart grids and the issuance of white certificate. In the transport sector, the French government has set targets to build 2000km of high-speed train by 2020, 1,500km of bus lanes built in the next 15 years, introduce labelling systems in cars, introduce taxes on fuels used by cars and introduce incentives to purchase energy efficient cars. The French government is also making it mandatory for large companies to conduct energy audit every 4 years.

Plate 7.6: *Round-table discussion with officials of ADEME*
Source: UNDP, 2015

European Commission: The Nigerian delegates visited the Energy Directorate of the European Commission in Brussels, Belgium. During a round-table interaction between the Nigerian delegates and the European Commission officials, the following issues emanated from the discussion:

- Energy demand and the price for energy are on the increase in Europe
- The drivers for energy efficiency in the EU are to mitigate climate change, to ensure energy security, to reduce consumers' energy bills, to create jobs, and to support European competitiveness.
- The Energy Efficiency Policy of the EU covers all end-use sectors - the households, public facilities, industry, and services, and energy supply and transmission
- Targets are clearly defined in the EU Energy Efficiency Policy
- Each country in the EU owns the responsibility to develop National Energy Efficiency Action Plan
- The public sector in the EU is to lead by example
- Energy audit is one of the key measures in the industry
- Training of personnel (for example energy managers in industries) is one of the key strategies to implement energy efficiency policy in the EU

Plate 7.10: Nigerian Team in the European Commission's Office in Brussels
Source: UNDP, 2015

Recylum: The Nigerian delegates visited the Management of a French company responsible for coordinating the collection and recycling of used lamps such as compact fluorescent lamps (CFLs), linear fluorescent lamps, light emitting diodes (LEDs) and other lighting products. The name of the company is Recylum and the Nigerian delegates were received by the Director-General and other staff of the Recylum. Also present at the meeting in Recylum was the Project Manager and other staff of UNEP en.lighten (Efficient Lighting for Developing and Emerging Countries) Initiative.

While briefing the Nigerian delegates on the objectives of the en.lighten Initiative, The Project Manager, Mr. Gustavo Manez said that the en.lighten Initiative was set up for the primary purpose to phase out inefficient lighting from the globe. He said the Initiative has conducted a study to access the true picture of the lighting situation in different countries including Nigeria. According to him, the en.lighten Initiative is focusing on key areas such as communication (awareness creation on the importance of transiting to the use of energy efficient lighting), quality control (ensuring that there are quality energy efficient lighting products in the market) and environmentally sound management (the proper handling and disposal of used lighting products). Mr. Manez said that the en.lighten Initiative is supporting regional blocks such as ECOWAS to develop regional lighting strategies including the collection and recycling of used lamps.

The Nigerian officials learnt form the meeting that a regional strategy will support the process of phasing out inefficient lighting from the ECOWAS region by 2016. During the meeting, the issue of harmonizing surveillance systems across the region to ensure that only quality energy saving lamps are found in the ECOWAS region was discussed and the idea was accepted by all parties. The Nigerian delegation unanimously accepted the concept of harmonize labelling system across the region. On the collection, handling and recycling of used lamps, a clear strategy for collection and recycling was proposed and decided upon.

In a presentation by the Director-General of Recylum, Mr. Herve Grimaud, he said that the regulatory framework underlying the operations of the Recylum is the Extended Producer Responsibility (EPR). According to him, the EPR is a regulatory evolution that progressively extends the responsibility of companies that place manufactured products on the market for the management of the products at the end of their life. He said that the goals of the EPR are to promote eco-design of products in order to limit environmental impacts, collect and recycle the end-of-life products in an environmentally sound manner and without injury to human health.

The EPR regulation provides that every manufacturer becomes individually responsible for collecting its own products and those manufacturers need to work together in order to manage the collection and recycling of their products in an efficient and cost-effective manner. The end-of-life cost must be visible to the consumers and the cost must be passed over to consumers. Mr. Grimaud said that the Recylum is a non-profit collection and recycling organization created in 2005 by four lamp manufacturers. The Recylum, with 22,000 collection points is part of Europe's network of 29 organizations collecting lamps, covering metropolitan France and other countries. The Nigerian delegates later visited the recycling plant managed by the Recylum and waste municipal collection point where used lamps are collected.

Plate 7.11: Nigerian delegates at the Recylum in Paris
Source: UNDP, 2015

UNEP En.lighten Team: The Head of Technology Unit of the UNEP, Mr. Zitouni Ould Dada with other staff received the Nigerian delegation at the UNEP Office in Paris. While welcoming the Nigeria delegates, Mr. Zitouni stated that energy efficiency is now one of the climate change mitigation strategies. He asserted that the goal of the UNEP en.lighten Initiative is to phase out inefficient lighting from the globe by 2016. Some of the issues discussed with the UNEP Team was the need for Nigeria to enrich its legislative framework to regulate collection and recycling of products and the framework should include incentives for consumer behavioral changes. The framework should also incorporate the strengthening of research centers to sustain technical knowledge development.

The Nigerian delegates also learnt the importance of MEPS and the need to create synergy between agencies of government by strengthening internal communication and coordination among stakeholders. The group recognized that adopting MEPS in Nigeria would be a good way to avoid poor quality products from entering the market. It was strongly recommended during the meeting that existing MEPS on lighting in the ECOWAS Region should be harmonized to have one standard for the region. Key suggestions from the discussion include:

- Nigeria to consider the possibility of increasing taxes on incandescent lamps.
- Promote end-use electricity metering system
- Develop case studies to convince key stakeholders of the value of MEPS.
- Increase dialogue between the Ministry of Power and the Energy Commission through the Energy Efficiency Programme.
- Consider the possibility of incorporating the updated draft on-grid and off-grid MEPS documents from the UNEP-ECREEE Cotonou meeting into the Nigeria Energy Efficiency Policy document.
- Nigeria will need to set MEPS for other lighting products aside CFLs where standard already exist
- Nigeria should also develop MEPS for light emitting diodes (LEDs)
- The UNEP En.lighten Project will support Nigeria to gather data to carry out economic analysis of increasing tax on off-grid lighting.
- It was suggested that Nigeria integrate off-grid lighting component into the energy efficiency policy being developed
- Put in place mechanism for the environmentally sound management of used lamps
- Nigeria to put in place standards for off-grid lighting products

Global Off Grid Lighting Association: During the tour, the Nigerian delegates were privileged to meet with the representative of the Global Off Grid Lighting Association (GOGLA). The presentation made by Johana Dieker, a representative of GOGLA initiated discussion among the delegates and several issues were raised. One of them was the issues around off-grid lighting products in Nigeria identified to include their high prices (the high cost of off-grid solar products) and the low quality of these products in the Nigerian market. There are also issues with the chargers and batteries of these products, and how they are used by consumers. Also, it was noted that the Nigerian population needs to be further sensitized on the importance of using energy-efficient off-grid lighting products.

It was also identified during the meeting that free distribution of off grid lighting products can be very damaging to an emerging market like Nigeria. Ms. Dieker proposed that the following types of programmes are more sustainable for the distribution of off grid lighting products - pay-as-you go systems and micro financing. Awareness creation on the cost and value of these lamps is essential to stimulate the market for off-grid lighting products. The GOGLA representative also explained that there are a few laboratories for testing off-grid lighting products in Germany, USA and India, she however noted that none is available in Africa. The delegates noted that there is an opportunity for one of the lighting laboratories in Nigeria to become a regional test center for off-grid lighting products (and the first in Africa). Key issues that will require action from the discussion are:

- Off-grid lighting MEPS need to consider voltage protection and batteries issue.
- The off-grid lighting MEPS should refer to IEC specifications and Lighting Africa Testing procedures to help solve the issue with the poor quality of off-grid products.
- Nigeria could use Lighting Africa videos to sensitize the population and promote off-grid lighting products.
- Look into the possibility of an off-grid lighting product test center at one of the laboratories in Nigeria.

Swedish Energy Agency: In a meeting with Emma Hagman Rang of the Swedish Energy Agency (SEA), the Nigerian delegates learnt about SEA's market surveillance system and enforcement activities. According to her, Sweden has one of the most advanced monitoring, verification and enforcement (MV&E) programmes in Europe, and they proactively engage with manufacturers and the market to monitor trade, to verify compliance and to enforce the regulations if any violations are found. The delegates learnt that the SEA market surveillance measures ensure that the Eco-design requirements are tested through in-house laboratory, external laboratories and technical document controls. Key enforcement options identified from the meeting are the use of dialogue, improvements of products, injunction that prohibits and withdraw products from the market, payment of fines and informing market surveillance authorities. Key outcomes of the discussion with the representative of SEA are:

- MV&E was acknowledged as a critical aspect of the integrated policy approach and a necessary programme to ensure importers and manufacturers comply with regulations
- The delegation recognized the need for training and technical support in the field of testing (course on market surveillance).

NegaWatt: The Nigerian Delegates met with the NegaWatt Team – Thomas Gueret and Jean-Pierre Moussally. The discussion with NegaWatt focused on the role energy efficiency will play in reducing energy demand. Since 1980, there has been increase in oil consumption than oil discovery and the International Energy Agency (IEA) stated that the peak of oil production was already met since 2010. The discussion with the NegaWatt established that energy efficiency will help to reduces energy demand globally[72].

[72] Capacity Development for Technical and Enforcement Personnel. In: Strategies for Enforcing Energy Standards and Labeling Scheme in Nigeria. A publication of the UNDP, December 2015

CHAPTER EIGHT

ENERGY EFFICIENCY AWARENESS CAMPAIGNS

A public awareness campaign is an information sharing effort to build public recognition and confidence through media, messaging, and an organized set of communication tactics. These campaigns usually target many people over a specific period of time to try and generate specific outcomes or achieve pre-determined goals[73]. Awareness campaigns are essential for the successful implementation of any energy efficiency programme especially when it involves the development and implementation of standards and labeling schemes. For energy efficiency programme to be sustainable, sufficient efforts and resources must be put in place to help stakeholders, especially the end-users to understand the importance and benefits of energy efficiency. The content of energy standards must be communicated to all stakeholders, that is the regulators, manufacturers, importers, retailers, and end-users.

Moreover, the design and structure of energy label must be communicated to stakeholders for easy understanding. The usefulness of any standards and labeling programme hinged greatly on the ability of stakeholders to understand the content of the standards and being able to interpret the information on the label. After a standard is approved, the very first task of government is to disseminate the content of the standard among concerned stakeholders. In many countries of the world, awareness campaign has been one of the long-term strategies to sustain the impacts of energy efficiency standards and labeling programmes. This Chapter will discuss some of the methods and activities embarked upon by the Nigerian government to create energy efficiency awareness.

Train-the-Informant Approach

Energy efficiency initiatives are designed to essentially change human behavior. The media can play a huge role to ensure that the required energy efficiency information is widely disseminated. The energy efficiency philosophy, being in the formative phase in Nigerian, and coupled with the technicalities surrounding the concept, media personnel may not have the capacity to effectively pass this information to stakeholders. To ensure the long-term sustainability of the energy efficiency campaign, it is important to build the capacity of media organizations and personnel. This was the approach of the Nigeria government in the early stage of Energy Efficiency Programme jointly supported by the GEF and the UNDP. To fill the capacity gap in the media, the Nigerian government through the Energy Commission of Nigeria and the National Centre for Energy Efficiency and Conservation organized a workshop specifically to train media personnel, to enhance their capacity to effectively report energy efficiency issues. The workshop attracted personnel from the print and electronic media institutions.

Sectoral Approach

There are specific sectors that will require immediate attention, simply because these sectors are energy intensive compared to other sectors. In the process of planning an awareness campaign, it is required that priority is given to these energy intensive sectors. Reducing energy consumption in these sectors may have short-term huge effect on the national grid, in the form of enhanced system optimization. In the energy efficiency campaign in Nigeria, the government prioritized certain sectors and they are enumerated below:

Hotel Industry: The hotel owners spend a large part of the electricity they consume on cooling and heating. The hotel industry is a major consumer of electricity in many cities. Energy accounts for the second largest spending after employment in hotel operations, representing 3% to 6% of hotel operating costs and accounting for approximately 60% of its CO_2 emissions[74]. In the Nigerian Federal Capital Territory alone,

[73] Bouder, S. (2013). Critical components for public awareness campaigns. https://advocacyunleashed.kontribune.com/articles/1371
[74] Celine Vadam. How to Reduce Energy Consumption in Hotels, 2015. https://www.costar.com/article/218364045/how-to-reduce-energy-consumption-in-hotels

there are about 120 hotels. The hotel owners in Abuja have organized themselves into an association called Hotel Owners Forum Abuja (HOFA). Recognizing the importance of the hotel industry to the energy sector, the government, in collaboration with the leadership of HOFA organized a sensitization workshop with the objective of enhancing the capacity of hotel owners and their managers to integrate energy efficiency best practices into the operations of their facilities.

Manufacturing Sector: The manufacturing sector currently consumes about 10% of the electricity generated in Nigeria[75]. In a growing economy like Nigeria, the sector has the potential to become a major consumer of electricity. The government is aware of this and sees the manufacturing sector as a priority sector to benefit from the energy efficiency campaign. To begin this process and working with the leadership of Manufacturers Association of Nigeria (MAN), the government organized a sensitization workshop for members of MAN to educate them on the benefits of energy efficiency, which will consequently reduce the energy demand in the manufacturing sector. The workshop attracted 119 participants from the manufacturing industry, government and NGOs.

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National Energy Efficiency Events

The government of Nigeria inaugurated annual events to campaign for energy efficiency. These events served as platforms to gather stakeholders yearly to discuss ways to promote energy efficiency best practices and to review progress made by government in the sector. Furthermore, one of the events focused on the roles that energy efficiency best practices and energy conservation will play in the course of implementing the Power Sector Reform (PSR) of the Federal Government of Nigeria. The PSR has expressly identified the adoption of national policy on energy efficiency as one of the strategies to achieve its objectives.

Plate 8.1: Some dignitaries at the 3rd National Energy Efficiency Summit

[75] GEF-UNDP. Promoting Energy Efficiency in Residential and Public Sector in Nigeria, 2011. The project document of a GEF-funded full-size project.

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Plate 8.2: Group photograph during the 3rd National Energy Efficiency Summit

Greening of Public Buildings in Nigeria

Office buildings and other facilities owned by the government (federal, state, and local governments) in Nigeria has been identified as major consumers of electricity. The GEF-supported Energy Efficiency Programme was designed to encourage national institutions to reduce the carbon footprint of their office buildings by embracing energy efficiency best practices. The Energy Commission of Nigeria (ECN) working with national partners commissioned the initiative “Energy Efficiency Retrofit of Energy Commission of Nigeria Building”. The retrofit is one of the demonstration projects under the GEF-funded Energy Efficiency Programme, with the aim to showcase ECN Building as a standard for other public buildings in Nigeria. Furthermore, it was also designed to help create awareness on the role of energy efficiency in achieving the objectives of the UN Sustainable Energy for All Initiative.

Plate 8.3 Dignitaries at the commissioning of the Retrofit Programme

The retrofit programme involved the replacement of the 408 four-foot linear fluorescent lamps (each rated 36W) with LED lamps (each rated 18W). The lighting on the fourth floor of the building was powered fully by a PV system mounted on the roof of the building. Sensors that are sensitive to human movement were installed in common rooms such as toilets and waiting rooms to automatically switch off the lamps in them when they are empty. The distribution boards in the building were replaced to reduce energy losses. The retrofit resulted in an estimated 15kW peak reduction.

Capacity Strengthening of Institutions

The energy efficiency campaign was extended to the 36 State Directors of the National Orientation Agency (NOA) including the Director of the Federal Capital Territory. In addition, the campaign targeted the Zonal Officers of the Consumer Protection Council (CPC), Zonal Coordinators and State Coordinators of the Electricity Consumer Association of Nigeria (ECAN), some NGOs selected from several states and other relevant government institutions. The campaign was carried out through a workshop held at the Federal Capital Territory, with a total attendance of 200 participants. The workshop was organized to help participants understand the benefits of energy efficiency and the roles it will play in achieving national development and environmental sustainability. Moreover, it was organized to strategically integrate energy efficiency into the programmes and grassroots oriented projects of participating institutions and organizations.

Plate 8.4: Group photograph of the participants

Participants at the workshop noted that the Nigerian government has paid more attention to energy generation with little emphasis on end-use energy management. They called on the government to as a matter of urgency give adequate attention to end-use energy efficiency. They observed the need to put in place policy that will encourage the retrofitting of public buildings. Stakeholders called on the Federal Government to establish an Energy Saving Trust Fund (ESTF) to enhance energy efficiency best practices in the country and that energy efficiency courses should be incorporated into the primary, secondary and tertiary institution's curriculum in Nigeria.

Energy Efficiency Awareness Campaign Among Nigerian Universities

Nigeria has a total of 128 universities comprising of state, federal and private universities. Significant energy savings can be achieved in the campuses of these universities. Also, the universities community is well positioned to increase energy efficiency awareness. The ECN, working in partnership with the National University Commission (NUC) organized a workshop specifically for the officials of Nigerian universities. The objective of the workshop was to create awareness among officials of Nigerian universities on the need to develop strategies and programmes to reduce energy demand in their various campuses.

Plate 8.5: Dignitaries at the meeting

Participants in the workshop observed that there is absence of effective electricity metering systems in most of Nigerian Universities. In other words, many offices, laboratories, and residential buildings in the campuses of Nigerian universities are not metered. They also noted that many universities in Nigeria do not have programmes and policies in place to promote energy efficiency and conservation. The university community is well positioned to spread the energy efficiency culture by integrating energy efficiency study into university curriculum as General Studies. This is currently absent in the university system. Most of the buildings in university campuses were built without putting into consideration the energy efficiency of the buildings. There are no incentives to encourage research and development in the area of energy efficiency, thus there is dearth of research material in this area.

It was agreed in the meeting that the NUC should partner with ECN to introduce energy efficiency studies into universities curriculum as General Studies. The management of universities were encouraged to regularly carry out sensitization on energy efficiency and conservation within their universities to change the behavior and attitudes of students and staff members. Participants stressed the need for universities in Nigeria to develop programmes and policy to promote energy efficiency culture in their various campuses. They called on the Government to make funds available in the national budget to support energy efficiency research and development. It was also recommended that yearly energy audit be carried out in all Nigerian universities and the audit should guide budgetary processes in the institutions and energy efficiency should be considered in the designs, constructions and equipment supplies to universities.

CHAPTER NINE

ENERGY EFFICIENCY PROJECTS IN NIGERIA

The electricity generated in Nigeria and transmitted through the national electricity grid is inadequate and unstable, leading to frequent power outages. This has forced a large portion of the industries, businesses, and households to rely on diesel and petrol generators as primary or back-up source of electricity. The use of private generators is expensive, and a source of greenhouse gas emission. The Nigerian government has put in place measures to address the shortage of electricity. The government has taken measures to increase electricity generation, which forms a major part of the policy objectives of the government. Beyond these measures to increase generation, the government, with support from international partners has initiated projects to enhance the efficient use of energy. The promotion of large-scale, national energy efficiency programme is a critical demand-side initiative to help reduce the energy consumption. These programmes have assisted the government to increase access to electricity and at the same time mitigate the emission of greenhouse gases resulting from energy generation. This Chapter will discuss the programmes that have been implemented in Nigeria to promote the efficient use of energy as well as the lessons learnt. Three major energy efficiency programmes have been initiated by the Nigerian government with technical support from international partners. They are:

1. Nigeria Energy Efficiency Programme
2. Nigeria Energy Support Programme
3. Sustainable Fuelwood Management

Nigeria Energy Efficiency Programme

In 2009, the GEF approved a grant for the Nigerian Government, through the Nigeria Federal Ministry of Environment (FME) to implement a project that will promote energy efficiency in the residential and public sectors. The overall objective of the project was to improve the energy efficiency of a series of end-use equipment (refrigerators, air conditioners, lighting equipment, electric motors and fans, heating appliances etc.) used in residential and public buildings (schools, hotels, offices) in Nigeria through the introduction of appropriate energy efficiency policies and measures (such as standards and labels) and demand-side management programs. The project was designed to strengthen the regulatory and institutional framework, develop monitoring and enforcement mechanisms, establish testing laboratories, provide training to appliance and equipment professionals, and launch a public outreach campaign to promote energy efficiency in Nigeria[76]. The project was executed by the Energy Commission of Nigeria.

Before the commencement of the project, there were multitudes of barriers that were identified that could hinder the achievement of the objectives of the project. The strategies to overcome these barriers are discussed below (Table 9.1).

Table 9.1: Barriers to energy efficiency best practices

Barriers	**Description**
Policy Barrier	At the commencement of the project, there was lack of clear policy framework and regulations to support the adoption of energy efficiency best practices. Policy and legislation are two elements that can help to change human behavior as well as sending the right signals and drivers to investors for market transformation. This

[76] Uyigue, E., Yapp, J., Lebot, B. and Odele, M. (2009). Overview of UNDP-GEF Energy Efficiency Project: Overcoming Barriers in Promoting Energy Efficiency in Nigeria. Paper published in the proceedings of the 6th International Conference on Energy Efficiency in Domestic Appliances and Lighting (EEDAL), Copenhagen, Denmark, 24-26 April, 2011. Page 107 – 114. http://iet.jrc.ec.europa.eu/energyefficiency/tags/eedal

	barrier has been addressed to a great extent; in 2015, the National Renewable Energy and Energy Efficiency Policy was approved by the Federal Government. Since them a lot of other policy documents were developed as already described in Chapter Two of this book.
Legislative Barrier	Not until 2013, there was no regulation in Nigeria that addresses end-use energy efficiency. The Standard Organization of Nigeria (SON) did not have standards that stipulate energy efficiency norms for end-use appliances. It is of great importance to have an energy efficiency act in Nigeria in order to have stronger mandate to promote energy efficiency; this is currently lacking in Nigeria. As a result, the Legislative Arm of Government is unable to use both the budget and oversight tool to ensure effective implementation of energy efficiency policy.
Information Barrier	The concept of energy efficiency was poorly understood in Nigeria even among policy makers and legislators. Awareness creation will go a long way to help people understand the concept and in turn change their behavior. Little information and research material is available at the government level on the potential impacts and cost effectiveness of energy efficiency policy and regulation. Many end users lack information about the availability of energy efficient equipment and the cost effectiveness of investing in efficient appliances.
Technical Barrier	Insufficient trained personnel and professionals is another barrier to energy efficiency in Nigeria. Out of the 150 respondents interviewed in the study conducted by Community Research and Development Centre in 2009, 77% of them said that no member of their organizations has been trained on energy management[77]. Nigeria as a country lacks sufficient energy efficiency experts and champions that will drive the implementation of energy efficiency policy and projects
Research & Development Barrier	There was no sufficient organized research materials and data to support the development of policy and legislation that will strengthen the efficient use of energy. The absence of coordinated and organized research materials and data was one of the barriers that hindered the design and development of sound energy efficiency policy and legislation. This barrier has slightly been addressed over the years.
Cost Barrier	Price is a very strong economic factor influencing the demand for goods and services. A total of 51% of respondent from a survey conducted by CREDC agreed that they consider the price of appliance before they purchase one. In many cases, the prices of less efficient appliances are low compared to the more efficient ones. Many stakeholders in Nigeria complained that the prices of energy efficient bulbs are on the high side compared to incandescent bulbs. The desire to minimize initial cost forces many consumers to purchase cheap and inefficient appliances. This is still a major barrier in the energy efficiency subsector.
Income Barrier	About 70% of Nigerians live below the poverty line of USD$2 per day[78] and as a result many are not able to afford the cost of energy efficient appliances which are sometime more expensive than the less efficient ones. This is the reason why many Nigerians go for secondhand goods. The proliferation of imported secondhand appliances may hinder the use of efficient appliances. The reason is that these secondhand products are cheaper compared to the new ones and easily available; the new and efficient ones may be unable to compete with them in the market.
Institutional Barrier	There was lack of capacity in government ministries and institutions on how to specifically proceed to implement and enforce energy efficiency regulations, and how to develop and support energy efficiency schemes such as standards, codes, certification and labels in order to speed up the market transformation process.
Market Barrier	Local and medium size manufacturers lacked capacity to develop and market more efficient appliances and are uncertain about the market demand of high efficiency

[77] Community Research and Development Centre. Energy Efficiency Survey in Nigeria: A Guide for Developing Policy and Legislation. A publication of the Community Research and Development Centre (CREDC). 2009. www.credcent.org

[78] UNDP. Promoting Energy Efficiency in Residential and Public Sector in Nigeria, 2011. A project document for a full-sized GEF funded project in Nigeria.

	models. Retail staff and commercial staff do not know how to market energy efficient appliances. Hence retailers do not offer a sufficient range of efficient equipment because of insufficient demand for this type of appliances
Governance Barrier	The problems facing the energy sector in Nigeria are partly systemic. Stakeholders have identified corruption in public offices as a potential barrier to the development of energy efficiency in Nigeria. This implies that a systemic problem will require systemic solution. The government has taken a giant step to address the problem of corruption in Nigeria by setting up two bodies, the Independent Corrupt Practices and other Related Offences Commission and Economic and Financial Crime Commission (EFCC) to combat corruption and other financial crimes.
Funding Barrier	Funding from government in the energy sector has concentrated on generation and distribution and little or none is allocated for the efficient use of energy. Again, many government agencies and programs especially energy efficiency projects are poorly funded because neither the executive nor the legislative arm of government has been adequately briefed on the benefits of energy efficiency programs.
Enforcement Barrier	Weak enforcement of national laws and regulations is another important barrier to the development of energy efficiency in Nigeria. Many of the regulatory and enforcement agencies are impaired with limited budgetary resources to carry out enforcement activities.
Competitive Barriers	Smaller domestic manufacturers worry that they may not have the financial or technical capabilities to compete with larger, more established manufacturers that have established partnerships with international consortiums and can benefit from their know-how. Furthermore, unless the government can stop the dumping of substandard products, domestic manufacturers may feel penalized if they must compete against imported products that fail to follow the necessary labeling regulations

Strategies to Overcome Energy Efficiency Barriers

*Energy Efficiency Policy and Regulations***:** The project assisted the Nigerian government to put in place a draft energy efficiency policy, which was submitted to the appropriate authority. Energy standards were developed for some selected end-use appliances – lighting and refrigerators. This was done to establish an enabling policy and institutional framework for the development of end-use appliances minimum energy performance standards (MEPS) and energy labels. The long-term impacts of this policy are the reduction in national carbon emissions through the adoption of more energy efficient appliances in the residential and public sector. Moreover, under this component of the project, technical assistance and capacity building were provided to the government so that the appropriate authorities can proceed with energy standard and label implementation.

Establishment of Energy Efficiency Testing Laboratories: During the project, energy efficiency testing centers for lighting and refrigeration appliances were established in the SON. The testing centers are expected to be beneficial to other ECOWAS States. These testing centers will support the relevant agencies of government to enforce energy efficiency standards and carry out surveillance activities. The enforcement procedures will cover the manufacturers, importers and retailers of these appliances and will ensure that all market actors are informed and are following the new regulation.

Training and Awareness Creation: This component was designed to build the capacity of stakeholders at the national level on the fundamental principles of energy efficiency, train relevant professionals and carry out public outreach. National professionals and policy makers were trained, and several studies were carried out to collect baseline data, which were analyze prior to the transformation of the markets.

Pilot Scheme to Install CFLs: Under this component, one million compact fluorescent lamps (CFLs) were distributed in residential and public buildings in different locations in the country. This pilot activity was carried out to quantify the economic, social and environmental benefits of replacing old incandescent bulbs with CFLs.

Challenges and Lesson Learnt

The proliferation of substandard CFLs in the market was one of the challenges encountered in the process of implementing the Nigeria Energy Efficiency Programme. Stakeholders expressed disappointment over the short life span of energy saving lamps in the market. Although there are schemes to control the quality of lighting products, but importers of these products do not know the content of the MEPS already put in place by the government. The challenge of power surge experienced in some parts of the country may contribute to the short life span of lighting products. Nigeria lacks well-structured e-waste management system; as a result, there was no coherent system of disposing used CFLs and other mercury-containing lamps. The use of CFLs to replace ICLs can create an environmental problem if there is no process in place to safely dispose used lamps.

The implementation of the project embraced the bottom-top approach. Stakeholders were adequately consulted at every stage of the project. This is opposed to the usual top-bottom approach to project implementation and policy development. Several consultation meetings were held with stakeholders to seek their opinion and inputs to give them a sense of ownership of the process. In this way, enforcement of policy will become very easy and as such will be driven by all stakeholders. Worthy of mentioning is consultation meeting with the Electrical Dealers Association of Nigeria (EDAN), major distributors and retailers of electrical appliances in Nigeria. After several consultation meetings with EDAN, the group promised to begin the importation of energy saving bulbs prior to the commencement of the policy. With the bottom-top approach, before policies are made through official channels, stakeholders are already willing to carry out the content of the policy. This is a demonstration of the importance of consulting with stakeholders when developing any policy.

Nigeria Energy Support Programme

The Nigeria Energy Support Programme (NESP) is an initiative of the European Union (EU) and German Federal Ministry for Economic Cooperation and Development (BMZ). The first phase of the Programme was launched in March 2013 and ended in February 2018. The NESP was implemented in partnership with the Federal Ministry of Power (FMP) and other partner institutions at the federal and state level. It is a technical assistance programme that advice the federal government on how best to provide reliable and sustainable electricity to its citizens. The NESP achieved this by encouraging investments in renewable energy, energy efficiency, and rural electrification. The first phase of the NESP consists of four units: Policy Reform and On-grid Renewable Energy; Energy Efficiency; Rural Electrification and Sustainable Energy Access; and Capacity Development and Training.

The implementation of the NESP laid a good foundation which led to the rapid development of the Nigerian off-grid market which according to the Rural Electrification Agency is worth 9.2billion dollars annually. This has resulted to the following: improved/better confidence to invest in the off-grid sector in Nigeria; increased private sector participation in the energy sector; increased activities of donor agencies like the (World Bank, USAID, AFDB) as well as equity investors like All-On.

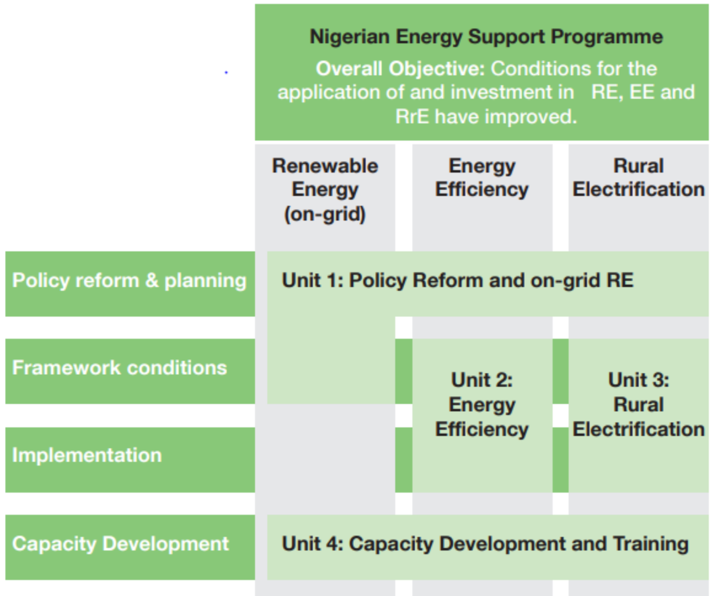

Fig. 9.1: Four pillars of NESP[79]

Some Achievements of the NESP

Policy: With the support of the NESP, the Nigerian government developed and adopted the policy document, the National Renewable Energy and Energy Efficiency Policy (NREEEP), a document which set clear targets for renewable energy and energy efficiency. The Rural Electrification Strategy and Implementation Plan (RESIP) was finalized. RESIP provides a basis for the Rural Electrification Agency (REA) to unlock financing such as the Rural Electrification Fund. Furthermore, the regulation for minigrid systems that is less than 1MW was developed in coordination with the FMP and the Nigeria Electricity Regulatory Commission.

Energy Efficiency: NESP prepared the Building Energy Efficiency Guideline, which contains instructions for architects on how to design buildings in an energy efficient way. The Building Energy Efficiency Code (BEEC) was developed, which stipulated minimum energy efficiency requirement for buildings.

Rural Electrification and Sustainable Energy Access: NESP supported the government to develop a mini grid regulation and supported the development of the Rural Electrification Strategy and Plan. Having provided the enabling environment for private investment in the sector, NESP supported five state governments in partnering with private developers using the public-private-partnership (PPP) model to construct and operate 6 mini-grids. Altogether, these solar based systems provide sustainable electricity to more than 10,000 people who previously did not have access to electricity. Additionally, productive users such as shop owners, welders and millers benefited from stable electricity.

The mini grids include:

- 85 kWp Solar System (with 80KVA diesel backup) operated by Rubitec in Ogun State
- 80 kWp Solar System operated by GoSolarAfrica in Sokoto State
- 100 kWp Solar System operated by Nayo Tropical in Nigeria State
- 50 kWp Solar System operated by CREDC in Cross River state
- 100 kWp Solar System operated by GVE in Plateau State

[79] Nigeria Energy Support Programme. Promoting Clean Energy Investment in Nigeria. https://www.giz.de/en/downloads/giz2016-en-promoting-clean-energy-investments-in-nigeria.pdf

Capacity Development: During its first phase, the NESP developed four training courses to foster skills development for the renewable energy market. The programme created training partnership network comprising 11 training academic and research institutions for the delivery of these courses. With the support of NESP, National Power Training Institute of Nigeria (NAPTIN) has embarked on an organizational development process. This will enable NAPTIN to become a market-oriented training institution for the clean energy market and a leader in the West African power sector.

Sustainable Fuelwood Management

The Sustainable Fuelwood Management (SFM) was implemented by the Energy Commission of Nigeria with support from the GEF and UNDP. The project was designed to enhance sustainable fuel wood production and consumption for socio-economic and environmental benefits, including carbon storage and sequestration. The activities of the project were carried out under the following components:

1. *Supply Side Management:* This involves the production and procurement of certified fuelwood from sustainable feedstock sourced from:
    - woodlands outside the protected forests in Cross River and Delta State in Southern Nigeria
    - farmer managed woodlots in Kaduna State in the Northern part of Nigeria

2. *Demand Side Management:* through the promotion of improved stoves/kilns in the domestic sub-sector as inclusive business to reduce fuel wood.
3. *Financing Model for Sustainable Fuelwood Management:* This component has provided inclusive financial products and services as well as market mechanisms for sustained market supply and demand for energy efficient stoves/kilns and certified fuelwood. Local manufacturing of these efficient cookstoves have been supported to make the cookstoves cheaper and more affordable to the target groups.

The Supply Side Management of the project focused on the sustainable fuel wood production and consumption through the establishment of rural farmer-managed woodlots of fast-growing trees that could be harvested and re-planted for fuelwood harvesting. This should bring about multiple environmental and socio-economic benefits, while ensuring that basic human development needs are met without compromising the ecosystem. Under the Fuelwood Demand Management component of the project, GHG emissions from the burning of fuelwood in the traditional 3-stone cookstoves have been reduced through widespread adoption of energy efficient wood/charcoal cookstoves. These efficient cookstoves are about 60-80% more energy efficient than traditional cookstoves.

Key Achievements:

- Over 200 hectares of new renewable woodlots for sustainable fuelwood harvesting have been established within Cross River, Delta and Kaduna States.

- More than twenty-five thousand (25,000) energy efficient wood/charcoal cookstoves were produced and distributed among communities in the three States.
- Sustainable Fuelwood Management (SFM) Demonstration Center was built and operated in each of the three (3) States.

- Energy Efficient Charcoal Production Systems have been built in each state for the sustainable production of charcoal from agricultural wastes, as against the traditional burning of logs of wood in shallow earth pits.

- Over 250 young women and men were trained as business agents for the promotion of clean cookstoves and woodlot establishment in Nigeria.

- Fourteen (14) Micro-finance institutions have been capitalized and capacitated to provide sustainable fuelwood management financing models that enables low-income groups in the target communities to access no-interest loans for the purchase of the energy efficient cookstoves

- Gender sensitive certified capacity building of 150 farmers on woodlot and nursery establishment in Cross River, Delta and Kaduna States

- Construction, installation and building of briquetting machines in selected locations in the 3 states were carried out

- Establishment and capacitation of SFM Cooperative Society of Nigeria (SFM-CSN) for the sustainability of SFM benefits beyond project's lifespan.

CHAPTER TEN

ENERGY CONSUMPTION AND HUMAN BEHAVIOR

Energy consumption is the amount of electrical energy and other fuels (gas, oil, propane, etc.) consumed in a building or facility within a billing period. It could also be referred to as the amount of energy consumed by a mechanical or electrical system within a given period. Energy consumption also refers to the total energy needed to perform work, such as manufacturing, transporting and others over a period. Energy consumptions is measured in kilowatt hour (kWh). Human behavior refers to the way human do things or respond to issues or stimulus. Consumer behavior refers to the selection, purchase and consumption of goods and services for the satisfaction of their wants.

There are several factors that can influence energy consumption and these factors can be placed under four categories - Environmental Factors, Social Factors, Cultural Factors and Economic Factors. Some of these factors may have positive influence on energy consumption, that is lead to increase in energy consumption while others may have negative influence on energy consumption, that is leading to decrease in energy consumption. For example, a study conducted in 2019 revealed that greenhouse gases, gross domestic product (GDP), population increase, and labor growth positively influenced energy consumption while feminine population increase, health care expenditure and energy taxes negatively influenced energy consumption[80]. In another report, it was revealed that the factors that affect energy consumption are income, age group, lifestyle and behavior of occupants as well as the physical characteristics of dwellings and the environment where the building is located[81].

Environmental Factors: Consumers' behavior is influenced by environmental factors such as temperature, humidity, rainfall, wind speed etc. For example, people may purchase certain products such as air conditioners during a particular time of the year when the temperature is higher.

Social Factors: Every man is a social being and we are required to interact with other people around us. To some extent, our likes and dislikes are influenced by the people around. In many cases, many people will always seek confirmation from other people around them to do things that are not socially acceptable. The social factors influencing consumer behavior are family, reference groups and roles and status[82].

Cultural Factors**:** It has been observed that human behavior is dependent on learning process. As individuals grow up, they are exposed to a set of values, perceptions, preferences, and behavior patterns as they socialize both within the family and a series of other key institutions. As a result, the individual develops a set of values, which determine and drive behavioral patterns. These values include achievement, success, efficiency, progress, material comfort, individualism, freedom, humanitarianism, youthfulness and practicality. This broad set of values is then influenced by the subcultures like nationality groups, religious groups, racial groups and geographical areas[83].

Economic Factors: Consumer behavior is influenced largely by economic factors which include personal income, family income, income expectations, savings, liquid assets of the consumer and consumer credit.

The Community Research and Development Centre embarked on a study to identify commercially and behaviorally low-cost ways of reducing energy consumption in the residential, public and private sectors in Nigeria. From the study, some of the behavioral patterns that could lead to wastage of energy are discussed below.

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Use of incandescent light bulbs: The common name for incandescent bulb in Nigeria is "yellow bulb" because of the yellowish color of the light rays emitted from the lamps. Many Nigerians are not familiar with the name 'incandescent bulb'. The study shows that 65% of our respondents claimed they use incandescent bulbs (Fig. 10.1). The use of incandescent bulbs for lighting is energy intensive. Only about 5% of total energy used by an incandescent bulb is converted into light energy, the remaining 95% is converted to heat energy[84]. The energy ratings of the incandescent bulbs found in the Nigerian market range from 40W to 200W, we have the ones rated 40W, 60W, 100W and 200W. It was found that in many places where people experience low voltage, people purchase the 100W and 200W in order to get a brighter effect. Also, many people use the high rating incandescent bulbs for outdoor lighting because they are brighter.

A major factor working against the shift from incandescent bulbs to energy saving bulbs is the cost. Energy saving bulbs are far more expensive than incandescent bulbs. The cost of energy saving bulbs in the market ranges between N800 to N1000. On the other hand, the prices of incandescent bulbs range from N30 to N100. Policy option for Nigeria will include the gradual phase out of incandescent lamps (ICLs) from the market and putting a ban on their importation and production. It is necessary to put in place policy to encourage the importation and production of energy efficient light bulb, especially LEDs lamp and this will lead to significant savings. The use of fiscal incentives as a strategy to encourage the use of energy saving lamps is important to increase their affordability. Awareness creation is also needed to change the behavior of Nigerians.

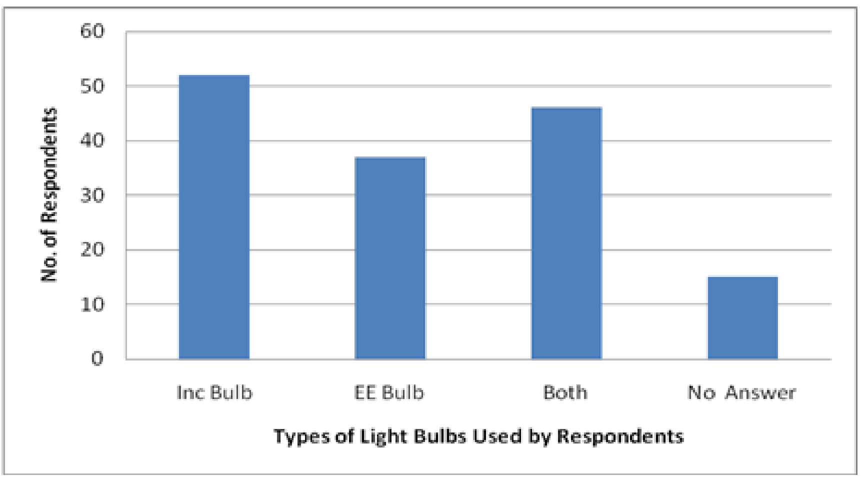

Fig. 10.1: Types of light bulbs

Putting on light to advertise goods: Many traders and food vendors use electric-powered lamps during the day to attract the attention of people to their shops and goods. Some food vendors use incandescent bulbs to heat up their food and at the same time draw the attention of people. In some of the restaurants, several ICLs are switched on at the same time for aesthetic purposes and to create illumination during the day.

Switching on outdoor lighting during the day: The study revealed that many Nigerians do not put off their outdoor lighting during the day. This was particularly very common in commercial and residential areas in many major cities in Nigeria. Even in public institutions such as universities and government ministries were also found to have their outdoor lighting switched on during the day. Many respondents blame the electricity distribution companies for this behavior. According to them, when there is power outage during the dark hours and it lingers into the day, they forget to turn off their outdoor lighting. A lot of energy can be saved if Nigerians cultivate the habit of putting off their outdoor lighting in the daytime. Energy saved from

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using natural light instead of light bulbs during the day can be made available for use in offices and for industrial activities.

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Proliferation of private water boreholes: In many cities and villages in Nigeria, many households, commercial and industrial buildings construct water boreholes. The reason for the proliferation of water boreholes is that many areas are yet to be served by municipal pipe-borne water infrastructure. The use of privately owned water boreholes is on the increase as more houses are being constructed. In many cases, you find two or more boreholes in one street. The submersible pump for constructing water boreholes for domestic use can reach up to 1500W rating. Apart from consuming a lot of energy, these machines exert a lot of stress on grid facilities. In many parts of the world, water is conveyed from a central system through a network of pipes to residential, public and private buildings. With this method, the energy used to take water from the ground and make it available to the people is greatly minimized.

Industrial activities in residential areas: Many cities in Nigeria are not properly planned. The practice of building industries in residential areas is unhealthy for the power grid. With this kind of practice, utility companies providing electricity are unable to effectively allocate energy to the various sectors. Moreover, because of the high energy consumption of the equipment used in the industries, the equipment exerts so much stress on the distribution grid, which were initially installed to serve residential areas. In this kind of system, it is difficult to allocate energy for the two sectors in a way to maximally satisfy everybody. It is also difficult for utilities to do load shifting. Proper planning of cities is imperative so that residential and industrial areas are separated.

Setting appliances on standby mode: Many people do not know that electrical equipment consumes energy on standby mode. Putting an appliance on standby mode is not the same thing as putting it off. Although the energy they consume is not the same as when they are switched on but putting them off when not in use can save some energy. Consumers should be appropriately informed by the manufacturers of electrical equipment that this equipment still consumes energy when placed on standby mode. A good way to do this is to inscribe it on the label or name plate of the equipment. The Standard Organization of Nigeria should ensure that energy labels are comprehensive enough to provide adequate information to consumers.

Simultaneous use of multiple appliances in public buildings: This is a common practice among public officers in Nigeria, especially the senior staff of an organization. Public officers do not pay individually for electricity and as a result they are not conscious of the way they use energy. The study revealed that many government buildings are not metered; thus, government officers are not accountable to the energy they use during office hours. Occupants of university hostels use all kinds of electrical equipment and they do not have restriction on the kind of equipment they can use in these buildings. It is a common practice for students to use all kinds of electrical heating equipment for cooking in their hostels. Individual rooms in student hostels are not metered; this encourages wastage as they are not held accountable for the energy they consume.

Leaving appliance on when not in use: The study revealed that many Nigerians do not put off their appliances when they are not in use. This practice can lead to significant wastage of energy in residential, private and public buildings. The reason for this could be that many Nigerians do not really pay for the electricity they consume. In many houses, the meters installed by the electricity distribution companies (DisCos) are no longer functioning. The DisCos officials then place these houses on estimated billing. This practice encourages the wastage of electricity, since they do not really account for what they consume. When people are placed on estimated billing, they are either overcharged or undercharged. One of the respondents in the study testified that before they were given the new prepaid meter, the DisCos in charge of their area was charging them over N2500 per month, but when the new meter was installed, they spent about N400 per month. This is a case of overcharging. Again, with estimated billing during protracted power outage, people still pay for what they do not consume.

Purchase of secondhand appliances: The Nigerian market is flooded with all kinds of secondhand appliances. Many Nigerian use one secondhand product or the other. They are cheaper to buy compared to the new ones. Stakeholders are on the opinion that secondhand products are more durable than the new ones. This assertion could be due to the presence of substandard goods in the market and the secondhand goods tend to last longer than them. Many of the secondhand products come from European, Asia and North American countries[85] and they may have been manufactured long time ago. The efficiency of these products is quite doubtful, and the possibility exists that they may have been rejected by the former users to purchase more recent and efficient appliances.

Factors Influencing Consumers Choice of Appliances

There are several factors that consumers consider when purchasing electrical equipment. An understanding of these factors could help to shape policy that will encourage people to buy energy efficient appliances. Consumer behavior has been described as the practice used when individuals, groups, or organizations select, use, or dispose of the product, service, ideas or experience to fulfil their needs and requirements[86]. Several studies have been conducted to understand customer behavior and identify the major factors influencing their buying decision. Most of these studies examined consumer behavior in association with demographic and socio-economic characteristics[87].

In a study that was conducted in 2014 to determine factors which influence consumers' purchasing decisions of private label food products, it was found that consumers buy products based on their lower prices compared to other similar brands[88]. From the same study, it was discovered that most of the consumers buy the products they think the quality is good. In another study conducted in 2015 to understand female's purchasing behavior and to know the role of female in purchase decision making process, it was revealed that 71% of the respondent's considered quality as their most inducing factor in their buying decision[89]. In the same study, it was also found that 10% of the respondents considered convenience as their inducing factor in their buying decision, 7% considered brand, 6% focuses on services, and 4% are influenced by the cost.

In Nigeria, a similar study was conducted to identify factors people consider before buying electrical appliances. All the respondents were drawn from the urban areas, the reason being that these places have access to electricity. The study was conducted in three major cities in Nigeria – Lagos, Benin City and the Federal Capital Territory, Abuja. A total of 150 respondents were randomly selected in these cities and interviewed. The study shows that respondents consider the following factors when purchasing appliances[90].

Beauty of the appliances: A total of 35% (Table 10.1) of the respondents stated that they look out for the beauty of the appliances when purchasing them. The most beautiful equipment may not be the most efficient in terms of energy consumption. Equipment that is beautiful and very attractive to the eye may also be very expensive compared to the one that is less attractive. A better understanding of this factors and how it relates to consumers behavior is important in the crusade to change consumer's behavior towards imbibing energy efficient culture.

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Table 10.1: Factors influencing consumer's choice of appliances.

Factors	Beauty	Manufacturer	size	Energy Rating	Price	Others
% of respondents	35%	68%	16%	47%	51%	17%

Price of the appliance: Price is a very strong economic factor influencing the demand for goods and services. Many respondents, 51% agreed that they consider the price of an appliance before they purchase one. This will be a very good tool to influence the behavior of consumers to purchase more efficient appliances. When the prices of less efficient appliances are low compared to the more efficient ones, government can come up with fiscal policy and instrument that will encourage people to go for the more efficient ones. From the study, price is the second most inducing factor considered when people purchase electrical appliances.

Size of the appliances: Only a few of the respondents consider the size of the appliances before making purchases; 16% of the respondents claimed that they consider the size of an appliance. Our findings revealed that the size does not necessarily mean that it consumes more energy. Consumers should be enlightened to know this fact.

The product/manufacturer's name: From the survey, 68% of the respondents purchase their appliances putting into consideration the manufacturer of these appliances. This is another very strong factor influencing consumer's choice of appliances. Many consumers believed that the products of certain manufacturers are more durable than others. Irrespective of the price of these appliances, the consumers go for these products thinking that it will last longer and are of better quality. This assumption may not always be correct.

The amount of energy an appliance consumes: A total of 47% of the respondents stated that they take this factor into consideration. As stated earlier, 71% of our respondents do not know how to access this information. Consumers should be enlightened on how to access this information. Manufacturers of electrical appliances should devise ways of making this information more vivid for consumers to access.

Durability: Some of the respondents claimed that they also look at the durability of any appliance before buying it. This is also linked to the product name or manufacturer. It is however unclear how they can precisely determine the durability of any product at the time of purchase.

The need for the appliance: Some of our respondents make their choice based on how important the appliance is to them.

Efficiency of the appliance: Some others consider the efficiency of the appliance before they purchase one. In Nigeria, the government is yet to develop minimum energy performance standards (MEPS) for most appliances. Again, the Standard Organization of Nigeria should be properly equipped to define energy efficiency standards for electrical equipment.

Maintenance cost/ease of repair: Many people would want to buy appliance that are serviceable and less expensive to maintain.

Consumer Rating: Some people are influenced by the general perception about an appliance. They believe that the more people accept a product, the better the product. This is another factor that influences consumers' choice of appliances.

Quality of the appliance: Some of the respondents said they consider the quality of appliances. Again, it is unclear how they can determine this at the time of purchase.

Performance output: Some respondents said they consider the output of the product before they purchase. Again, they also consider the number of functions the product is able to display.

Provision of Warranty: Provision of warranty is another factor that consumers put into consideration when they are purchasing appliances.

Appendix 1: Luminous efficacy comparison for CFLs

Table 1 – Efficacy Comparison of CFLS

Configuration	Lamp Power (watt)	Minimum efficacy (Lumen/W) based upon initial Lumen data
Bare Lamp	< 15 ≥ 15	≥ 45 ≥ 60
Covered reflector	< 15 15 ≤ LP < 19 19 ≤ LP < 25 LP ≥ 25	≥ 40 ≥ 48 ≥ 50 ≥ 55
With reflector	< 20 > 20	≥ 33 ≥ 40

1. Take the performance and electrical requirements at the end of the 100-hour ageing period. The lamp efficacy shall be the average of the lesser of the lumens per watt measured in the base up and or/ other specified positions. Use wattage placed on packaging to select proper specification efficacy in this table, not measured wattages. Labeled wattages are for reference only.
2. Efficacy is based on measured values for lumens and wattages from the pertinent test data. Wattages and lumens placed on packages may not be used in the calculation and are not governed by this specification.

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About the Author

Etiosa Uyigue has been in the forefront of promoting sustainable energy in Nigeria and across the West African Region since the year 2006. He led and supervised the Team that organized the National Dialogue in Nigeria in 2008 with the objective to integrate energy efficiency policy into Nigeria policy framework. In 2009, he supervised the first energy efficiency survey in Nigeria; the survey was conducted to provide guidance for developing policy and legislations to promote energy efficiency. Severally, he had supported the United Nations Development Programme (UNDP) Nigeria Country Office in developing the project documents of Global Environment Facility (GEF) funded energy-related projects. Between 2011 and 2015, he served as the National Programme Coordinator in the UNDP Nigeria Country Office to implement a GEF-funded Energy Efficiency Programme. Furthermore, between 2015 and 2017, he served as a Consultant with a French company - Alternatives pour l'énergie, les énergies renouvelables et l'environnement (AERE) to develop the minimum energy performance standards (MEPS) for air conditioners in Nigeria under the Nigeria Energy Support Programme (NESP) implemented by the GIZ and the European Union.

At the regional level, he served as the Institutional Advisor for CLASP to implement a project aimed at supporting the implementation of energy efficiency policy for cooling appliances in the ECOWAS Region funded by the Kigali Cooling Efficiency Programme (K-CEP). He also coordinated the drafting of a policy document on strategies to scale up renewable energy market in Africa which was presented for distribution during the International Conference on Renewable Energy in Africa in Dakar in April 2008. He also supported the UNDP Nigeria Country Office to draft the Nigeria National Cooling Action Plan. He currently served as the Executive Director of the Community Research and Development Centre. He lives in Abuja, the Federal Capital Territory of Nigeria with his family.

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