Energy Efficiency for a Sustainable Built Environment in Nigeria

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ABSTRACT

Nigeria is a fast growing economy but suffers from serious setbacks due to lack of power supply and the widespread use of ecologically and economically questionable private diesel and petrol generators accounting for over 50% of the active generation capacity. In 2013, the Nigerian Energy Support Programme (NESP) was set up to address and improve this situation. The Programme is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in cooperation with Nigerian partner institutions, and funded by the European Union and the German Government. It aims at improving the conditions for the application of and investments in renewable energy and energy efficiency as well as the promotion of rural electrification. Part of the Programme's activities is on energy efficiency in buildings, to ensure that electricity is saved through concrete measures like contributions to shaping the framework conditions and the implementation of pilot projects as a promotion and awareness creation mechanism.

This conference contribution reports on the approach and on the achievements accomplished so far in the building area. Key to success in developing framework conditions and related procedures is a participatory approach to ensure acceptance and feasibility, the focus on achieving actual energy savings, and the creation of an enabling environment for implementation and roll-out.

Keywords: *affordable housing, energy saving, building code*

1. INTRODUCTION

1.1 Content of this contribution

This contribution presents the Nigerian Energy Efficiency Support Programme (NESP), and specifically the activities and results achieved so far in the building area. It presents the general objectives of NESP, and continues with the activities in the building sector. Chapter 2 starts with describing the status on the ground, to better understand the setup of the programme presented in chapter 3.

Chapter 4 shows a key result, namely the Nigerian Building Energy Efficiency Guideline (BEEG), and chapter 5 continues with the Nigerian Building Energy Efficiency Code currently under development. The contribution concludes with a short outlook.

1.2 Objectives of the Nigerian Energy Support Programme

The overall objective of the Nigerian Energy Support Programme (NESP) is to improve the framework conditions for the application and investment in renewable energy, energy efficiency, and rural electrification. Specifically, it is the objective to ensure that concrete energy efficiency measures generate energy savings and contribute to reducing the load on the electricity grid. In Nigeria, the residential sector accounts for about 78% of the final energy consumption and consumes around 58% of the total electricity consumption. This situation compounded with the over 17 million units housing deficit in Nigeria certainly explains the urgent need for interventions to improve the conditions in the following areas (GIZ NESP, 2015 and GIZ NESP, 2014):

Policy: As the policy framework was not existing, NESP supported in developing an energy efficiency policy with an energy efficiency action plan as the implementation mechanism. The policy outlines target activities such as developing building energy codes and guidelines.

Standards: Standards on energy efficiency in buildings do not yet exist as the building code in Nigeria only addresses structural strength and fire safety. It is the intention of Nigeria's Government to integrate energy efficiency standards into the already existing building code in order to reduce building energy consumption.

Awareness Creation: Awareness creation could lead to more interest on energy efficiency issues, hence NESP focuses on implementing pilot projects on energy efficiency measures that demonstrate the technical and economic feasibility of energy efficiency, while also implementing public campaigns targeting specific stakeholders to increase knowledge on the benefits of energy efficiency.

Training: Knowledge on energy efficiency in buildings is lacking as many experts are not qualified in the area of energy efficiency concepts and technologies. NESP has developed curricula and handbooks on energy efficiency in building design, energy audit, and energy management. NESP is supporting training institutions with these curricula and handbooks and would train them as trainers in the sector.

2. STATUS ON THE GROUND: OVERVIEW OF THE NIGERIAN BUILDING SECTOR

2.1 Building legislation

The current building code dates from 2006 and does not address energy efficiency and renewable energy use. It is a set of rules to be implemented and enforced by regional governments, currently mainly referring to the structural system, general safety, and fire safety.

While in rural areas legislation is practically non-existent, in urban areas, the building codes and building permit procedures are relevant, except small buildings defined by building area or by building volume. However, building laws are not sufficiently respected, and there is lack of enforcement. People have disregarded the existing code, and often the control that should come from the responsible ministries is very ineffective because of corruption.

The causes of non-compliance with the legal framework are essentially related to:

- The lack of staff for the monitoring of construction sites;
- The lack of sanctions in proven cases of violation of the regulations constituting bad examples which impact on the decision for new constructions;
- The lack of information and communication on the one hand, the lack of good practices in terms of housing on the other hand, also regarding the laws regulating the materials and methods of construction in the built environment;
- The poverty of households;
- The corrupt practices.

The advert effect has been frequent collapse of buildings, water leakages, and abuse of set-back lines. However, there is awareness of this problem, and awareness of the need for improvement regarding compliance and control, and enforcement.

2.2 Energy utilisation in Nigeria's building sector

Availability of data for policy making is a prerequisite, and efforts for data gathering must follow a coordinated approach, meaning that data gathering must be institutionalised in responsible agencies. The National Bureau of Statistics mission is to generate, on a continuous and sustainable basis, socio-economic statistics on all facets of development in Nigeria. However, data on building energy consumption is not yet readily available (National Bureau of Statistics, n.d.).

With a population of over 170 million, Nigeria is the most populous country in Africa and the eighth most populous country in the world. According to the United Nations, one in six Africans is Nigerian. The population growth rate is projected to be between 2.5 and 2.7% per annum in the next 20 years. The population of Nigeria is therefore forecast to potentially grow to 310 million by 2035 (GIZ NESP, 2015). The present Government has committed to construct 17,760 houses annually as a short term plan to meet the over 17 million units housing deficit. With the population growth and the increased access to technology it is expected that building energy consumption will continue to increase. This stresses the importance of implementing energy efficiency measures in the building sector and particularly in the residential sector. In the residential sector, tenement, compound, bungalows, and block of flat housing types are the dominant housing options available to households in Nigeria. Also, the majority of rental and ownership households are concentrated in buildings considered old fashioned, while only a small number of ownership households occupy block of flat buildings accompanied with modern facilities and services commonly found in high-income neighbourhoods of Lagos, Abuja, and Port Harcourt.

Most buildings occupied by the higher proportion of households in Nigeria are considered to be over aged and some are in need of renovation and timely maintenance. Governments have low impact on housing provision in Nigeria as the majority of buildings are owned by individuals, family, cooperative groups and societies, as well as multinational real estate companies.

Regarding electricity supply, Nigeria depends on thermal and hydro power plants for its energy production. According to Nigeria Electricity Regulatory Commission (NERC) statistics, 80% of actual generation capacity in 2015 comes from gas based power plants, while the remaining electricity comes from hydro power plants (GIZ NESP, 2015). However, Nigeria's peak energy generation amounts only to a maximum of about 5,000MW with a peak demand forecast of almost 13,000MW and 10,000MW off peak, meaning that the electricity supply of about 60 million Nigerian relies on private diesel and petrol generators (Federal Ministry of Power, n.d. and GIZ NESP, 2014).

Regarding energy consumption, around 85% of Nigeria's consumed energy comes from biofuels and waste. Almost 90% of that energy is consumed for residential usage. Similarly, based on data from the International Energy Agency, residential usage accounts for about 58% of the final electricity consumption in Nigeria. Likewise, it is the residential sector (households) where the increase over the ten-year period is evident (GIZ NESP, 2015).

3. SETTING UP THE ENERGY EFFICIENCY IN BUILDINGS COMPONENT OF NESP

3.1 Basic requirements

Wide application of energy efficiency requires a policy framework and legislation imposing energy efficiency minimum requirements. However, requirements will only be respected when controlled and enforced, and efforts for control and enforcement will be only feasible if there is societal support for the legal obligation. Societal support will emerge from understanding the challenges in the electricity sector and energy efficiency legislation as a means of problem solving. Thus, case studies are important to demonstrate technical and economic feasibility, and trainings are essential to further qualify those active in the construction and real estate business as well as civil servants concerned with checking, control and enforcement. Energy efficiency for a sustainable built environment in Nigeria is achievable by engaging the right stakeholders in all activities to ensure buy-in of energy efficiency concepts.

3.2 Modules of the energy efficiency in buildings component of NESP

The energy efficiency in buildings component in NESP is based on three pillars:

- Stakeholder involvement and awareness creation to generate societal support for the new framework conditions and legal requirements to come.
- The development of standards such as an energy building code regulating energy efficiency in the building sector.
- Implementation of pilot projects to demonstrate feasibility of complying with the new requirements.

An essential element of the first pillar is the Building Energy Efficiency Guideline (BEEG). It provides useful information to professionals in the building sector on key factors to consider when implementing energy efficiency measures in Nigerian buildings. BEEG was launched in June 2016 by the Federal Ministry of Power, Works and Housing with the support of NESP and the EU. More information is provided in chapter 4.

The Building Energy Efficiency Code (BEEC) mentioned above is an essential element of the second pillar and is currently under development. It is developed in cooperation with the Federal Ministry of Power, Works and Housing and Department of Development Control (AMMC) Federal Capital Territory Administration Abuja, as the Federal Code is adopted and implemented on states level. Implementation in Department of Development Control (AMMC) Federal Capital Territory Administration Abuja will be voluntary at first, in order to gain experience and improve procedures prior to imposing legal obligations. More information is provided in chapter 5.

Pilot projects demonstrate feasibility of complying with the new requirements and create material for dissemination to various stakeholder groups. Currently, the following pilot projects are being carried out:

- A Solar Water Heater (SWH) pilot project is being implemented with the aim of demonstrating the technical and economic feasibility of solar water heating technologies. By end of 2016, the SWH systems (68 units and 212 m^2 module area) of thermosiphon flat plate collectors will be installed at a boarding secondary school in Jos (Plateau State) to cater for the bathing needs of 1,000 students. The objective of the pilot project is to increase the use of solar water heaters in boarding schools in Nigeria, and to educate students on solar energy utilisation.
- In 2016, an Energy Audit of the Federal Ministry of Power, Works and Housing building was conducted. Based on the building energy use analysis and the audit results, it was observed that there is much room for improving energy efficiency. Recommendations for energy management in the building include low cost, medium cost and high cost energy efficiency measures. The objective of the pilot project is to increase awareness on energy management and the related benefits in public buildings and to provide a template for carrying out similar energy audits in other public buildings.

4. BEEG: BUILDING ENERGY EFFICIENCY GUIDELINE

The first Nigerian Building Energy Efficiency Guideline (FMPWH-NESP, 2016) includes a general introduction of energy efficiency in buildings at the beginning. Then it divides technically into two parts, namely active and passive elements of energy efficient building, and presents a design guideline how to proceed in building design to achieve an energy efficient building in Nigeria.

The Guideline also includes a description and assessment of building energy simulation and calculation tools as well as whole building design tools and sustainability certification models used globally. The regulatory framework necessary for the implementation of building energy efficiency in Nigeria is presented, and regional hazard to consider when designing buildings in Nigeria is discussed.

The Guideline concluded most importantly with case studies on building typologies, in order to assess and quantify the status quo of calculated energy demand and the impact of specific energy efficiency measures, showing how to improve on future building energy efficiency standards. The building typologies and climate conditions analysed in the case studies have been defined together with Nigerian architects and builders. Because of the lack of data it was not possible to follow a bottom-up approach but it was necessary to apply a model approach based on experts' knowledge. The following building types were analysed: residential buildings (bungalow and apartment) and office buildings (small and large). Two climatic zones have been tested for the building typologies, namely hot and humid climate and hot and dry climate. Although Nigeria has 6 geopolitical zones and 4 climate zones according to Köppen climate classification, the Guideline distinguishes only roughly between the two climates mentioned above. Simplifications were also necessary due to budgetary reasons. In order to define the impact of energy efficiency measures on each building type, a Building As Usual (BAU) scenario was defined for each typology. The BAU represents the usual construction practice in Nigeria and was derived mainly from responses to questionnaires circulated to construction professionals in Nigeria including local knowledge. Three variants on the BAU were modelled with incremental energy efficiency improvements following the concept of energy efficiency hierarchy: to reduce energy demand by passive measures, and to supply remaining energy demand by energy efficient active technologies.

The defined variants for the guideline are:

- Variant 1: Reducing energy demand by simple implementable measures, e.g. improving orientation, optimising window sizes.
- Variant 2: Variant 1 with additional measures, e.g. insulated walls, double glazing.
- Variant 3: Variant 1 and 2 with additional measures such as PV installation to generate electricity.

The simulation tool used for the analysis was DesignBuilder version 3, a whole building dynamic energy simulation tool using the software energy plus for calculating annual energy consumption of building designs. It also has the capacity of analysing both passive and active energy efficiency measures. The main outputs presented in the Guideline are annual energy consumption, annual energy cost, CO_2 emissions reduction, and hours of thermal comfort.

The Guideline promotes the objective of bioclimatic design strategies for Nigeria, in order to minimise heat gains and to promote heat loss by means of building orientation facing mainly north and south with overhangs or external shading. These are the most cost effective measures as they require no or low additional investment cost which is of paramount importance for societal support and wide spread application of energy efficiency in building.

5. BEEC - BUILDING ENERGY EFFICIENCY CODE

The starting point for developing the Nigerian Energy Efficiency Building Code (BEEC) was the analysis of existing energy efficiency building codes implemented in countries on all continents and evaluation studies if available.

Among others, the European Concerted Action on the Energy Performance of Buildings Directive (EPBD) and the EU-funded QUALICHeCK project provided important insight and ideas for discussing the specification for the development of the BEEC with Nigerian Stakeholders (EPBD-CA, 2016 and QUALICHeCK, 2016).

Usually, building energy codes consist of the following elements:

- Scope of the energy building code
- Definition of cost optimum energy performance minimum requirements and calculation methods how to determine them
- Publication of the assessment result (e.g. Building Energy Declaration: DEC, Energy Performance Certificate: EPC, Building Energy Rating: BER)
- Qualification requirements for experts issuing EPCs, BERs or DECs
- Control system, penalties and enforcement

In Nigeria, the challenges for developing a building energy code are manifold:

- There is a lack of knowledge how to plan and construct energy efficient buildings.
- There is a lack of standardised and quality assured materials and products needed for energy efficient buildings.
- The energy building code should avoid increasing investment cost for mass housing, at least in the beginning (urgent need for affordable housing).
- There is a lack of data to determine the status quo of energy efficiency and thus difficulties in determining energy performance minimum requirements.
- Cost optimum levels are nearly impossible to define because of lack of transparency and problems with corruption.
- Input data for energy performance calculations are hardly available or difficult to access.
- Qualification of experts entitled to issue energy performance certificates is an enormous challenge.
- Another huge challenge is the qualification of civil servants entitled with checking whether the building design and the completed building complies with the energy regulation.
- The difficult economic situation of the country is another problematic aspect.

The high importance of affordable housing puts simple but effective no-cost measures to the fore, such as correct building orientation to avoid solar gains and facilitate heat losses, and choosing the correct arrangement of windows (bioclimatic building design), in order to reduce cooling demand.

This creates additional challenges, namely the need to coordinate the approach with urban planning procedures, and the need to agree on the use of calculation tools suitable for taking into account sun exposure of facades depending on orientation and other site-specific features such as natural shadowing.

All these difficulties explain why the code will be voluntary at first, and compliance with the code will be rewarded with incentives. Nevertheless, the code should be developed as a fully functional framework to be implemented on the level of pilot cases, in order to gain experience and create awareness on new necessary building requirements and how to achieve them. Voluntary systems precede mandatory systems to give stakeholders the chance to learn and adapt.

Because of the expected fast increasing electricity consumption and the limited generation capacity lagging far behind demand, energy efficiency requirements clearly refer to the completed building and not only to the building design. It is of paramount importance to increase energy efficiency in reality. It is also evident that the code will only be effective if regularly controlled. In this regard it is planned to entitle civil servants involved in checking building documents and completed buildings and issuing building permits and permits of use to also check whether energy efficiency minimum requirements are met. In Nigeria, the responsible public authority is called Development Control. Collaboration with the Department of Development Control (AMMC) Federal Capital Territory Administration Abuja will be crucial for developing a solution effective in the Nigerian environment. Integrating energy efficiency compliance checks in the daily routine of Development Control will require a substantial training effort.

6. CONCLUSION AND OUTLOOK

Implementation of building energy efficiency codes is essential for improving energy efficiency in the building sector. In 2013, interviews were carried out during the SEEA-WA project in most ECOWAS countries to investigate the status quo regarding energy efficiency building codes and to collect information about the most important barriers for developing and implementing such codes. The results showed that the major problem is not only the lack of legislation but the fact that laws are transferred from abroad, usually from Europe or from America, and are not sufficiently adapted to the needs of the respective country (ECREEE, n.d.).

Thus, BEEC development builds upon the prevailing conditions, and strongly considers local resources and skills available in Nigeria. Energy efficiency for a sustainable built environment is achievable by engaging the right stakeholders to ensure buy-in of energy efficiency concepts. In addition to building related requirements and frameworks conditions to encourage the uptake of energy efficiency measures, monitoring and enforcement procedures must be put in place.

It is important to plan monitoring and control procedures right from the beginning, in order to ensure that verification procedures proving that energy minimum requirements are met can be carried out with justifiable effort. These procedures serve to ensure quality, and if necessary to enforce compliance, in order to create an impact and actually increase energy efficiency.

Because of the enormous housing demand, financing options and the implication of the energy efficiency code to be developed have to be borne in mind. On the one hand, affordable housing for the middle-income class is a key issue for achieving development goals, and specification of minimum energy efficiency requirements has to respect this prerequisite. It must be considered that the projected time horizon for payback from energy efficiency measures is short, due to the rather insecure political environment. On the other hand, energy efficiency minimum requirements must be sufficiently ambitious to qualify buildings compliant with the code for financing with new financing instruments such as climate bonds (Climate Bonds Initiative, n.d.).

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