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Developing a Building Energy Efficiency Assessment Tool for Office Buildings in Ghana: Delphic Consultation Approach

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Abstract

In Ghana, the inability to solve peak demand constraints by finding a balance between reducing demand and increasing supply has resulted in power rationing coupled with erratic electricity supply. Various studies have reported the enormous influence energy assessment tools, contribute to solving building energy demand. However, no building energy standards are in place in Ghana and this is aggravated by lack of data for building energy consumption. As a first step towards developing a building energy efficiency assessment tool this paper aims to identify applicable energy efficient building assessment categories and criteria for the Ghanaian Built environment. As building assessment methods involve multi-dimensional criteria, a consensus based approach is used to conduct the research. Hence, the Delphi technique is selected and conducted in two successive consultation rounds involving professionals and highly informed local experts from academia, government and industry in the domain of building energy assessment methods. The results reveal that international assessment methods are not fully applicable to the Ghana built environment, as reflected in the identification of new energy efficient building assessment criteria. The research is focused in Ghana and similar developing countries grappling with building energy problems. It is expected that findings from the study will provide further directions towards the full development of building energy assessment tool in such regions.

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Keywords: Building Energy Demand; Ghana; Energy Assessment Tool; Delphi Technique

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1. Introduction

Recent economic development has propelled increase in building energy consumption in most developing countries, African countries not being excluded. Hui [1] averred that, developing countries are experiencing an increase in construction of buildings however, the uptake of efficient technologies are low due to the energy prices and market. In Ghana, it is projected that consumption of electricity is increasing by 10% per annum due to the surging population's demand for energy [2]. One major challenge and critical developmental goal of most growing economies is the need to increase the energy capacity to meet its rising energy consumption base.

Ghana's population over the years has been on the increase with strides in economic growth; however, the same cannot be said of the energy situation [2]. Statistics show that marginal increase has been seen in energy supply as compared to the burgeoning population growth [2]. Currently it is estimated that 55% of Ghana's capacity to generate electricity is presently attributed to hydro-based sources; Akosombo (1,020 MW), Kpong (160 MW) and Bui (400MW) [3]. The remaining percentage of the energy supply is derived from thermal based plants in which the operation is based on using fuel sources such as natural gas and oil and converts energy stored in them into electrical energy [3]. At present the renewable source contributed to the national grid from a solar farm provides only 2.5 MW to the total supply [3]. Electricity consumption in Ghana can be broken down into four main sectors; residential, non-residential, industrial and street lighting. As at 2015, the bulk of the energy was consumed by the industrial sector with the second highest consumer sector being the residential sector. Over the decade the non-residential energy demand has increased by over 100% [3]. In Ghana, electrical energy in residential and non-residential buildings is largely used for air-conditioning due to the warm humid climate. Electrical appliances and lighting also consumes the electricity used in this sector

Rising energy consumption has had severe environmental impacts including increasing energy demand, global warming, air pollution and acid rain [4]. In Ghana, power rationing coupled with erratic electricity supply has ensued due to the inability to find a balance between reducing demand and increasing supply [5]. The increasing demand for energy is among other factors, caused by the numerous newly constructed air-conditioned commercial buildings, especially in the metropolitan areas of Accra and Kumasi. The incessant blackouts and lack of reliable energy supply has had a negative effect on the economy resulting in job cuts and lower productivity [6]. In most developed countries, there is the usage of building energy standards to curb some of these impacts. Energy regulation is one of the most frequently used instruments for energy efficiency improvements in buildings [7]. However, Iwaro and Mwasha [8] unearthed in their study that more than 40% of emerging markets do not have an energy standard in place, 20% have mandatory, 22% have mixed and 16% proposed. As identified by Iwaro and Mwasha [8] in the year 2010, Ghana is amongst developing countries lacking building energy assessment tool and as at present this is still absent. The aim of this paper is to identify applicable energy efficient building assessment categories and criteria for the Ghanaian Built environment and narrows down to office buildings situated in this region. The research is focused in Ghana and similar developing countries grappling with building energy problems. As building assessment methods involve multi-dimensional criteria, a consensus based approach is used to conduct the research.

2. Related works and conceptual model development

Cole [9] posited that the use of environmental criteria outside the regions it was originally designed for is scientifically wrong. He argues that building categories and criteria should be tailored and prioritised to reflect the peculiar regional conditions. Over the years, international systems have been modified in various ways for their uptake in various regions. Yet, extant literature show that studies have been done to adapt building assessment criteria to meet local conditions. Chang et al. [10] conducted a study to adapt SBTool in Taiwan. Utilizing the Analytical Hierarchy Process (AHP), the aim was to prioritise the regional and environmental dimensions to suit Taiwan local conditions. In Hong Kong, Lee and Burnett [11] customised the SBTool using a survey and an in-depth interview to fit the regional context. Alyami et al. [12] also looked at the development of an environmental assessment tool for the Saudi Arabian region. One overarching hypothesis from their study was that leading methods are not fully applicable for a particular region. This lends notion to what Cole posited [9]. Currently in Ghana, no building energy standards is in place [13]. Lack of data for building energy consumption also remains a significant drawback for extracting general conclusions on the energy performance of the building stock [14, 15]. How can one tell whether a building in