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Identifying and weighting indicators of building energy efficiency assessment in Ghana

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Abstract

Ghana a sub-Saharan country has seen relative improvements in some aspects of the economy howbeit the energy supply deficit within the region is a burgeoning problem. In most emerging markets, the building sector is among the sectors increasing most rapidly; and has seen the uptake of building energy efficiency assessment worldwide. In this study a weighting system is developed to form the basis of building energy efficiency assessment tool for Ghana. In achieving this a Delphi-Analytic Hierarchy Process (AHP) framework is presented to analyse building energy indicators. The framework consists of three main steps. Firstly, the identification of various indicators. Secondly the Delphi method is applied and an indicator list of 21 is determined. In the third step, an analytical hierarchy process model has been conducted and the expert Delphi method has been used to obtain weighted list of these identified indicators from professionals and highly informed local experts from government, academic and industry. Results from the AHP revealed that "building design" and "energy efficiency of building facilities" are of top priority to the Ghanaian built environment. It is argued that the development of the weighting system brings about a new appreciation of climate influence on the built environment and its corresponding effect on building energy efficiency measurement. The customized weighting system does not eliminate the socio-economic environment of the region in question but provides the recognition of variables necessary for effective measurement of building energy efficiency.

Keywords: Energy Efficiency; Building Energy; Delphi-AHP; Ghana

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1. Introduction

Ghana's economic growth has seen relative improvements in certain sectors through it relatively peaceful co-existence and stable democratic rule. Despite hopeful developments within the sub-Saharan African country, there are still several structural challenges faced. One critical challenge is the energy supply within the country. Ackah et al. [1] averred that economic development across the globe is linked to the availability of energy and also its reliability. In recent years, the country has been plagued with energy supply deficits which has resulted in power rationing [1]. This has come with its antecedent effects including job cuts and lower productivity [2]. Across the globe, solving such issues have seen the uptake and use of building energy efficiency standards. The energy consumed in a building or within a building system such as an air conditioning or heating can be addressed using energy regulation [3]. Frequently used for ensuring energy efficiency in most buildings is the building energy standard or energy regulation [4]. Studies however, show that the uptake of these building energy standard is quite low in developing countries and with some still not having any standard in place [5;6]. The limited information about developing countries reflect an information gap surrounding the development, use and effectiveness of building energy regulations for building energy conservation. In Ghana, currently there are no building energy standards [6]. This situation is exacerbated by paucity of data on building energy consumption profiles and represents a significant hurdle in the analysis of energy performance of Ghanaian building stocks [7,8]. Despite efforts made in the demand side management of energy including the introduction of an appliance rating system, the lack of building energy standard represents a significant drawback in building energy efficiency.

Globally, a plethora of building evaluation procedures and building environmental implements are in usage whilst others are being developed. Notable amongst them is the Leadership in Energy and Environmental Design, LEED and the British Research Establishment Environmental Assessment Method (BREEAM). The orientation of these tools and others like these is titled towards the assessment of buildings and its impact from the perspective of their sustainability demands [9]. Reports also confirm that energy use reduction only, is not essentially the priority when exploring a sustainable energy building [10]. This brings to question their ability to provide appropriate assessment of building energy for other countries especially exploring both socio-economic and ecological factors. It therefore, becomes imperative to prioritize the sustainable needs of a region when developing a building energy efficiency tool. This study builds upon a previous study that developed appropriate criteria and categories for the Ghanaian milieu [11]. In this study, the primary aim has been to answer two main questions; firstly, what are the relevant building energy efficiency indicators for the Ghanaian environment and secondly what weights should be attached to these indicators. To answer these questions, the study adopts the use of a Delphi-AHP framework. Identifying building energy indicators is imperative and plays a pivotal role in the development of an energy efficiency assessment method.

2.0 Research approach adopted
2.1 Use of Delphi-AHP framework

As sustainable building assessment criteria are generally considered multi-dimensional criteria [10], scientific evidence suggests that a consensus-based approach is best suited to the development of comprehensive and effective building environmental assessment categories and criteria [12]. In this study, the Delphi-AHP framework is adopted. Prior usage of the Delphi method and AHP to resolve complicated challenges underlines the probability of employing both methods as systematic management tools to deal with innovation planning in public R&D comprising complicated missions like organizing internal R&D, financing external R&D projects and providing support for scientific communities. The concept of the Delphi method has been extensively employed in additional complicated decision resolving issues associated with technological modification, economic and social pressure like the assessment of the crucial factors relating to the new product enhancement, and choosing probable novelties for national system of innovation [13]. Though the Delphi method is a useful instrument for brainstorming and evaluating crucial factors, results from the Delphi may require additional research in managing moderate consensus among professionals. The AHP which was initially instituted by Saaty, can be the supplementary research for a Delphi study [14]. The AHP is an extensively used instrument in multi-criteria decision-making. The principle of the AHP is that a decision is broken down into a hierarchy structure to enhance decisions to be made more manageable and easier [14]. Additionally, the Delphi consultation may be implemented prior to the AHP to refine a set of factors. In this study a Delphi-AHP (DHP) based methodology is as well adopted to create a qualitative and quantitative measurement system, when choosing and prioritizing vital indicators for predicting building energy efficiency.