COST OPTIMIZATION TECHNIQUES FOR SUSTAINABLE BUILDINGS: ANALYSIS BEYOND ENERGY PERFORMANCE CERTIFICATES

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The need for the UK to satisfy its legally binding commitment with the Kyoto Protocol to reduce greenhouse gas emissions to 12.5 per cent from 1990 levels by 2012 is approaching. The Energy Performance Buildings Directive (EPBD) of the European Commission of 2002 has a primary aim of establishing and applying energy certification programmes in order to guarantee reduction in energy consumption. A number of tools have been recently introduced or revised to satisfy the EPBD requirements including the introduction of Energy Performance Certificates (EPCs) in 2008. As a tool EPCs have been one of the tools being promoted through the construction industry and are available to clients, professionals as well as the public. Their main aim has been to facilitate informative decision making and the application of best practice of creating a more sustainable future. Even though there are a variety of tools that can be used to attest sustainability credentials, it has been noticed from a preliminary survey that an overarching tool would be required to streamline the anticipated whole life cycle cost appraisal and analysis, as opposed to over-concentrating on the selected methods of assessing probable energy performance of facilities. This research therefore investigates the whole life cycle approach to cost optimization that would consider energy certificates as a part of a more robust appraisal and analysis of development proposals. It concludes that while EPCs are essential, there is a risk of poor appraisal of key factors that could impinge on the overall delivery of facilities that meet the EU directive on Energy performance in buildings.

Keywords: energy performance certificates, sustainability, cost management, green building.

INTRODUCTION

The Royal Institution of Chartered Surveyors (2007) describe sustainability as a process that aims at “ensuring that our businesses, public services, natural resources, economy and community have the capacity to continue into the future”. Practically, there many ways of achieving sustainability in the built environment; however, energy supply, land contamination, resource efficiency and transport are some of the key issues driving sustainable agenda in modern times. Boyle (2005) explains that “although the complexity of sustainability is recognized it is not yet understood and that with respect to buildings, sustainability is still poorly defined”. To date attempts

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have been made to bridge the issues concerning buildings and sustainability through European directives such as the Energy Performance Buildings Directive (EPBD) and through international agreements such as the Kyoto Protocol, both of which are legislative drivers for sustainability (Cheshire, 2007a). The main aim of this research was "to investigate whether there has been an overarching sustainable decision making tool that could be used to support cost optimization for sustainable buildings". Even though there are a variety of tools that can be used to attest sustainability credentials, it has been noticed from a preliminary survey that an overarching tool would be required to streamline the anticipated whole life cycle cost appraisal and analysis, as opposed to over-concentrating on the selected methods of assessing probable energy performance of facilities.

RATIONALE FOR THE RESEARCH AND METHOD

Having observed the practical implementation of energy performance certificates (EPC's) taking shape in the industry it became important to assess the impact such certification would have in the construction process. Lack of information on decision making tools that can facilitate appraisal and analysis of sustainable buildings has been a compelling rationale for this research. The objectives for the research were twofold.

1. Explore how energy performance certificates would contribute to improving sustainability within the industry.
2. Identify the current tools and techniques available to aid sustainable decision making within the construction process.

A questionnaire survey was used to gather primary data for the research. In total there were 37 responses from the 85 web based surveys issued; representing a response rate of 43.5%. Conclusions for the research have been based on the results from the survey.

THE ROLE OF ENERGY PERFORMANCE CERTIFICATES

In response to the Kyoto Protocol agreement the European Union began to make progress on energy efficiency within the construction sector. However, it was not until 2002 that the EPBD was formed by the European Union. According to Rey, *et al.* (2007) "*the directive was introduced primarily to establish and apply energy certification programmes in order to guarantee energy saving and reduce CO_2 emissions as a consequence of the EU commitment to comply with the Kyoto Protocol*". It specifically targeted buildings as a result due to recognizing that property was a major contributor to energy usage, therefore carbon emissions release (Watts, 2008). The objectives of the EPBD, with regards to energy performance of buildings are outlined by Rey *et al.* (2007). These are.

1. Establish a calculation method for the integrated energy performance of buildings.
2. Application of minimum requirements on the energy performance of new buildings.
3. Energy certification of buildings.
4. Energy audits in large buildings.
5. Regular inspection of boilers and air conditioning systems.

However, Watts (2008) contended that "there are significant areas that the directive does not consider such as construction of buildings, the distribution of materials and the disposal of waste". Part of the EPBD strategy was aimed at modifying the behaviours of people and companies through the introduction and use of Energy Performance Certificates, or EPC's (Watts, 2008). According to Watts (2008) "any investment decision to buy or occupy a particular building could be better informed with the introduction of these certificates which notifies potential clients or buyers about the energy performance of specific buildings". Priewasser (1999) discusses that varying human behaviour patterns also contribute to the ecological sustainability and environmental stresses that are already determined by certain factual or structural conditions of the construction industry. He argues that until recently, solving environmental problems primarily focused on improving ecological quality of products, processes and technologies, together with other sectors such as energy use, industry and tourism and the like. However, the changes of personal behaviour patterns and the decision making process of people also plays an important role in sustainability where decisions of some stakeholders in large and complex projects need to include environmental, sustainability and 'whole life' (infrastructure life-cycle) considerations (Kumaraswamy *et al.*, 2004). This means that the energy performance certificates, though important, form only part of the end products of the sustainable construction process.

THE NEED FOR COST OPTIMISATION TECHNIQUES

According to McGilligan *et al.* (2008) "article seven of the EPBD specifically demands that when buildings are constructed, sold or let, an energy performance certificate should be produced". The certificate indicates the amount of energy consumed with a standardized use of the building and includes cost-effective recommendations to suggest how the energy performance may be improved (ibid; Wang *et al.*, 2009). In view of the demand for energy performance certified constructed facilities, there has been a need for a paradigm shift in the appraisal and analysis of construction products prior to their development so that they can include, among other things, a holistic approach that assess sustainable factors, as early as possible within the life cycle of a product. The recommended key areas of cost optimization, as far as sustainability is concerned include, but not limited to.

1. Operational Energy: Measured in kWh per year (or CO2) per m2 of building, is the energy used for the day-to-day operation of the building or structure. Ways of reducing this energy include maximizing good day-lighting, controlling solar gain, value engineering internal heat gains and the use of passive engineering techniques such as thermal mass.
2. Embodied Energy: is the energy used in the creation of the materials utilized in the construction, and is measured in GJ (or CO2) per m2.
3. Transport Energy: Currently not covered in the EPBD (Watts, 2008), transport energy is measured in CO2 per m2 of construction which is the amount of energy used to deliver staff and materials to site.
4. Waste: Measured by m3 per m2 of construction covering the physical waste created and is another factor that EPBD currently does not take into consideration according to Watts (2008). Silva and Vithana (2008) believe that there are three principle categories construction waste can be divided into, these are labour, machinery and material waste.

WHOLE LIFE CYCLE COST SYSTEM TO OPTIMISE SUSTAINABILITY COSTS

Looking at some of the key areas for cost optimization for sustainability under the EPBD, it can be observed that their approach to cost optimization is disintegrated in nature, and lacks a holistic approach. A realist approach to optimize such costs could be, but not limited to whole life cost systems. Such tools would be useful to aid decision makers at any point of the construction process. Currently, discounted cash flow techniques, expressed through a whole life cycle cost (WLCC) mechanism, is a sure way of optimizing the costs for building products and their respective elements. The main challenge, however, is that of incorporating an ever increasing level of variables that have no historical data and are full of uncertainties that could be difficult to predict. For instance the level of future energy consumption and its pricing mechanism would depend on many factors that would difficult to model in a whole life cycle cost model.

Over the years, "the construction industry has got a good grasp with calculating prices for designing and constructing buildings in general but it has been known for a long time", according to Ashworth and Hogg, (2002), "that it is unsatisfactory to evaluate the costs of buildings on the basis of their initial costs alone; where some consideration must also be given to the costs-in-use necessary during the lifetime of the building" (ibid). Ashworth and Hogg (2002) describe whole life costing as: "an obvious idea, in that all costs arising from an investment decision are relevant to that decision". This can be backed by Rose (2009) who mentions that "the lifecycle costs of buildings dwarf the initial construction price and states that: the salaries of those occupying a commercial property, for example, are estimated to be around 90% of the total life cost of that building". While the whole life cycle cost optimization techniques are theoretically known, they are difficult to apply when appraising sustainability credentials of a building.

SUSTAINABLE DECISION MAKING SYSTEMS

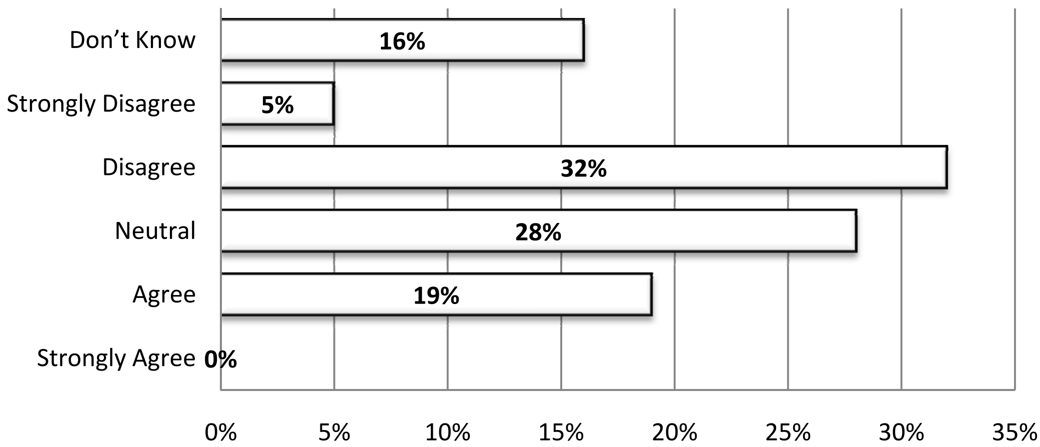
Sustainable decision making is described by Seager (2008) as a particularly challenging problem due to the complexities of both the industrial and ecological systems, together with the objectives of various stakeholders and the uncertainties that come with estimating the various risks, costs and benefits. He believes that understanding sustainability requires combining investigative methods and multiple perspectives to identify multidimensional concepts. Environmental multi-criterion decision analysis is a tool that acts as a single analytic-deliberative framework to allow the identification of conflicts or opportunities for compromise between different stakeholder groups. However, Seager (2008) believes that more research is required in an area called sustainable decision making, policy and design. Based on the difficulties of sustainable decision making tools, a survey was conducted to see if existing techniques such as cost planning, whole life cycle costing, and the like could be used in conjunction with other design based decision tools to create an overarching tool necessary for decision making processes.

ANALYSIS BEYOND ENERGY PERFORMANCE CERTIFICATES

There are many aspects of energy performance certification that were included in the survey. However, due to lack of space, they cannot be included herein. The most important question from the survey pertaining to this research was the "respondent perception of the adequacy of current decision making systems for sustainable construction" amongst which cost optimization is. From the survey, the following observations have been made.

1. Assessment of how energy performance certificates contribute to improving sustainability within the industry: Respondents were of the view that energy performance certificates have an impact in the immediate range, especially for facilities that have been refurbished to ensure that they meet the demands of the directive. Respondents were also of the view that using the current certification system developers can build a model that can be used from inception to ensure that emissions are well modelled, prior to the commencement of the construction processes.
2. Identify the current tools and techniques available to aid sustainable decision making within the construction process: Figure 1 summarizes the information obtained from respondents when they were asked to state their perception on whether the "the current tools available within the construction industry are adequate enough at aiding the decision making process with regards to addressing sustainability issues".

Figure 1: Respondent were asked about "the perception of the adequacy of current decision making tools for sustainable construction"



The information in Figure 1 points to the inadequacy of the existing tools for decision making. In fact, respondents were aware of the importance of the following tools and techniques. They recognize as most effective to sustainable decision making in construction are:

- Part L of the Building Regulations
- Code for Sustainable Homes
- BREEAM (Building Research Establishment Environmental Assessment Method)
- LEED (Leadership in Energy and Environmental Design)
- Whole life-cycle costing
- Site waste Management Plans
- Environmental Impact Assessments (EIA's)

CONCLUSION

Essentially, the main aim of this research was "to investigate whether there has been an overarching sustainable decision making tool that could be used to support cost optimization for sustainable buildings". Using the information from the survey, it can be concluded that there is no single tool available that could be used to optimize the costs for sustainable buildings. However, the respondents are aware of the available tools and techniques such as BREAM and whole life cycle costing that can facilitate decision making. While EPCs are essential, there is a risk of poor appraisal of key factors that could impinge on the overall delivery of facilities that meet the EU directive on Energy performance in buildings are left out at initial phases of the development; which would result in poor sustainable credentials of the constructed facilities. The challenge therefore is to develop a system that could gradually incorporate the complexities of sustainability during the appraisal and analysis of cost decisions within the construction process.

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