Abstract
The growing interest in and awareness of sustainable development in the last decade has been remarkable. The construction industry has taken the centre stage in driving sustainable development through sustainable construction due to its impacts in the society. It has been argued that 80% target reduction of greenhouse gas emissions in the United Kingdom (UK) by 2050 can be realised if the industry recognises the need for sustainable retrofitted building projects. It has been revealed that there is a possibility for substantial reduction of greenhouse gas emissions in the environment through sustainable retrofitted building projects. However, the challenges of delivering sustainable retrofitted building projects are enormous and complex in the industry particularly with key stakeholders’ lack of managing project knowledge in making informed and appropriate decisions. This can improve if the industry recognises the need of a knowledge system that will enable key stakeholders to make informed decisions in the delivery of sustainable retrofitted building projects. This paper presents a conceptual framework that would assist key stakeholders in managing project knowledge in making an informed decision towards delivering of sustainable retrofitted building projects. This was achieved through the review of literatures. The conceptual framework recognises the need to understand the social, economic and environmental issues and aspects of sustainability in delivering sustainable retrofitted building projects. It also considers certain decision components. The framework was formulated through critical literature review in consideration of some existing decision support frameworks.

Keywords: Sustainability, managing knowledge, climate change, key stakeholders, sustainable retrofitted building project, decision support.

1. Introduction
It is well documented that much research has been undertaken into sustainable development as it relates to sustainable construction and a number of decision tools have resulted (Poch et al., 2004, Du Plessis, 2007, Udeaja et al., 2008, Blackwood et al., 2014). However, this paper focuses on the application of making an informed decision for sustainable retrofitted building projects. The framework presented here was formulated through a critical review of relevant literature on decision support tools; sustainable development concepts; current practices in sustainable construction; the barriers and drivers of delivering sustainable retrofitted building projects; and aspects of managing project knowledge. The components of the conceptual framework these include: problem identification; identification and determination of objectives; knowledge maps; knowledge acquisition by key stakeholders; sustainability assessment; identification and comparison of alternatives; estimating of criteria weightings; evaluation of choice in making an informed decision, and finally, the means of measuring results. All of these components are designed to enhance stakeholders’ ability to make informed decisions.

These components will be further elaborated and described for clearer understanding of the decision process. The work reported in this paper is part of an on-going doctoral research study which aims to develop a decision support system prototype for delivering sustainable retrofitted building...
projects.

2. Theoretical Underpinnings

The evident consequences of global climate change have become widespread with significant increase in global temperature and extreme weather conditions (Stern, 2006, IPCC, 2007, Nelson et al., 2010, Stolarski et al., 2010). The United Kingdom (UK) government and other governments worldwide are taking actions to address climate change and remedy its adverse effects (Sayce et al., 2007, Pitt et al., 2009). This has led to the UK government’s ambitious target of 80 per cent reduction in greenhouse gas (GHG) emissions by 2050 (DCLG, 2008, Boardman, 2012).

The construction industry has been identified as one of the major contributors of greenhouse gas GHG emissions given that it consumes a large amount of energy (Low et al., 2014). Specifically, it has been documented that the building sector is responsible for 40 per cent of energy consumption and one-third of all GHG emissions worldwide (UNEP, 2009). In the UK it is estimated that buildings consume over 45% of UK energy and generate approximately 50% of GHG emissions (Stern, 2006, Boardman, 2007). These figures are evidence of how significantly building can impact on energy consumption and its substantial negative effects in our environment. The consequences of GHG emissions have made the demand for sustainable construction inevitable.

However, since an estimated 70% of buildings existing today in the UK will still be in use or standing by 2050 (Kapsalaki et al., 2012), it is clear that existing stock is a more important target than new buildings. It has been argued that sustainable construction particularly on building retrofits is one of the most effective ways or strategies to achieving sustainable development (Stafford et al., 2012, McManus et al., 2013) and that an effective approach to sustainable retrofitting building projects would contribute greatly to achieving the aforementioned ambitions to reduce GHG emissions. It is widely accepted that the need for sustainable retrofitted buildings particularly in the UK is essential (Ma et al., 2012, Booth and Choudhary, 2013, Owen et al., 2014, Dixon et al., 2014). It has been revealed that the retrofit market is not only large, but provides the perfect opportunity to improve the energy performance of the buildings (Boardman, 2012). Sustainable retrofitting building has been defined as an improvement made to an existing building that leads to an increase in the overall efficiency of that building (SMA, 2011, Fulton et al., 2012). BCA (2010) also defines sustainable retrofitting building as the ‘the provision, extension or substantial alteration of the building envelope and building services in an existing building in order to reduce CO₂ emissions’. The World Business Council for Sustainable Development revealed that embarking on such projects can contribute greatly to tackling climate change and fostering the concepts (economic, social and environment) of sustainability (WBCS, 2008). Additionally, delivering sustainable retrofitted building projects have been acknowledged to have tremendous economic, health, social and environmental benefits (Dong et al., 2005, Verbeeck and Hens, 2005, USEPA, 2010, Syal et al., 2014).

However, notwithstanding that the aforementioned benefits of delivering sustainable retrofitted building projects are well established and documented yet delivering the projects has faced a lot challenges and obstacles particularly with key stakeholders lack of managing project knowledge in making appropriate and informed decision (Duah et al., 2014). In fact, such decisions can have negative effects if not appropriately made due to their possible negative impacts on building performance and stakeholders’ satisfaction (British Retail Consortium, 2012, IEA, 2012). These existing challenges in the industry points to the fact that some form of ‘knowledge management’ (KM) would be hugely beneficial in attaining sustainable construction (Shellbourn et al., 2006, Shari and Soebarto, 2012) This is particularly so in the case of sustainable retrofitted building projects. The need to manage knowledge in delivering these projects is vital in order to have an improved understanding of key knowledge issues in the built environment and to improve on key stakeholders’ understanding of varied technologies in achieving sustainable construction (Yudelson, 2009). Eliufoo (2008) argued that sustainable buildings can be achieved if construction activities are informed by new resources of knowledge and expertise. The identification of the needs of key stakeholders’ can assist in making informed choices by providing answers to their questions, requirements and satisfaction (Newcombe, 2003, Olander and Landin, 2008, Yang et al., 2009, Macharis and Turcksin, 2012, De Brucker et al., 2013). Therefore, authors such as Duah et al. (2014) have emphasised the need for a well-managed project knowledge representation presented in a good format that could help key stakeholders in making appropriate decisions in delivering sustainable retrofit projects. According to Davoudpour et al. (2012) and Pan and Dainty (2012) it is essential to explore knowledge management principles to develop a decision support system to enhance key stakeholder’s decision capabilities in having the required knowledge to make informed decisions as it regard the issues surrounding retrofitted building.

3. Conceptual DSS Framework for Key Stakeholders

The previous section has highlighted need a systematic and effective evaluation tools founded on knowledge-based decision criteria, for the selection of sustainable technologies that would assist stakeholders in making informed sustainable decisions.

A number of authors, such as Reddy and Painully (2004); (Wang et al., 2009); Pan and Dainty (2012); Dangana and Pan (2013) argue that one of the main problems of achieving sustainable construction is due to the nature of the multifaceted decision-making tasks of choosing sustainable technologies from...
different range of options and aligning these with stakeholder needs. Factors like lack of skills, uncertainties, higher cost, risks, the conflicting interests of different professional disciplines, and the huge number of different technological options have complicated the decision making process for stakeholders (Reddy and Painully, 2004, Dainty and Ison, 2005, Wang et al., 2009, Buchholz et al., 2012). These factors have tended to influence stakeholders towards tried and tested sustainable decisions instead of assisting in making informed choices.

However, a number of studies have developed methodologies/framework to support the management of key stakeholders and their decisions in construction projects. For example, Bourne and Walker (2005) developed a framework for visualising and mapping stakeholder influence in the construction industry. Yang et al. (2009) developed a framework which explore critical factors for stakeholder management in construction projects, Bourne (2011) developed stakeholder circle methodology to identify and prioritise the influences of the project stakeholders and Isaacs et al. (2013). Blackwood et al. (2014) developed SAVE framework for knowledge integrated approach based on assessment, visualisation and enhancement. Pan and Dainty (2012) developed a systematic approach for UK house building organisations to identify value based decision criteria and quantified their relative importance for accessing building technologies systematically. These research studies have dealt with stakeholder management in the construction industry, but they have not developed a decision support system (DSS) that would assist key stakeholders in making an informed decision for delivering of sustainable retrofitted building projects. Therefore, there is a need for a tool to assist decision makers in the industry to systematically select sustainable technology which addresses different issues in order to obtain a holistic decision output (Wang et al., 2009). Such a DSS when developed should assist stakeholders to classify available information, consider the consequences and minimise the possibility of decision dissatisfaction or mistakes. The use of a sustainable technology decision tool would significantly reduce or eliminate the negative impact of buildings on the environment and as well achieve key stakeholders’ satisfaction in the long term (Yudelson, 2009). Consequently, a conceptual DSS framework has been formulated and this is illustrated in Figure 1. This conceptual framework will then require the collection of empirical data that will result to development of a decision support prototype.

![Figure 1: Conceptual Decision Support System Framework](image-url)
3.1. Identification of the problem

Building evaluations usually starts from identification of a problem then formulating attributes, objectives and goals (Van Pelt, 1993, RICS, 2001). The problem is structured to provide adequate specification of objectives so that attributes can be identified (Akadiri, 2011). The problem with key stakeholders in decision-making in delivering sustainable retrofitted building projects has been identified to be due to lack of efficiency in managing project knowledge. The key stakeholders in sustainable retrofitted building projects include; the client; government; design professionals (architects, civil, electrical and mechanical engineers), project managers, contractors and their supply chain: including manufacturers and suppliers.

3.2. Determination of the objectives

The key stakeholder’s objectives in the project have to be determined. Key stakeholders and their information needs will be identified using a set of procedures, developed by various authors, including those drawn from information-technology and knowledge management fields (Blackwood, et al., 2004, Butler et al., 2003, Gilmour and Blackwood, 2006). The work of Blackwood et al. (2014) were used to identify the key stakeholders involved in the project and their means of interaction and classify their information needs and intervention points. Each of the identified key stakeholders will be involved in the identified vectors of information flow which include: knowledge capture in reports, phone calls, meeting minutes, documentary data analysis as well as an expression of individual experience. These will need to be examined and evaluated by the key stakeholder’s in order to understand the use of relevant information in making informed decisions in delivering retrofitted building projects.

3.3. Knowledge Learning Procedure for Key Stakeholders

Knowledge has been described as the product of learning, which is personal to an individual or organisation (Orange et al., 1999). Patel et al. (2000) argue that knowledge is a body of information, coupled with understanding and reasoning. It has also been stated that there is no single repository for project knowledge in the industry (Udeaja et al., 2008) hence the need to capture project knowledge during construction activities. The key stakeholders will capture knowledge in the learning procedures (Udeaja et al., 2008) to enable an informed decision. The learning procedure will contain information relating to the ‘project knowledge’ (Udeaja et al., 2008, Blackwood et al., 2014) and this process will focus on knowledge that can enable or assist key stakeholders in making an informed and appropriate decision. The knowledge learning procedure previously described in terms of information flow includes knowledge captured during meetings, phone calls, interviews, seminars, expressions of individual experience, and documentary analysis. The information will be reviewed by the key stakeholders and its use discussed. Hence the key decision points where information is used to support a decision will be identified and established.

3.4. Knowledge Maps

Wilcox (2008) argues that ‘the knowledge map’ has been identified to be one of the most effective processes in managing project knowledge in making an informed decision. Knowledge maps (such as contacts, web pages and building plans related to the project) will be considered by the key stakeholders to assist them in managing the required projects knowledge for appropriate decision-making. After the consideration of these knowledge maps then the need to review sustainable assessments is necessary for informed decisions.

3.5. Sustainability Assessment

In delivering sustainable retrofitted building project, it is necessary to incorporate and manage the information that is necessary in order help identify key decision points before making an informed decision. Sustainability assessment comprises of key indicators that incorporates sustainability and sustainable construction. At this stage, there is a need for key stakeholders to evaluate ideally relevant information that relates to sustainability and sustainable construction and also consider the impacts of various decisions on sustainability before they are implemented. This will avail key stakeholders the opportunity to avoid decision dissatisfaction. The next stage is to identify the alternatives to be rated in the decision-making process.

3.6. Identify Alternatives to Be Rated and Compared

This stage is to identify alternatives and compare them. This step has been argued to be based on the decision project components and structure (Van Pelt, 1993). There is no limit to number of alternatives, but policy makers have suggested that to facilitate the decision-making process and to avoid confusion, the number of alternatives should not be more than seven (Van Pelt, 1993, Akadiri, 2011). The list of alternatives concerns the aggregation of the identified components already discussed in this paper and also, interactive communication and engagement with the key stakeholders.

3.7. Estimate Weight of Alternatives

Having identified and aggregated alternatives, it is important and instructive that they are weighted. Akadiri (2011) argued that in any list of items some items may be more important than others. In this aspect the knowledge gathered through some of the components discussed will enable the key stakeholders to consider and facilitate the most appropriate decisions in delivering sustainable retrofitted building projects. Additionally, it is necessary to consider the three aspects of sustainability (social, economic and environmental) in weighing the decision alternatives or options.
3.8. Evaluation and choice of alternatives and making an informed decision

Finally, there is a need to evaluate and choose between alternatives in order to facilitate appropriate decision-making and also help in decision satisfaction (Akadiri, 2011). The key stakeholders as the decision makers will evaluate the information provided in the system. Some studies have considered quality of information and steps provided in a DSS as an integral part of user decision satisfaction, effectiveness and confidence (Bailey and Pearson, 1983, Bharati and Chaudhury, 2004, livir, 1987). The evaluation of alternatives provided in the system precedes an informed decision.

4. Discussion and Conclusion

It has been acknowledged and documented that the activity of sustainable retrofitting remains a very complex process in the industry. Considering some of the challenges slowing the delivery of sustainable retrofitted building projects particularly the lack of managing project knowledge, it is clear that knowledge management has been neglected in sustainable construction. This has pushed the key stakeholders in industry to keep reinventing the wheel in new projects because they do not acknowledge the need to capture and reuse of project knowledge in the past and present project life styles. It is demonstrated in this paper and revealed that the role of Knowledge Management (KM) in the industry remains a potential advantage and solution in delivering sustainable retrofitted building projects if adopted fully in the industry.

This paper has presented a DSS conceptual framework which addresses a key knowledge issue in making informed and appropriate decisions in delivering sustainable retrofitted building projects. This hitherto had not been adequately addressed in the industry. This was due to the absence of knowledge based decision support system in delivering sustainable retrofitted building projects. The developed conceptual DSS framework also addresses the increasingly problematic issue of key stakeholders’ lack of managing project knowledge which has resulted to lack of informed decision-making in delivering retrofitted building project. However, having reviewed the literatures to formulate a DSS conceptual framework, it is imperative to state that good knowledge management strategy aimed at elucidating knowledge in making an informed decision in delivering sustainable retrofitted projects is a priority in the industry. The need to incorporate knowledge steps in technological options as regards to delivering of projects in the industry is important and should be encouraged in order to achieve informed decisions which in turn will facilitate the uptake of more retrofitted building projects which will result in reduction of greenhouse gas house emission in the UK in particular with respect to its 2050 reduction target.

References

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