STAKEHOLDERS PERSPECTIVE ON SUSTAINABLE TECHNOLOGY SELECTION TO ACHIEVE ZERO CARBON RETAIL BUILDINGS

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In the design and construction of sustainable retail buildings, there are various stakeholders involved with the overall aim of selecting appropriate sustainable technologies to reduce energy consumption and carbon emissions. Previous studies and literature review indicate there is no comprehensive selection process to assist stakeholders. This can be classified as a complex multi-criteria decision problem due to the high number of alternatives, potential solutions and variety of stakeholders (e.g. clients, professional advisors, end-users) with multiple, often conflicting, objectives leading in turn to the slow take-up of sustainable technologies. There is a demand for a systematic and effective evaluation tool for the selection of sustainable technologies based on the needs of stakeholders. This paper is part of an on-going study to develop a decision making system to assist stakeholders in the selection process and aims to establish the decision criteria for the selection of sustainable technologies for existing retail buildings based on the clients' (retailers') perspective. The arguments are informed by a combination of literature review and an in-depth case study with a leading construction company in the UK. The data collected was both qualitative (establishing and verifying decision criteria) and quantitative (establishing weightings and priorities). Five broad decision criteria currently used by clients in the selection of sustainable technologies to achieve reductions in energy and carbon were established (i.e. cost, time, proven success of technology, risk and sustainability). Using AHP survey and expert opinions, the identified criteria were weighted and ranked, with risk (37%) being the most important, followed by cost (22%), proven success (20%) and time (12%), and sustainability (9%) the least important factor. Although the established criteria would be most relevant for the selection of sustainable technologies for existing retail buildings, it will also be beneficial for new build retail buildings and be transferable to other types of buildings.

Keywords: criteria selection, decision making, stakeholders, sustainable technologies, zero carbon, retail buildings.

INTRODUCTION

There are several simple and cost effective sustainable technologies (STs) that exist today and the integrated use of such technologies could enhance energy efficiency and

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reduce emissions in the construction industry (IEA 2012). Carbon Trust (2009) estimates that using simple and cost effective technologies that already exist could result in a net cost saving to the UK economy of more than £4.5bn and could reduce carbon emissions from the UK's non-domestic buildings by 35% by 2020. However, despite the economic and environmental benefits of STs, there has been a slow uptake; with nine out of ten technologies that hold the potential for energy and carbon emissions savings not selected by construction professionals (Carbon Trust 2009, BRC 2012, IEA 2012). Designers and clients face significant challenges in the selection of appropriate sustainable technologies (Akadiri et al. 2013, Pan et al. 2012, Dangana 2012). This is due to the fact that the selection of sustainable technologies is a complex task, with the rapid development of technological alternatives, lack of skills and knowledge, uncertainties, risks and a large number of technological alternatives and decision criteria all needing to be considered (Dangana 2013, Pan et al. 2012, Wang 2009). The selection of STs can have significant implications on building performance and stakeholders' satisfaction, creating long-term problems and hindering the adoption of such technologies (IEA 2012, BRC 2012). It is therefore necessary to base sustainable technology selection decisions on a clear understanding and a proper evaluation.

The study on which this paper reports is part of an on-going research project which aims to optimise the process, energy and carbon efficiency in retail construction by capitalising on sustainable technology. Preliminary literature review and exploratory studies indicate there is a slow uptake of sustainable technologies by stakeholders in the retail construction industry in the UK (Dangana et al. 2012). Currently, designers, constructors and retailers interested in adopting sustainable technologies in the retail construction industry have no comprehensive evaluation approach to review and select technologies (Catalina et al. 2011, Akadiri et al. 2013). There is thus a demand for a systematic and effective evaluation tool for the selection of such sustainable technologies (Pan et al. 2012, Devoudpour et al. 2012, Akadiri et al. 2013). This presents a big challenge for stakeholders in the retail construction industry in relation to implementation strategies that will support sustainable retail buildings and overcome the barriers which influence the slow uptake of sustainable technologies.

An earlier study (Dangana 2013) explored the composition of the main stakeholders involved in the selection process. The study developed a set of criteria predominantly from the perspective of a main contractor and their clients/supply chains. The criteria were clustered in such a way that they contribute to each stakeholder's objectives and are brought together into an overall multi-actor perspective (Brucker 2013).

This paper aims to focus on the client (retailer) in the selection of STs for retail buildings. Based on expert opinions the study involved clarifying the decision context; establishing decision objectives; identifying, clustering and assessing decision criteria; and, finally, quantifying the relative significance of the clients' criteria using the analytical hierarchy process (AHP) technique.

STAKEHOLDER MANAGEMENT

Freeman (1984) defines a "stakeholder" as an individual or group of individuals who can influence the objectives of an organization or can be influenced themselves by these objectives while Banville et al. (1998) describes a stakeholder as everyone with a vested interest in a problem that can either affect, be affected by, or is both being affected by and affecting the problem. There are various classifications of stakeholders; Mainardes et al. (2012) proposed a new model of stakeholder

classification with six stakeholder types (regulator, controller, partner, passive, dependent and non-stakeholder), which is similar to the classification made by Roloff (2008) in which the stakeholders can be categorized into stakeholder groups of regulators, customers, workforce, political actors, social environmental etc.. Freeman's (1984) proposed model includes a broader spectrum of stakeholders, not only the traditional ones (clients, shareholders, members of staff, suppliers and competitors). This creates the issue of how to deal with all the stakeholders simultaneously, which is simply not possible. However the utilization of criteria prioritizing stakeholders can overcome this problem (Macharis et al 2012) by focussing on certain specific groups. It is thus necessary to first analyse who the stakeholders are and what are their respective interests (Mainerdes et. al 2012).

Stakeholder management is the process of systematically gathering and analysing qualitative information to determine whose interests should be taken into account when developing and/or implementing a policy or programme (Chinyo et al 2010, Mainardes 2012, Macharis 2012). Stakeholders' needs can provide an indication of concerns, problems and the stakeholder requirements of the projects. It is thus important to identify stakeholders' interests, and this can be achieved by exploring their needs and constraints which will enable a satisfactory and realistic solution to be found to meet the needs of the stakeholders (Macharis et al. 2012). The stakeholder circle methodology can be used to identify key stakeholders', develop an engagement strategy and communication plan to satisfy the needs and objectives of the stakeholders' (Chinyo et al 2010).

Stakeholder management in construction projects

The importance of stakeholder management has been identified in several studies (Newcombe 2003, Macharis 2012, Brucker et. al. 2013). However, there has been a poor record of stakeholder management in the construction industry, due to the complexity and uncertainty of construction projects and the vast number of stakeholders involved. This is due to inadequate engagement, unclear objectives and inadequate communication with the stakeholders (Loosemore 2006).

Yang et al. (2009) explored the critical success factors for stakeholder management in construction projects in Hong Kong. The study identified 15 critical success factors which were verified and ranked by professionals in the construction industry. The top three factors were: (1) managing stakeholders with social responsibilities (economic, legal, environmental and ethical), (2) exploring the stakeholders' needs and constraints to the project, and (3) communicating with and engaging stakeholders properly and frequently. The study clarifies the highly prioritised factors and can be used as an assessment tool to evaluate the performance of stakeholder management.

Stakeholders' perspective on the selection of sustainable technologies

There are various stakeholders involved with the overall aim of selecting the appropriate sustainable technologies to reduce energy and carbon emissions and achieve sustainable retail buildings. However, this is complex multi-criteria decision problem due to the high number of alternatives, potential solutions and various stakeholders (e.g. clients, professional advisors, end-users) leading to the slow take-up of sustainable technologies. Also, due to the lack of formal available measurement criteria or strategies, selection is currently based on knowledge-based techniques (Wang et al. 2009, Catalina et al. 2011). These methods do not provide adequate solutions to prioritise and assign weights to the relevant selection criteria based on the needs of stakeholders (Akadiri et al. 2013). It is therefore important to have an in-

depth understanding of each stakeholder's objective (Macharis et. al. 2012) and develop a systematic selection process to identify and prioritise relevant criteria based on the needs of stakeholders (Catalina 2011). Due to the complicated nature of the selection of STs, the multiple criteria decision analysis methodology would be adopted and the analytical hierarchy process (AHP) technique would be used to prioritise the criteria for the selection of STs.

AHP for the selection of sustainable technologies

Analytical Hierarchy Process (AHP) is a well-known multi-criterion decision making technique. It was developed by Saaty in the 70s as a theory of measurement concerned with deriving dominant priorities from paired comparisons of homogeneous elements with respect to a common criterion or attribute (Macharis et al. 2012). It has found widespread application in complex decision-making problems involving various stakeholders and alternatives with conflicting criteria, to arrive at a consensus decision (Wang 2009, Pan et al. 2012, Akadiri et al 2013).

AHP is a well-known technique that breaks down a decision-making problem into several levels in such a way that they form a hierarchy with uni-directional hierarchical relationships between levels. The top level of the hierarchy is the main goal of the decision problem. The lower levels are the tangible and/or intangible criteria and sub-criteria that contribute to the goal. The bottom level is formed by the alternatives to evaluate in terms of the criteria. AHP uses pairwise comparison to allocate weights to the elements of each level, measuring their relative importance with Saaty's 1-to-9 scale, and finally calculates overall weights for evaluation at the bottom level. If A and B are the elements to be compared, then "1" defines that A and B are equal in importance, and "9" defines that A is extremely more important. The method also calculates a consistency ratio (CR) to verify the coherence of the judgements, which must be about 0.10 (10%) or less to be acceptable.

Considering the current problem of selecting the appropriate ST to achieve sustainable retail buildings and the lack of a process to prioritise and assign weights to relevant criteria for the selection process (Akadiri et al. 2013), the AHP method is recommended. The AHP process transforms comparisons which are mostly empirical into numerical values and this is the distinctive feature of AHP when compared to other comparing techniques which allow the elicitation of both qualitative and quantitative data to arrive at a desired goal (Pan et al. 2012, Wong et al. 2008). The problem is broken down into a hierarchy of criteria that can be easily analysed and compared in an independent manner. The five main steps of AHP are: (1) Define the problem and determine the objective, (2) Structure decision problem into a hierarchical model, (3) Perform a pairwise comparison for the lower levels, (4) Undertake a consistency test and (5) Estimate relative weights of the components at each level.

METHODOLOGY

The research presented in this paper is part of an on-going research study employing an action research approach within a broad case-study based design (Yin 2007). The research will lead to the development of a decision-making system that will promote the uptake of sustainable technologies in the retail construction industry and assist retail construction stakeholders (e.g. retailers, contractors, architects and construction professionals) in evaluating and selecting the appropriate sustainable technologies. The system is based on the concept of multiple criteria decision analysis (MCDA)

with due regard to sustainable development. Within the system technologies can be analysed, evaluated and finally compared to allow the selection of the optimal variant according to a set of criteria (Huang et al. 2011) based on stakeholder objectives. This study builds on the findings from an earlier exploratory study by the researcher (Dangana 2012, Dangana 2013), which identified the key stakeholders and their selection criteria for the selection of STs for retail buildings.

The survey-based approach is currently used by researchers for examining decision criteria for the selection of sustainable technologies (Chen et al. 2010, Wong et al. 2008). This is useful in identifying the broad decision criteria but does not provide an in-depth exploration of the underlying considerations for the decision (Pan et al. 2012). To overcome this problem and address the value-laden and context-specific issues of technology decision making; this study consisted of two surveys; an initial general survey followed by an analytical hierarchy process survey (AHP) using the action-research approach with a leading construction company in the UK (Company A). The data collected was both qualitative (establishing and verifying decision criteria) and quantitative (establishing weightings and priorities).

General Survey

The general survey consisted of interactive discussions using semi-structured interviews with the identified stakeholder groups to evaluate and validate the pre-defined criteria identified from literature review and previous research. The study was also used to select professionals with relevant qualifications and experience to participate in the AHP survey. The interviews were conducted with 20 senior management personnel from Company A involved in the roles of technical, commercial, retail construction, sustainability, procurement, marketing and customer services and three sustainability managers of retail clients of Company A. The established decision criteria was presented and explained to the participants in the general survey. Some participants provided more criteria or sub-criteria for consideration, while some suggested minor modifications to the criteria. As this was a pilot study to check the success and usefulness of the developed decision making systems, the study was limited to five broad criteria which were approved by the participants as most relevant to use in the AHP survey and illustrate the current industry concerns over the use of sustainable technologies.

AHP Survey

This was followed by a one-day workshop to conduct the AHP survey with Company A at an organizational level with ten senior managers predominantly involved in sustainable retail construction, client facing and job winning roles. The workshop was set up in an interactive and constructive way, allowing ample space for the participants to contribute to the real problems at stake. The value tree of five decision criteria to be used for the AHP questionnaire survey was explained and participants then performed pairwise comparisons using the scale developed by Saaty (2006).

The first phase of the questionnaire asked for the criteria to be ranked in a given context and second phase asked for a pairwise ratio/importance response for each of those ranked factors. The comparisons were made using a scale of absolute judgements that represented how much more one element dominated another with respect to a given attribute. The results relied on the judgements of experts to derive priority scales and it is these scales that measure intangibles in relative terms (DCLG 2009).

RESULTS AND DISCUSSION

There are several methods currently available for selection of STs; however they are inadequate as they overemphasise the quantitative and financial criteria, but overlook qualitative factors such as improved human comfort and environmental sustainability (Wong et al. 2008, Pan et al. 2012). Secondly they do not provide a process for prioritising and assigning weights to the relevant selection criteria (Akadiri et al. 2013). This study has generated a set of both qualitative and quantitative key criteria currently used by clients in the selection of STs as explained below. These are consistent with the criteria identified from literature review and reflect the five broad issues which affect the selection of STs by clients.

General survey

The results of the general survey indicate five broad criteria currently used by clients in the selection of STs as explained below.

- Proven success of technology (Success)

A carbon saving of 75% by 2050 is achievable at no net cost (Carbon Trust 2009); however, it will be difficult to realise these savings and additional savings from new technologies without innovation (Carbon Trust 2010, IEA, 2012). Innovation in the non-domestic building sector represents a significant opportunity to help meet the UK's GHG emissions targets. Similarly, a study by Aberdeen Group (2008) identified the need for innovation as one of the top five pressures driving the green retail enterprise. Leading retailers are keen to use innovative products and processes in their construction processes to achieve reductions in energy and carbon emissions. However, due to the newness of several innovative sustainable technologies and lack of skills, with most of the technologies not performing as expected, there is a preference for technologies with evidence of proven success in reducing the energy and carbon emissions. This could be based on the fact that the technology has been used on other building types (schools, hospitals, houses, etc.), by other retailers or even trialled or piloted by organisations such as the British Research Institute or Energy Trust. There is a need for innovative sustainable technologies to be fully endorsed and supported (Pan et al 2012) and to create the right framework to encourage both development and deployment by stakeholders (IEA 2012).

- Time and ease to install sustainable technology (Time)

Refurbishing and retrofitting existing buildings can improve the energy efficiency and environmental performance and will be a crucial step in making significant inroads toward tackling climate change. In many cases, an existing building is either vacated or partially closed as it is refurbished. A participant from the general survey mentions 'The closure of a retail store (such as grocery) even for a day can be a great loss to the owner, with busier stores losing up to £500,000 in sales'. The use of technologies which require extended periods of closure of the store is particularly challenging when they impact on store trading and sales. Hence, retailers/clients prefer to install those technologies which have the least impact on occupiers and involve little or no disruption to store trading, such as the use of off-site technologies. Clients using off-site production technologies benefit from faster construction times, less waste, less noise and disruption to neighbours, and lower site accident rates as well as improved health and safety.

- Cost of the technology (Cost)

The use of energy efficient technologies in retail buildings can reduce the energy costs by 20% and this represents the same bottom line benefit as a 5% increase in sales (Carbon Trust 2010). However, cost is one of the major barriers when implementing sustainable technologies, due to higher upfront cost and the lack of financial benefits and incentives for stakeholders (Wong et al 2008, Dangana 2012, Pan et al 2012). Also, many sustainable technologies do not yet offer an acceptable payback period for clients which is critical to environmental and energy efficiency. A simple payback method is most often used by clients looking to recoup costs and determine how long it will take to break even on the investment. This is achieved by dividing the incremental cost by the net annual operational savings (energy savings and maintenance impact). Due to the frequency with which a retail store needs to be refurbished, the acceptable payback period of 2-5 years is preferred by clients rather than the average 8-10 years for most technologies.

- Sustainability

There are various new sustainable technologies, with a potential for saving energy and improving efficiency for retail buildings. However, due to the newness of the technologies there is little or no evidence to prove how effective they are. Clients are becoming increasingly conscious of sustainability; in terms of what the energy and carbon saving would be. Although this is difficult to prove for immature technologies, data might be available in different forms such as BRE testing, accreditations by well-known organizations, or data from a pilot study, all of which could increase the confidence of the client when selecting such technologies.

- Impact of technology on customers (Risks)

Sustainable technologies can have an effect on the end-users of the buildings, such as the customers. Retailers recognise that a greater understanding of customers is needed to enhance customer satisfaction and retail performance. They are mindful of the impact a technology would have on the customers as this could either increase or reduce their sales and profits. Some retailers would not install a sustainable technology, no matter how energy efficient it might be, if it might have a negative impact on customers. For instance, in grocery and convenience stores, refrigerators and freezers make up a significant portion of total energy use, with the selection of freezing and refrigeration systems playing an important role in energy efficiency (Evans et al. 2007) and the extent to which such technologies are positively perceived by customers most probably hinges around functionality. A report from Consumer Focus recommended that supermarkets should achieve efficiency savings by putting doors on all freezer units and explore and progress consumer acceptance to doors on chillers (Allder & Yates 2009). However, some retailers are still not making use of such technologies as customers do not like the idea of doors on fridge-freezers. Thus the positive or negative impact of the technology on customers is a key factor in the selection of STs.

AHP Survey

The aim of the AHP survey was to evaluate the comparability of the established decision criteria currently used by retailers for the selection of STs.

The results were first analysed for each participant to establish the weighting and ranking (Figure 1) for the five broad criteria (cost, sustainability, time, proven success, and risks). The results highlight the different view of the participants, however, the CR for each participant was within the acceptable range, and was reliable and consistent to establish the combined weighting and ranking for the stakeholder group.

All the results were combined to provide a consensus ranking and weighting for the group using the AHP technique (Table 1). The risk criterion was found to be the most important attribute for the group with a score of 34%.followed by cost (22%), proven success (20%) time (12%) and sustainability as the least important (9%).

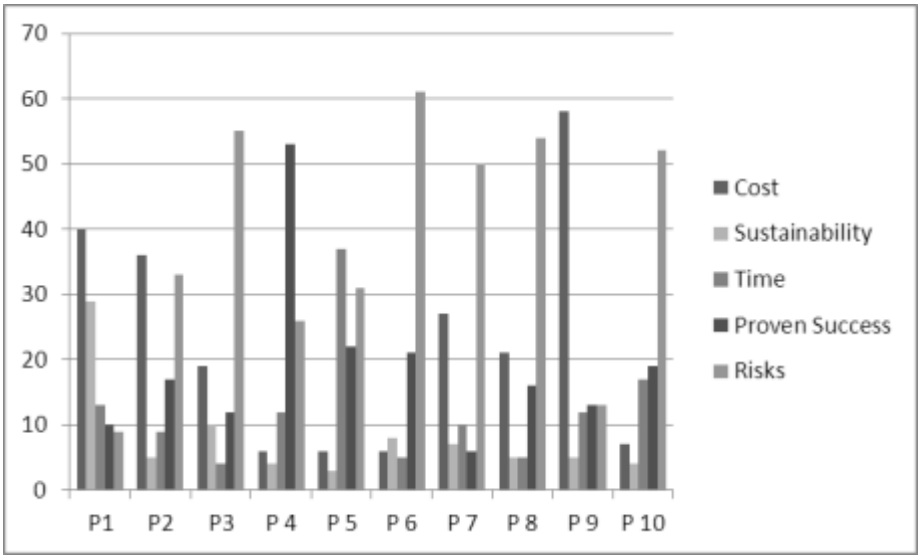

Figure 1: Ranking and weighting of criteria by all participants.

The scores for the various attributes in Table 1 clearly denote that the group under study places much emphasis on the risk posed by the technologies and the effect it would have on the end-users of the building. The sustainable features of the ST (sustainability), was considered the least important criteria, this could be due to the fact that it is difficult for clients to quantify the energy and carbon saving compared to the other factors.

Table 1: Combined comparison matrix of selection criteria used by clients

	Cost	Sustainability	Time	Success	Risks	Weights	Ranking
Cost	1	2 7/8	1 5/7	1 1/7	½	22%	2
Sustainability	1/3	1	7/9	4/9	2/7	9%	5
Time	4/7	1 2/7	1	4/7	3/8	12%	4
Success	7/8	2 2/9	1 3/4	1	½	20%	3
Risks	1 8/9	3 2/3	2 2/3	2	1	37%	1

An essential feature of AHP is the consistency test, which aims to eliminate the possibility of inconsistencies by providing a consistency ratio (CR). Saaty's suggests that a CR equal to 10% is acceptable. If the CR value is lower than 10%, the established weight results are valid and consistent, but if larger than 10% the matrix is considered inconsistent. The CR was thus used to determine and justify the inconsistency in the pairwise comparison made by the participants. The results of this study indicate a CR of 0.3% which is within the acceptable range of 10% and the established weights are thus reasonably consistent.

The sample size of 10 participants for AHP survey might seem limited. However, AHP is a subjective method and with a large sample size there is a tendency for respondents to provide arbitrary answers which can result in inconsistencies (Wong et al 2008).

CONCLUSIONS

There has been a slow uptake of STs by stakeholders in the retail construction industry. Previous studies have indicated the lack of a decision making system for the selection of appropriate sustainable technological innovations (Akadiri et al. 2013, Catalina 2011, Pan et al. 2012, Dangana et al. 2012) to optimise the process, energy and carbon efficiency for retail buildings. This can be classified as a complex multi-criteria decision problem due to the high number of alternatives, potential solutions and various stakeholders involved. It is important to have an in-depth understanding of each stakeholder's aspiration to arrive at a consensus decision to select the appropriate technology.

The study reported in this paper established five broad decision criteria (cost, time, proven success of technology, risk and sustainability) currently used by clients in the selection of STs to achieve reductions in energy consumption and carbon emissions. The established criteria were selected and approved as most relevant by the participants and illustrate the current industry concerns over the selection of STs. Using AHP survey and expert opinions, the identified criteria were weighted and ranked in the following order with risk being the most important and sustainability the least important factor: risk (37%), cost (22%), proven success (20%), time (12%) and sustainability (9%). The established weights and ranking are considered to be reliable and consistent as the CR was 0.3% and within the acceptable value of 10%.

The findings contribute to widening the understanding of selection criteria as well as their degree of importance based on stakeholders' needs; improving the quality of the decision by making informed decisions that are more explicit, rational and efficient. The study has focused on the objectives of the client (retailer) but, the process can be applicable to other stakeholders. The various stakeholders' objectives can be visualised in a value-tree to assist stakeholders in making a more informed decision to achieve sustainable retail buildings.

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