Study on Risk Management for the Implementation of Energy Efficient and Renewable Technologies in Green Office Buildings

Mosly, Mr. Ibrahim[1]
Zhang, Dr. Guomin[2]

[1]PhD Candidate, School of Civil, Environmental and Chemical Engineering, RMIT University, Melbourne, VIC, Australia, ibrahim.mosly@hotmail.com

[2]School of Civil, Environmental and Chemical Engineering, RMIT University, Melbourne, VIC, Australia, kevin.zhang@rmit.edu.au

Beyond Today's Infrastructure

Abstract

Sustainability is becoming an important subject these days in many countries around the world. This is mainly due to increasing governmental and public awareness about reducing the impacts of climate change on our environment. Green buildings are able to reduce greenhouse gas emissions and consumption of natural resources. Reducing either water or energy consumption is achieved in green buildings with the aid of certain types of advanced technologies. This is done in order to help these buildings become more environmentally friendly. Unfortunately, these technologies are relatively new and may present a number of risks during various phases of their lifecycles, affecting different project stakeholders. This paper will focus on the risks of energy efficient and renewable technologies (EERTs), which are mainly implemented in green office buildings. These risks are divided into four categories: heating, ventilating and air conditioning (HVAC), lighting, solar, and wind. It will present a comprehensive review of a number of risks pertaining to the application of EERTs. Furthermore, it will emphasize the need to create a risk management framework for EERTs implemented in green office buildings due to the current lack of research carried out to investigate and treat these potential risks.

Keywords:

Risk; Energy efficient technology; Energy renewable technology; Green office buildings

I. Introduction

Australia is considered to be one of the countries with the highest production of greenhouse gas emissions per capita (Garnaut, 2008). Approximately 10 percent of Australia's greenhouse gas emissions come from commercial buildings (CoIE, 2007). To reduce these emissions, sustainable measures should be employed. Green buildings are one solution that can help in reducing the amount of greenhouse gas emissions.

In the case of green office buildings certain types of technologies have been invented and used to help these buildings become more environmentally friendly, either by reducing the amount of water and energy consumption or by generating energy from renewable resources. Unfortunately, these technologies are relatively new and may present significant levels of risks during the different lifecycle phases of the technologies and the green office buildings. The technologies reviewed in this paper are divided into four main categories. Two categories are for the energy efficient technologies which relate to HVAC and lighting, while the other two categories are for the energy renewable technologies using solar and wind resources. This paper reviews a variety of risks that might occur due to the use of EERTs in green office buildings. In addition, it emphasizes the need to create a risk management framework for the EERTs implemented in green office buildings

II. Energy Efficient and Renewable Technologies Implemented in Green Office Buildings

Energy efficient technologies for HVAC and lighting were examined in this paper because 33% of energy in commercial buildings was consumed by HVAC and 26% of energy was consumed by lighting (CoIE, 2007). These percentages represent a high portion of energy consumption and should be carefully considered. On the other hand, energy renewable technology using solar and wind was investigated because it can be feasibly implemented in office buildings without being too concerned with the topography and location of the office building. This is not the case with other renewal sources such as hydropower which heavily depends on the availability of suitable sites with specific topography as well as a river with a flowing water source (Breeze, 2005).

After review of a number of five and six stars rated green office buildings in Australia, it was found that nine EERTs were mostly used in these buildings. Table 1 summarizes these technologies according to their categories (Mosly and Zhang, 2010):

Table 1: EERTs implemented frequently in Australian green office buildings

Category	Technologies
HVAC	Radiant systems, chilled beams, underfloor air distribution and natural night ventilation
Lighting	Energy efficient light bulbs and motion sensors
Solar	Photovoltaic cells and solar thermal systems
Wind	Wind turbines

III. Risk Management

Risk is defined as the undesirable consequence of activities such as loss of human life, adverse health effects, loss of property and impacts to the natural environment which takes place due to natural or human activities (Modarres, 2006). You can simply define it as the result of uncertainty on goals (AS/NZS, 2009). Risk from an engineering viewpoint is associated with the exposure of recipients to hazards and can be articulated as the combination of probability and consequence of the hazard (Modarres, 2006). In other words, majority of barriers, challenges, impediments, issues, limitations, and others can be treated as risks, since they have a probability of occurrence and a consequence on the technology stakeholders.

Risk management represents a group of coordinated activities to guide and make control over an association with regards to risk. The risk management procedure is a systematic function of management policies, measures and practices to the activities of communicating, consulting, setting up the context, and identifying, analyzing, evaluating, treating monitoring and reviewing risk (AS/NZS, 2009).

IV. Methodology

A total of 66 different sources were evaluated during the literature review process. It included books, journal articles, conference papers, reports and official internet websites. ScienceDirect, ProQuest, and Scopus databases were used to find journal papers. Google search engine was also used to look for conference papers, reports and internet websites, while the RMIT University Library catalog was used for the books search.

The selection criteria was to look for sources that investigated or reviewed the risks of EERTs with an increased focus on the specific EERTs listed in Table 1. Terms such as risks, barriers, limitations, drawbacks, disadvantages, issues, hazards, threats, dangers, hurdles, impediments, problems, and obstacles were used for the search.

Identifying risks for each of the selected specific technologies was a challenge because few authors have investigated this area. Furthermore, some technologies were investigated more often than others. On the other hand, many papers that discussed generally the risks of EERTs were found in the literature. Because of this, and because of the need to develop a comprehensive list of risks, sources that identified the risks of EERTs in a general manner were also used. This step made it possible to compile an inclusive list of risks.

In this paper, sources that identify the risks of the specific EERTs will be referred to as specific sources, while sources that identify the risks of EERTs in general will be referred to as generic sources. Section V discuss in detail the risks of EERTs implemented in green office buildings.

V. Risks of Energy Efficient and Renewable Technologies

Table 1 includes a list of commonly implemented EERTs in green office buildings in Australia. Table 2 presents risks associated with the application of EERTs that were identified from 66 references listed in Table 3. These references were categorized under four main categories: HVAC, lighting, solar and wind, with a focus on certain technology within each category. This was done in order to ensure the implementation of EERTs technologies as a part of this research.

Table 2: List of risks of EERTs implemented in green office buildings

Risk	Risk Number
Uncertain payback period	1
Lack of access to funds	2
Hidden costs	3
Lack of access to information about technology	4
Low product and performance reliability	5
Lack of availability of skilled personnel	6
Presence of system constraints	7
Low consumer demand and acceptance	8
Lack of access to the technology itself	9
Lack of access to necessary spare parts	10
Introduction of new, superior technology	11
Operation failure	12
Misplaced incentives	13
Aesthetically unpleasing	14
Future change in regional climate	15
Future unavailability of tax credit or incentives	16
Weather fluctuation (rain, wind, snow, etc.)	17
Leakage of hazardous material	18
Fire risk	19
Physical degradation	20
Uncertain governmental policies	21
Surface condensation and mold growth	22
CO2 suffocation	23
Responds slowly to temperature changes	24
Causes draught & thermal discomfort	25
Unauthorized building entrance	26
Causes headaches, skin rash and depression	27
Glare risk from collector sunlight reflection	28
Dangerous emissions from unit production	29
Causes noise & building vibration	30
Birds collision	31

As mentioned earlier, the risks listed in Table 2 were acquired from various sources. These sources are summarized in Table 3 where references are classified according to their topics under certain technology category. The table includes information such as technology categories, risk category (generic or specific), references, and methods of investigation and risk number.

Table 3: Summary of the sources used to identify the risks of EERTs

Category	Generic/ Specific	References	Methods	Risk Number
Energy efficient and renewable technologies	Generic	(Cooke et al, 2007), (Sovacool, 2009a), (Adhikari et al, 2008)	Interviews	1, 5, 6 2, 4, 13, 14, 16 4, 10, 16
		(Singh et al, 2006)	Survey	4, 5, 9, 21
		(Martinot, 1998)	Case study and interviews	4, 6
		(Parthan et al, 2009)	Literature review	6, 13, 21
Energy efficient technologies	Generic	(Pinkse and Dommisse, 2009)	Interviews	5, 6, 8
		(Greden et al, 2007)	Survey and focus groups	5, 11, 15, 16, 21
		(Reddy and Shrestha, 1998)	Survey and interviews	4, 8, 9
		(Brown, 2001)	Case studies	4, 13, 21
		(NRTEE, 2009), (Meyers, 1998)	Literature review	1, 4, 5, 6, 8, 13, 16, 21 2, 3, 5, 6, 9, 13
Renewable energy technologies	Generic	(Reddy and Painuly, 2004)	Survey	1, 2, 3, 4, 5, 8, 13, 16, 21
		(Owen, 2006), (Painuly, 2001), (Tsoutsos and Stamboulis, 2005), (Hassett and Borgerson, 2009), (Mirza et al, 2009), (Abbasi and Abbasi, 2000)	Literature review	2, 13 1, 2, 4, 5, 6, 7, 8, 9, 21 5, 8, 12, 21 1, 5, 11, 12 2, 4, 5, 6, 9, 10, 21 12, 14, 28, 29, 30, 31
		(Komendantova et al, 2009)	Interviews and case studies	21
		(Sovacool, 2009b)	Interviews	1
	Photovoltaic cells, solar thermal systems and wind turbines	(Turkenburg, 2000), (OECD/IEA, 1998), (Evans et al, 2009)	Literature review	1, 8, 14, 21, 30, 31 14, 18, 29, 30, 31 5, 14, 29, 30, 31
	Photovoltaic cells and solar thermal systems	(Tsoutsos et al, 2005)	Literature review	14, 18, 19, 29
HVAC	Radiant systems	(Yudelson, 2008), (Feustel and Stetiu, 1995), (McDowall, 2007)	Literature review	6, 22, 24 5, 7, 25 18
	Chilled beams	(Alexander and O'Rourke, 2008), (Dieckmann et al, 2004), (Henderson, 2003), (Roth et al, 2007), (Schultz, 2007), (Barnard and Jaunzens, 2001)	Literature review	7, 23 6, 22 7, 22 6, 7, 14 7, 25 22, 26
		(Melikov et al, 2007)	Case study	25

Table 3 (continued): Summary of the sources used to identify the risks of EERTs

Category	Generic/ Specific	References	Methods	Risk Number
HVAC (Continued)	Underfloor air distribution	(Chao and Wan, 2004) (Alajmi and El-Amer, 2010)	Case study	25 6, 22
		(Webster, 2005)	Literature review	4, 5, 6, 22, 25
		(Hui and Li, 2002) (Woods, 2004) (Bauman and Webster, 2001)	Literature review	4, 25 5, 22, 25 4, 6
		(Zhang and Yang, 2006)	Survey and interviews	1, 3, 4, 5, 6, 7, 8, 22, 25
	Night natural ventilation	(Roetzel et al, 2010) (Martin and Fitzsimmons, 2000) (Conahey et al, 2002)	Literature review	26 7, 26 26
		(Kubota et al, 2009)	Interviews & case studies	17, 26
		(Torcellini et al, 2004)	Case study	5
Lighting	Energy efficient light bulbs	(BBC, 2008) (HC, 2009) (Janis and Tao 2005)	Literature review	27 18, 27 12
		(Yuen et al, 2010) (Houri and Khoury, 2010)	Case study	5, 7 5, 7, 8
	Motion sensors	(Stein and Reynolds 2000) (Lovorn, 2009)	Literature review	5 5
Solar	Photovoltaic cells	(Diarra and Akuffo, 2002)	Literature review	4, 5, 6, 17
		(Realini, 2003) (Chiabrando et al, 2009) (Dunlop and Halton, 2006) (Hayter et al, 2002)	Case study	20 28 20 17
	Solar thermal systems	(Philibert, 2006)	Literature review	1, 6, 8, 13
		(Kalogirou, 2009)	Case study	14
Wind	Wind turbines	(Bussel and Mertens, 2005) (Dutton et al, 2005) (Gipe, 2004)	Literature review	30 5, 12 30, 31
		(Weaver and Forsyth, 2006)	Survey	4, 5, 9, 12
		(Grant et al, 2008)	Case study	14, 30

VI. Discussion and Findings

There are two types of risks as outlined in Table 2, which may apply to all categories or only to certain categories. For instance, hidden costs can occur to any technology in all categories but glare risk might only affect solar technologies. Other risks, such as system constraints, may vary from one technology to another, whether or not those technologies belong to the same category. For example, in HVAC both chilled beams and underfloor air distributions (UFADs) share the same risk of system constraints but the constraints are different. In the case of chilled beams, the constraint risk is in the form of a reduction in the capacity of the beam when placed directly above a source of high heat load (Schultz, 2007). But when it comes to UFADs, a constraint risk can be in the form of uneven air distribution (Zhang and Yang, 2006).

From Table 3, the references identifying specific risks represent the major portion of literature review at 45 sources, whereas 21 sources identifying the generic risks of EERTs were considered in this study. Nine sources had investigated the risks of photovoltaic cells, which represents the largest number among the selected EERTs. On the other hand, only a limited number of sources investigating the risks of motion sensors (two references) and radiant systems (three references) were found in the literature. More focus should be given to identifying the risks of these technologies. Risks of chilled beams and UFADs were found in seven sources. Moreover, five references discussed the risks of night natural ventilation and energy efficient light bulbs. Finally, six references mentioned solar thermal systems and eight mentioned wind turbines risks.

The methods that the authors have used in these references were identified in Table 3. The main methods used were literature review, surveys, interviews and case studies. Literature reviews represent the most common method used at 59%, followed by case studies at 20%. On the other hand, surveys and interviews were the least common methods used by the different authors at only four percent and eight percent, respectively. Finally, some references used combined research methods, which represented nine percent of total methods used. The low usage of surveys and interviews could be due to the difficulty of gathering data by these two methods. Nevertheless, these two methods are significant for data collection and should be used widely.

Risks were segregated into five main segments:

A = one to five references,
B = six to 10 references,
C = 11 to 15 references,
D = 16 to 20 references, and
E = 21 to 25 references.

It was found that 16 risks were placed in segment A, 12 risks were placed in segment B, zero risks in segment C, two risks in segment D, and only one risk in segment E. Out of the 31 identified risks, only three risks were mentioned in more than 10 different references.

These risks are:

1. Lack of access to information on technology (segment D),
2. Lack of availability of skilled personnel (segment D), and
3. Low product and performance reliability (segment E).

Several factors might have led to this outcome, such as, importance of these risks and scope of references reviewed. Therefore, stating that risks from segment E are more critical than risks from segment A can be misleading. Experts' opinion will be required at this stage in order to get a realistic picture of the position of each risk.

From Table 3, the average number of risks identified per reference is only 3. This indicates a lack of comprehensiveness in risk identification for EERTs. Extra work should be done in this area to guarantee that the majority of risks are covered. This will benefit the stakeholders by giving them easier access to information on the risks of EERTs and increasing their awareness.

The scarcity of references that investigate or discuss the potential risks of EERTs has a negative impact on the technology stakeholders, as most of the available materials are promoting these technologies by covering its advantages and benefits. It is vital that more attention should be given to the investigation of the risks of EERTs so that these risks can be managed in order to improve the products and reduce any harmful impact on the stakeholders.

A risk management framework can significantly assist in promoting the technologies by basically identifying, analyzing, evaluating, treating and continuously monitoring and reviewing the risks of EERTs implemented in green office buildings.

VII. Future Work

Future work related to this study can be divided into three main stages. The first stage will be to carry out a questionnaire survey targeting industry experts and professionals. A sample size of 400 participants will be approached. Identifying the critical risks, affected stakeholders and lifecycle phases at which these risks might occur at, will be the major outcomes of this survey. The survey will be divided into three main parts: the first part will consist of demographic questions; the second part will require the participants to evaluate each risk according to its likelihood of occurrence and impact on its stakeholders in order to get the risk level; and the final part will require the participants to select which stakeholders might be affected by the risks, as well as at which phase of a lifecycle this might occur for all the identified risks.

The second stage of future work will be to conduct interviews with industry experts. The number of interviews will be between 10 and 20 interviews and will be scheduled in turn to find the best methods to manage the critical risks in each of the four categories. Interview questions will be open ended in order to get as much information as possible from the participants.

Finally, a risk management framework will be developed including all previously collected information on risks of EERTs and the best approach to manage them. This framework will be validated through a case study investigation of a six star rated green office building in Australia.

VIII. Conclusion

This paper has reviewed the potential risks of EERTs implemented in green office buildings. It has revealed an overall lack in the number of publications that investigate the risks of these technologies and has proposed a need to develop a risk management framework in the context of EERTs implemented in green office buildings. This will increase awareness among the different technology stakeholders and will promote the usage of EERTs, which in turn will lead to a reduction in greenhouse gas emissions that have an influence on climate change.

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86 Energy efficiency measures implementation strategy . . . 88. ix.Â Energy efficient buildings are those which consume less energy while maintaining or even improving the comfort conditions for their occupants compared to standard buildings. Energy efficient buildings result not only in less environmental impact but are also economically sustainable and resilient. The building sector accounts for the majority of electricity consumption in Nigeria and will inevitably increase significantly in absolute terms in the coming years driven by a rapidly increasing population, migration from low energy consuming rural dwellings to urban centres, and improvements in liv This paper aims to explore the risks of applying energy efficient and renewable technologies (EERTs) in Australian green office buildings. An online questionnaire survey was conducted in several Australian states and territories to identify and evaluate the potential critical risks that may influence the implementation of EERTs.Â [8] I. Mosly, G. Zhang, Study on risk management for the implementation of energy efficient and renewable technologies in green office buildings, in: Proceedings of the Transition to Sustainability Conference, Auckland, New Zealand, November/December 30 â€" 03, (2010). [9] B. Sovacool, The importance of comprehensiveness in renewable electricity and energy efficiency policy, Energy Policy, 4 (2009) 1529 â€" 1541. Technical and Economic Aspects of Energy Saving at the Stages of the Building Life Cycle. Pages 36-44. Kutsygina, Olga (et al.) Preview Buy Chapter 24,95 â,¬. Making Decisions in the Field of Energy Management Based on Digital Technologies. Pages 45-54. Burkov, Vladimir (et al.)Â Application of Digital Technologies in Human Resources Management at the Enterprises of Fuel and Energy Complex in the Far North. Pages 321-328. Zaychenko, Irina (et al.)Â Building-Integrated Photovoltaics Technology for the Facades of High-Rise Buildings. Pages 768-777. Generalova, Elena (et al.) Preview Buy Chapter 24,95 â,¬. The Development of Energy Efficient Facing Composite Material Based on Technogenic Waste. Pages 778-785. Vitkalova, Irina (et al.)