International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org, editorijaiem@gmail.com
Volume 2, Issue 2, February 2013 ISSN 2319 - 4847

The Development of a Newly Designed Building Performance Survey Framework for Energy-Efficient Building: A Review

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ABSTRACT

There exists a well-known gap between occupants and building's energy-efficient designs. A comprehensive building performance diagnostic technique, Post Occupancy Evaluation (POE) may surpass the current evaluation method and reduce the gap between occupants and building's energy-efficient design. For these reasons, the aim of this research is to develop a framework for the identification of problems in respect to energy-efficient design which affecting occupants' comfort. The objectives of this research are to determine the energy-efficient building in Malaysia, to identify the effects of energy-efficient design problems towards occupants' comfort, and to propose a holistic occupant survey framework for the rating of energy-efficient design problems which affecting the occupants' comfort. This research will be conducted in energy-efficient buildings in Malaysia. A new building performance survey framework will be constructed and tested on the selected energy-efficient building. The tested result will be analyzed using Statistical Package for Social Science (SPSS) in order to determine its reliability and validity. The research outcome shall contribute to the development of energy-efficient building through the identification of inefficient performance of the current building. Thus the newly designed building performance survey framework will be able to improve the occupants' comfort of energy-efficient building in the future.

Keywords: energy-efficient design, energy-efficient building, Post Occupancy Evaluation (POE), building performance

1. INTRODUCTION

In the current situation, reducing the consumption of energy from various sectors has been becoming the main agenda for sustainable development. According to United Nations Development Program (2009), in many countries, municipalities and public buildings have been the principal targets for energy efficiency programs, both at the national and local levels. The U.S. Congress drafted Section 914 of the Energy Policy Act of 2005 to address not just more energy efficient or "green" buildings but rather high performance buildings that combine the objectives of reducing resource energy consumption while improving the environmental impact, functionality, human comfort and productivity of the building (National Institute of Building Sciences, 2008). Since the energy-efficient designs of a building are aimed to fit occupants' comfortability, hence it can be said that occupants are the end user of a building, and their requirements and perceptions towards energy-efficient design can bring a significant improvement to the building.

Post Occupancy Evaluation (POE) is one of the ideal methods to analyze energy-efficient design of a building after occupancy. POE systematically analyzes and identifies successful design features to repeat in the future (Watson, 2003). Among the benefits of POE are improvement of the design databases, standards, criteria, and guidance literature, better-informed design decision-making, and understanding of the consequences of design (Preiser, 2002).

In this study, the term "energy-efficient building" is used as a collective term for different types of buildings made to reduce energy consumption, the aim of these buildings is to cope with the problems derive from the over consumption of natural resources mostly coal, which is used by building during its operational process. At present, there are three (3) office buildings specifically designed with energy-efficient features in Malaysia. They are Ministry of Energy, Communications, and Multimedia office building or well known as Low Energy Office (LEO); Secondly, Green Energy Office (GEO) which housed the office building for Malaysia Green Technology Corporations; and lastly, Energy Commission office building or known as ST Diamond. Those buildings are the initiatives demonstrated by the government to fully engage in the sustainable development, which is in line with the vision 2020 in the effort to become a developed nation.

2. PROBLEM STATEMENT

The development of green building rating system such as Leadership in Energy and Environmental Design (LEED), and Malaysian Green Building Index (GBI) reflected the current focus of the building performance objectives mostly on

optimizing energy and resource efficiently. However, according to Department of Energy (2001), in the development of energy efficiency program for building, it is important to appreciate the fundamental purpose of the building is neither to save nor use energy. Somewhat, the building is there to serve the occupants and their activities.

Evidence from recent post-occupancy evaluations done by Abbaszadeh et al., (2006) suggests that, there were potential for green building to enhance the IEQ, however, they often fall short. Their research found out that, although some of the best green buildings can rank higher than the best conventional buildings in terms of occupants experience toward comfort, health and productivity, a few of the lowest scoring buildings on user experience are also reported as green building. Occupants demand high performance of energy-efficient design with the aim of improving their comfort. The relationship between occupants' satisfaction and building's IEQ can be positively correlated with better building performance (Wilkinson et al., 2011).

According to Leaman, Stevenson, and Bordass (2010), building performance analysis can be studied from three different perspectives such as, occupants, environmental performance and, economic value. Occupants' perspective towards building performance is focused on how well their needs are met; for the environmental performance, energy and water efficiency are assessed, and; economic value of building is in regard to whether the building makes economic sense, such as value for money or return on investment. Most of the time, client or building owner and designer are more interested in building's environmental performance and economic value since these two perspectives have direct impact in reducing the energy cost. Thus, occupants' perspective is often neglected due to its insignificant economic value. Understanding the experience of the buildings from the occupants' point of view is equally important as its technological performance (Leaman, Thomas & Vandenberg, 2007).

The importance of the research on occupants' point of view towards building performance has draw researchers attention in recent years and has sparked the development of various types of IEQ surveys instrument. From the research done by Peretti & Schiavon (2011), they had identified ten of the IEQ surveys as shown in Table 1.0 (please refer to Appendix I). However the current surveys are not comprehensive enough, the result from the current surveys were unable to directly pointing out the problems of the building's design which cause the low performance of IEQ criteria, and the surveys were also not specifically meant for energy-efficient building.

If a comprehensive building evaluation which encompasses occupant's perspective is not being conducted to the energy-efficient building, energy-efficient building design team would not easily identified the problems that affect the building performance, since, occupants are the end user of the building, and the occupants' behavior while using the building can directly affected the building performance. Even though, the development of energy-efficient building in Malaysia is still at the beginning stage, the industry player should focus not only on the development of new energy-efficient building solely but the study on the existing energy-efficient building must not be neglected as well. A comprehensive building performance diagnostic technique which includes occupants' perspective in identifying the problems causing the low performance of IEQ is needed in order to reduce the gap between occupants and building's energy-efficient design.

According to Ng (2005), there are four types of building performance assessment methods as shown in Table 1.1, such as, Post Occupancy Evaluation (POE), Building in Use Assessment, Building Quality Assessment (BQA), and Total Building Performance (TBP). From the Table 1.1 (Please refer to Appendix II), it can be concluded that POE encompasses the most comprehensive building performance analysis from occupants' perspective compared to other methods, whereas the variables of instruments involved are questionnaire, interview, and observation which is related to occupants' perspective, and the period of assessment carried out is for after occupancy. Hence, by the reasons stated above, POE is the most suitable building assessment method from occupants' perspective.

A comprehensive building performance diagnostic technique, Post Occupancy Evaluation (POE) may surpass the current evaluation method and reduce the gap between occupants and building's energy-efficient design. For these reasons, the aim of this research is to develop a framework for the identification of problems in respect to energy-efficient design which affecting the occupants' comfort.

3. RESEARCH OBJECTIVE

The following objectives were identified in response to the research question:

(i) To determine the energy-efficient building in Malaysia.
(ii) To identify the effects of energy-efficient design problems towards occupants' comfort.
(iii) To propose a holistic occupant survey framework for the rating of energy-efficient design problems which affecting the occupants' comfort.

4. SCOPE OF RESEARCH

The relationship between occupants' satisfaction and building's IEQ can be positively correlated with better building performance (Wilkinson et al., 2011) as so, the evaluation measure criteria for the energy-efficient design of the buildings are based on the key physical environmental parameters of Indoor Environmental Quality (IEQ) performance; such as thermal comfort, ventilation, lighting, and noise etc.

The Ministry of Energy, Green Technology and Water (KeTTHA) building is the maiden energy-efficient building project in Malaysia; the building has even won the 2006 ASEAN building energy awards (Ministry of Energy, Green Technology and Water [KeTTHA], 2006). In the following years, the development of energy-efficient building in Malaysia continued to flourished, Malaysia Green Technology Corporation building was awarded Green Building Index (GBI) certified certificate; and the ST Diamond building was awarded GBI Platinum and Green Mark Platinum which is the Singapore sustainable building rating tool (Koay, 2011). Although, the buildings have obtained the award and certified by sustainable building rating tools assessment, the efficiency of the building performance still not on par as the expected performance (Ng & Akasah, 2011). One of the Malaysian showcase energy-efficient building projects, Malaysia Green Technology Corporation office building has yet to achieve its desired performance though after three years in operation (Choong, 2009). Thus the proposed survey framework will be tested on the Malaysians' showcase energy-efficient buildings, the buildings are the Ministry of Energy, Green Technology and Water (KeTTHA) building and Energy Commission building which are situated in Putrajaya, and Malaysia Green Technology Corporation building located in Bandar Baru Bangi.

According to Peretti & Schiavon (2011), building occupants are a valuable source of information for IEQ. Hence, the sampling of research will be focusing on the occupants of the selected building. Random sampling is used to determine the sample size for each selected building.

5. LITERATURE REVIEW

5.1 Definition of Energy-Efficient Building

In literal meaning, energy-efficient building can be defined as a building require less energy to operate compared to conventional type building which usually consume a lot amount of energy in order to sustain its daily operation needs. Due to its low energy consumption characteristic, energy-efficient building seems to be the best solution to mitigate the current environmental problems faced by human being in this century. Although, there are countless of advantages of energy-efficient building contribute to the environment, to date, there is still no specific definition for energy-efficient building. The vague definition of energy-efficient building might cause a setback during its implementation and the desired effects will hard to achieve. As so it is crucial to draw and highlight a clear as well as thorough definition of energy-efficient building. In this section a definition of energy-efficient building will be derived from the summary of the previous research related to the term of energy-efficient building used by researchers from various studies and fields.

Hauge et. al. (2010) define energy-efficient building as building made to reduce energy consumption to different degree, it includes, low-energy buildings, passives houses, LEED buildings, and green buildings. Another research done by Zhang & Leimer (2011) titled low energy certificate – An exploration on optimization and evaluation of energy-efficient building envelope, refer green building as energy-efficient building. Furthermore, according to Krope & Goricanec (2009), the awareness of the importance of energy efficiency of building has brought to the development of energy-efficient (saving) building, and it includes low energy buildings, 3 litres house, passive house, zero-energy house, energy self-sufficient house, and plus-energy house. Thormak (2001), conducted a research to analyze the recycling potential of a low-energy dwelling (45 kWh(162 MJ)=m2) in Sweden. In the research, the low energy building and passive houses were referred as energy-efficient building. In addition, Bauer & Scartezzini (1997), in their research on a simplified correlation method accounting for heating and cooling loads in energy-efficient buildings, one of the studied buildings is a simulated passive solar office room.

While, a research conducted by Ahmed et. al., (2009) in regard to the analyze of building performance data for energy-efficient building operation, during the research they have selected an energy-efficient building with many sustainable energy features such as solar panels, geothermal heat pumps and heat recovery systems as case study building. On the other hand, Kim et. al. (2010) conducted an analysis of energy efficient building design through data mining approach. In their research, the energy-efficient building design for the building includes the building location, envelope (walls, windows, doors, and roof), heating, ventilation and air conditioning (HVAC) system, lighting, controls, and equipment. Kantrowitz (1984), research on energy-efficient building, describes energy-efficient building is a building designed with energy-efficient design such as HVAC and lighting system.

Based on the research done in previous studies, it is found that, the researchers are tend to form a collective agreement between one another in term of their understanding of energy-efficient building. Energy-efficient building can be defined as a building using energy-efficient design strategies in reducing its energy consumption in order to achieve low energy consumption. It includes, zero energy building, passive house, low energy building, LEED buildings, green buildings, energy self-sufficient house, plus-energy house and any other buildings that has been specifically designed

with the aim of achieving energy-efficiency. In this study, the term "energy-efficient building" is used as a collective term for different types of buildings made to reduce energy consumption; they are Low Energy Building or Low Energy Office (LEO) and Zero Energy Office (ZEO).

6. LOW ENERGY OFFICE (LEO) AND ZERO ENERGY OFFICE (ZEO) DEFINITION

6.1 Low Energy Office (LEO)

(i) Low energy building concept is based on improving the building envelope to reduce heating and cooling demand, and using high efficiency equipments as well as renewable energy sources (Fadi et al. 2009).

(ii) LEO certification shall consist of a description of their energy characteristics, must provide information for prospective userd concerning a building's energy efficiency and additionally may also include options for the improvement of these energy characteristics (Luis et al., 2009).

6.2 Zero Energy Office (ZEO)

A net zero energy building (ZEB) is a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies (Tocellini et al., 2006).

7. BUILDING PERFORMANCE ANALYSIS

"Building performance" in simple terms is defined as the behavior of a product in use in BS5240. According to Clift (1996) it can be used to denote the physical performance characteristics of a building as a whole and/or its parts. This thus relates to a building's ability to contribute to fulfilling the functions of its intended use (Williams, 1993).

A. Need For Evaluation Of Building Performance

There are at least three major purposes for evaluating building performance (Manning, 1987):

(i) To learn how buildings actually perform from existing buildings through their users and the various professionals included. This will provide useful knowledge in the specifications of users-requirements in proposed new buildings.

(ii) To assess the possible consequences of design options and their impact on performance. This enhances design effectiveness for future buildings.

(iii) To determine the extent to which the performance of the completed building meet the initial target performance specified in the design stage.

8. POST OCCUPANCY EVALUATION (POE)

POE is defined as the process of systematically evaluating the extent to which a facility, once occupied for a period of time, meets the intended organizational goals and user-occupant needs (Preiser et al., 1988). These methods aim to study the effectiveness of designed environments from human user perspective (Zimring et al., 1980).

A. Process of POE

According to Khalil & Husin (2009), there are three (3) phases and steps involved in conducting POE. The phases of POE process are namely, i) planning, ii) conducting and iii) applying.

8.1 Planning

During the planning, all preliminaries agendas such as objectives of conducting POE are defined. This is to ensure that POE is organized and initiate the process of evaluation. It also can be called as pre evaluation phase, where it determine feasibility study of a building, review and provide analysis of building performance, define the strength and weakness of the building and identify who are the building users or occupants. This is vital in establishing research plan before evaluation starts. Strategic levels then require to proposed manpower or resources to sense of the data in terms of the questions asked in the beginning of research.

8.2 Conducting

Data collection is the key task in conducting POE. At this phase, the building users are identified in order to develop data collection; whether based on interviews or questionnaire. This phase is where the evaluation takes place and it is important to ensure that all data collection procedures are monitored and managed. After evaluation conducted, the data is analyzed. This involved the finding and making sense of the data in terms of the questions asked in the beginning of research.

8.3 Applying

Application of POE involves reporting the findings, recommending and planning actions. The report finding depends on the purpose to conduct. The purpose could identify problem and unsuccessful performance in facilities. Report's findings are implemented, actions are taken and the effects of the actions are measured.

9. ENERGY-EFFICIENT DESIGN PROBLEMS WHICH AFFECTING THE OCCUPANTS' COMFORT WITH RESPECT TO IEQ CRITERIA

The research done by Wong, N. H. et. al. (2005) in Singapore showed that fully glazed facade that has been increasingly used in the country causes higher energy consumption and thermal discomfort due to higher solar gain. Meanwhile, Altan, H. et al. (2008) revealed that glazed facades are potential sources of unwanted overheating and glare effects that cause indoor discomfort and result in necessity for ventilation and cooling services which again increase energy consumption in buildings. Bülow-Hübe, H. (2008) studied on glazed office building in Sweden identified lack of window blinds/shades can cause thermal discomfort.

In Denmark, a research conducted by Sebastian, W. (2008) shown that, windows and doors ranked the top of the identified problems which causing the air leakage in the building. Paul, W. L. & Taylor, P. A. (2008) study showed that occupants of the green building were more likely to perceive their work environment as warm, and occupants who felt warm was more likely to describe their work environment as poor and this might caused by the poor air conditioning system in the building. Mumma, S. A. (2002) in his research identified that radiant cooling system facing the design problem such as condensation and radiant asymmetry. Lim, J. H. et al. (2006) research found that in radiant floor cooling system, floor surface condensation and comfort are major concerns for field application. Zhen, T. & James, A. L. (2006) research on the building with radiant cooling system showed that local discomfort are the identified problem that can cause occupant's discomfort.

Wagner, A. et. al. (2007) conducted a study in German low energy office building found out that, the result of four week summer field study on thermal comfort with 50 subjects in a naturally ventilated office building in Karlsruhe, Germany, show that thermal sensation votes do not correspond to calculated predicted mean votes. Heerwagen, J. & Diamond, R. C. (1992) research found that only 20% said daylight was sufficient for working, 92% said they used the electric ceiling light to supplement daylight and 91% who said daylight was "just right" also used electric lights. A research done by Wilkinson, S. J et. al. (2011) showed that most of the energy-efficient buildings share a common problem which is lack of privacy. The summaries of findings from the studies that were carried out by the above researchers are tabulated based on the part of energy-efficient design in Table 2.0 (Please refer to Appendix III).

10. METHODOLOGY

Research Methodology is an important part in executing an academic research. The purpose of the research methodology is to arrange the research mechanism and so the research can be carried out smoothly and effectively. Hence, research methodology can be considered as a systematic framework based on sequences and aimed to achieve the research objectives. Overall, the procedures to carry out the research methodology can be summarized as follows.

10.1 Introduction

The increase of energy consumption year over year has been getting attention from many parties. This is because the over consumption of fossil energy could lead to the increase of greenhouse gasses and bring to the major environmental destruction. Besides that, it might also due to the increase of fossil energy prices as a result of high demand from all over the world. These reasons have caused many countries started to seek for alternative energy.

The development of renewable energy in Malaysia is not lacking behind compared to other countries in the region; in fact, Malaysia has started its renewable energy developments since decades ago. The development of three showcases energy-efficient buildings are the pioneer projects initiated by the government of Malaysia. The buildings are known as Ministry of Energy, Communications, and Multimedia office building, Energy Commission office building, and Malaysia Green Technology Corporation office building. These three showcase buildings have set a benchmark for the future development of energy-efficient building project. Hence, it is crucial to maintain the performance of the buildings.

In order to achieve the research aim and objectives, a research methodology has been constructed. This research will be carried out in three phases; the first phase involves preliminary study, literature review, and mapping previous study. After the completion of the first phase, the second phase of the research will be started with construct initial survey framework, survey framework development, content validity test and pilot study. The third phase or the final phase involved preliminary study, framework testing, data collection, data analysis, and lastly conclusion, and recommendation. The flowchart of the research methodology is shown in Figure 3.0 (Please refer to Appendix IV). The following section of this chapter will discuss in detail about each phase of the research methodology.

10.2 Methodology Procedure

Methodology procedure needs to be arranged systematically in order to achieve the aim of this research. The procedure is started from topic selection, followed by identifying issues, objectives, scopes, data, data collection, data analysis, conclusion and recommendation and finally the thesis write up.

To achieve the objectives of this research, the following steps will be carried out:

1. A preliminary research on the factors that affect the performance of energy-efficient design for the energy-efficient building.

2. Data collection on previous study will be conducted and a check list will be formed and sent to energy consultants, energy management consultant, project officer, and architects. These are the key people involved in the construction and design of the energy-efficient buildings. Both approaches are important, in order to understand the energy-efficient design problems which affecting the occupants' comfort.
3. Survey framework will be formulated after the information from preliminary literature review is obtained.
4. After the survey framework is formulated, content validity test will be carried out. The content validity of this research will be tested by referring to the key people involved in the construction and design of the energy-efficient buildings.
5. Pilot study need to be conducted right before the proposed survey framework are sent to the respondents. Pilot study is very important to:
   - Test the adequacy of the questions in the survey framework.
   - Test the efficiency of the sampling.
6. After the pilot study has been conducted, proposed survey framework will be tested on the occupants in the selected energy-efficient building.
7. The data will be collected after being filled up by respondents;
8. The proposed survey framework will be examined and weighted.

10.3 Literature Review

Literature review is the information or data obtained before the research is being carried out, and the information gathered is based on the previous research which carried out by researchers. In addition, literature review aimed to achieve the background of the research topic and obtains a suitable research methodology. Literature review is also aimed to obtain the facts and information that can reinforce the research which will be executed.

The information gathering of the energy-efficient building will contribute to better understanding of the energy-efficient design. Meanwhile, the subject area of design for energy-efficient design such as background, definition, type, causes and effects, and its variations further strengthened the understanding.

Survey framework is formed in this study in order to identify the problems causing the low performance of IEQ criteria in the energy-efficient building. The study from the literature review will be used to identify the potential questions for the survey framework.

10.4 Mapping Previous Study

In this stage, the IEQ criteria and energy-efficient design parameter are identified. This is the continuing process from the literature review. Only the suitable energy-efficient parameter and IEQ criteria are selected based on the mapping process from previous study.

10.5 Survey Framework Design

The information gathered from the literature review, interview session and site visit, will identify the energy-efficient design criteria in the building. The information will be used to formulate the survey framework. Generally, the survey framework will be consisting of three parts:

Part A: General information of the respondent

Part B: Identification of problems which affecting the occupants' comfort

10.6 Content Validity Test

The content validity test is a tool to assess the validation and correctness of the survey framework contents. This process is important to determine the questions asked in the survey framework are reliable and capable of achieving the research objectives. The content validity of this research will be tested by referring to the energy consultants, energy management consultant, project officer, and architects. These are the key people involved in the construction and design of the case study buildings. They will be asked to fill in a form and state whether the questions in the survey framework are highly relevant, moderate relevant or lowly relevant. Apart from that, the duplication of the questions will be also tested by asking the expert verification.

10.7 Pilot Study

Pilot study will be conducted before the survey framework been finalized. It is a small scale of preliminary study performed before the main research purposely to check the feasibility or to improve the design of the research tools. Pilot study is important to evaluate the efficiency and adequacy of the sampling.

10.8 Survey Framework Testing

After the pilot study, the constructed survey framework will be tested on the occupants from the identified energy-efficient building. Meanwhile, a survey from the Building Usable Study (BUS) methodology will be carried on the occupants in the same buildings. The BUS survey will be act as a control subject for the IEQ criteria where the constructed survey framework can be tested on its effectiveness in identifying problems which affecting the occupants' comfort corresponding to the IEQ criteria. BUS methodology is chosen because it has the same IEQ criteria in the questionnaire as the survey framework.

10.9 Sampling Data Analysis

After retrieving the feedback from the respondents, the data will be analyzed through SPSS software. The data will be collected through the proposed survey framework and incomplete form will not be used for analysis purpose. The reliability test is by using Cronbach α coefficient as a measurement tools. If Cronbach α less than 0.3, reliability is in low level and cannot be accepted. If Cronbach α is greater than 0.7, this reveal that consistency is in high level and is acceptable. Basically for each question, respondents have four options which are strongly affect, moderately affect, slightly affect and does not affect. This data will be analyzed based on the degree of severity of the factors to the respondents.

The severity index is computed by the following equation:

Severity Index (IS) = [(∑4i=0(ai* xi) / 3] × 100 %

Where:

ai = constant, expressing the weight given to i th response, i = 1,2,3,4

xi= the variable expressing the frequency of the i th responses, for i= 1,2,3,4 and illustrated as follows :

x1= the frequency of “strongly affects response”.

x2= the frequency of “moderately affects response”.

x3= the frequency of “slightly affects response”.

x4= the frequency of “does not affects response”.

11. EXPECTED OUTCOMES

This research hopefully will successful improve the current survey instruments. Critical user satisfaction towards energy-efficient design will be highlighted in order to provide clearer information regarding the perception of users towards energy-efficient design. Problems causing the inefficiency of energy-efficient design will be identified and hence will improve the future design of the energy-efficient building. Hopefully this research will be a useful reference and guidance for local contractors, architects, engineer, energy consultants, CREAM, CIDB or even academic to ensure the continuous development of energy-efficient building. And the result of the Post Occupancy Evaluation will be used as a newly designed building performance survey framework for energy-efficient building in the future

References

[1] United Nations Development Programme (2009). Promoting energy efficiency in buildings: lessons learned from international experience, retrieved July 11, 2011, from pg. 7 on http://www.thegef.org/gef/sites/thegef.org/files/publication/EEBuilding_WEB.pdf

[2] National Institute of Building Sciences (2008). Assessment to the US Congress and US Department of Energy on High Performance Buildings, retrieved December 7, 2011 from pg. 5 on http://www.nibs.org/client/assets/files/hpbc/NIBS_HighPerformanceBuildings_Report.pdf

[3] Watson, C. (2003). Review of building quality using post occupancy evaluation, retrieved July 11, 2011, from pg. 4 on http://www.postoccupancyevaluation.com/publications/pdfs/POE%20OECD%20V4.pdf

[4] Preiser, W. F. E. (2002). The evolution of post-occupancy evaluation: toward building performance and universal design evaluation. In Federal facilities council technical report no. 145 (2002). Learning from our buildings: a state-of-the-practice summary of post-occupancy evaluation. Washington, D.C.: National Academy Press.

[5] Department of Energy (2001). Federal energy management program, low-energy building design guidelines, energy-efficient design for new federal facilities, retrieved July 11, 2011, from pg. 1 on http://www1.eere.energy.gov/femp/pdfs/25807.pdf

[6] Abbaszadeh, S. , Zagreus, L. , Lehrer, D. , & Huizenga, C. (2006). Occupant Satisfaction with Indoor Environmental Quality in Green Buildings. In Proceedings of Healthy Buildings, Vol. III, 365-370, from http://escholarship.org/

[7] Wilkinson, S. J., Reed, R. G. & Jailani, J. (2011). User Satisfaction in Sustainable Office Building: A Preliminary Study. Proceeding of the 17th PRRES Pacific Rim Real Estate Society Conference, Gold Coast, Australia, _ , from http://www.prres.net/

[8] Leaman, A., Stevenson, F., & Bordass, B. (2010). Building evaluation: practice and principles [electronic version]. Building Research & Information, 38(5), 564–577. Retrieved December 6, 2011, from http://www.tandfonline.com

[9] Leaman A., Thomas, L & Vandenberg, M. (2007). ‘Green’ Buildings: What Australian Building Users Are Saying [electronic version]. EcoLibrium, November 2007. Retrieved December 6, 2011, from http://utsescholarship.lib.uts.edu.au/

[10] Peretti, C. & Schiavon, S. (2011). Indoor environmental quality surveys. A brief literature review. Indoor Air 2011. Dallas, June 5-10. Retrieved November 11, 2011, from http://escholarship.org/

[11] Hauge, A. L., Thomsen, J. & Berker, T. (2010). User evaluation of energy-efficient buildings. Proceedings of Renewable Energy Conference 2010, Trondheim, Norway.

[12] Zhang, H. & Leimer H. P. (2011). Low energy certificate – an exploration on optimization and evaluation of energy-efficient building envelope [electronic version]. Science China Technological Sciences, 54(1), 1-6. Retrieved December 6, 2011, from http://www.bbs-international.com/
[13] Krope, J. & Goricanec, D. (2009). Energy efficiency and thermal envelope. In Mumovic, D. & Santamouris, M. A Handbook of Sustainable Building Design and Engineering: An Integrated Approach to Energy, Health and Operational Performance. Sterling, VA : Earthscan. pp. 23 – 33.
[14] Thormak, C. (2001). A low energy building in a life cycle – its embodied energy, energy need for operation and recycling potential [electronic version]. Building and Environment, 37(2002), 429-435. Retrieved December 7, 2011, from http://www.sciencedirect.com/
[15] Bauer & Scartezzini (1997). A simplified correlation method accounting for heating and cooling loads in energy-efficient buildings [electronic version]. Energy and Buildings, 27(1998), 147 – 154. Retrieved December 7, 2011, from http://www.sciencedirect.com/
[16] Ahmed, A., Ploennings, J., Gao, Y. & Menzel, K. (2009). Analyze building performance data for energy-efficient building operation. In Proceedings of 26th W78 Conference on Information Technology in Construction. International Council for Building Research Studies and Documentation, CIB W 78.
[17] Kim, H., Stumpf, A. & Kim, W. (2010). Analysis of an energy efficient building design through data mining approach [electronic version]. Automation in Construction, 20(2011), 37 – 43. Retrieved December 7, 2011, from http://www.sciencedirect.com/
[18] Kantrowitz, M. (1984). Energy Efficient Buildings: An Opportunity for User Participation [electronic version]. Journal of Architectural Education, 37(3/4), 26 – 31. Retrieved December 7, 2011, from http://www.jstor.org/stable/1424802
[19] Ng, C. J. (2005). Development of Total Building Performance (TBP) Assessment System for Office Buildings. Msc. Thesis. University of Singapore.
[20] Ministry of Energy, Green Technology and Water (KeTTHA) (2006). 2006 Asean Energy Efficient Buildings Best Practices Competition. Retrieved December 6, 2011, from http://www.kettha.gov.my/
[21] Koay, A. (2011, July 5). Diamond Building: A shining example of energy efficiency. The Star. Retrieved December 6, 2011, from http://thestar.com.my/
[22] Ng, B. H. & Akasah, Z. A. (2011). An overview of Malaysia green technology corporation office building: A showcase energy-efficient building project in Malaysia. Journal of sustainable development, 4(5), 212 – 228.
[23] Choong, M. Y. (2009, December 15). Major breakthrough. The Star. Retrieved July 2, 2010, from http://thestar.com.my/
[24] Wilkinson, S. J., Reed, R. G. & Jailani, J. (2011). User Satisfaction in Sustainable Office Building: A Preliminary Study. Proceeding of the 17th PRRES Pacific Rim Real Estate Society Conference, Gold Coast, Australia, _ , from http://www.prres.net/
[25] Fadi, C, Husaunndee, A., Inard, C. & Riederer, P., (September, 2009) A new methodology for design of low energy buildings, Energy and Buildings 41(9), 982-990.
[26] Luis, P.L., Ortiz, J., Pout, C. (2008), A review on buildings energy consumption information, Energy and Buildings, 40 (2008) 394-398.
[27] Torcellini, P., Pless, S., & Deru, M. (2006). Zero Energy Buildings: A Critical Look at the Definition. Retrieved on January 15, 2010, from pg. 3-7 at http://www.nrel.gov/docs/fy06osti/39833.pdf
[28] Clift, M. (1996). Building quality assessment (BOA) for offices. Structural Survey, 14(2), 22-25
[29] Williams,B. (1993). Editorial: What Performance. Property Management. 11(13)._.
[30] Manning, P. (1987). ‘‘Environmental evaluation.’’ Build. and Environment, 22(3), 201–208.
[31] Preiser, W.F.E., Rabinowitz, H.Z. and White, E.T. (1988), Post Occupancy Evaluation, Van Nostrand Reinhold, New York.
[32] Zimring, C. M. & Reizenstein, J. (1980), Post-occupancy Evaluation: An Overview, Journal of Environment and Behavior, 12 (4), 429-450.
[33] Khalil, N. & Husin, H. N. (2009). Post Occupancy Evaluation towards Indoor Environment Improvement in Malaysia’s Office Buildings. 2(1), 186-191.
[34] Wong, N. H., Wang, L., Chandra, A. N., Pandey, A. R., & Wei, X. (2005). Effects of double glazed facade on energy consumption, thermal comfort and condensation for a typical office building in Singapore [electronic version]. Energy and Buildings, 37(6), 563-572. Retrieved December 6, 2011, from http://www.sciencedirect.com/
[35] Altan, H., Ward, I., Mohelníková, J., & Vajkay, F. (2008). Daylight, Solar Gains and Overheating Studies in a Glazed Office Building [electronic version]. International Journal of Energy and Environment, 2(2), 129-138. Retrieved December 6, 2011, from http://www.naun.org/
[36] Bülow-Hübe, H. (2008). Daylight in glazed office buildings. A comparative study of daylight availability, luminance and luminance distribution for an office room with three different glass areas. Report EBD-R--08/17. Retrieved December 8, 2011 from http://www.ebd.lth.se/

[37] Sebastian, W. (2008). Envelope Air Leakage in Denmark – A status report [electronic version]. Europäisches BlowerDoor-Symposium Mai 2008, 22-29. Retrieved December 7, 2011, from http://www.inive.org/
[38] Paul, W. L. & Taylor, P. A. (2008). A comparison of occupant comfort and satisfaction between a green building and a conventional building [electronic version]. Energy and Buildings, 43(11), 1858-1870. Retrieved December 6, 2011, from http://www.sciencedirect.com/
[39] Mumma, S. A. (2002). Chilled ceilings in parallel with dedicated outdoor air systems: addressing the concerns of condensation, capacity and cost. ASHRAE Transactions 108(2): 220-231. Retrieved December 6, 2011, from http://www.ashrae.org/
[40] Lim, J. H., Jo, J. H., Kim, Y. Y., Yeo, M. S. & Kim, K. W. (2006). Application of the control methods for radiant floor cooling system in residential buildings [electronic version]. Energy and Buildings, 41(2006), 60-73. Retrieved December 7, 2011, from http://www.sciencedirect.com/
[41] Zhen, T. & James, A. L. (2006). Radiant Slab Cooling: A Field Study of Occupant Thermal Comfort [electronic version]. Second National IBPSA-USA Conference, Cambridge, MA, 245-351. Retrieved December 6, 2011, from http://www.ibpsa.us/
[42] Wagner, A. Gossauer, E. Moosmann, C., Gropp, Th. & Leonheart, R. (2007). Thermal comfort and workplace occupant satisfaction – Results of field studies in German low energy office buildings [electronic version]. Energy and Buildings, 39(2007), 758-769. Retrieved December 6, 2011, from http://www.sciencedirect.com/
[43] Heerwagen, J. & Diamond, R. C. (1992). Adaptations and Coping: Occupant Response to Discomfort in Energy Efficient Buildings
[44] Wilkinson, S. J., Reed, R. G. & Jailani, J. (2011). User Satisfaction in Sustainable Office Building: A Preliminary Study. Proceeding of the 17th PRRES Pacific Rim Real Estate Society Conference, Gold Coast, Australia, from http://www.prres.net/

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