IMPORTANCE OF OCCUPANTS' EXPECTATIONS FOR ACCEPTANCE OF GREEN BUILDINGS: A LITERATURE REVIEW

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ABSTRACT

The buildings, where people live, work, and protect people from nature's extremes, yet they also affect human health and environment in countless ways. The increasing consensus on climate change has resulted in escalating demands on the public to make better environmental choices in building construction. The term 'green design' has been used fairly consistently over the past decade to emphasize such environmental performance of buildings. Many studies have found that the construction clients are demanding assurance of their buildings' long-term economic and environmental performance and costs. Further, the occupants have been favourably disposed to green buildings from their conventional environments. Moreover, in the early stages of a transition towards sustainability, the priorities placed on environmental issues are subscribed by society as a whole and those implicit in building owner's priorities and expectations. Hence, the modern practice has extended and complemented the conventional building construction process to achieve sustainable or high performance building. Accordingly, key research papers were reviewed in this research paper in order to identify occupants' expectations and its importance for the acceptance of green building. Literature stated that there is more potential to change the existing buildings to be more 'green', as the quality of built environment is a major expectation of building occupants. Further, most of the occupants expect quality indoor environment with properly controlled and maintained temperature, humidity, noise, lighting and thermal comfort parameters within buildings. It is due to the certainty of reaching their expectations specially to obtain comfortable working environment. Hence, it implies that the occupants' expectations are significance for the acceptance of any green building specially in moving from their typical working environments. The reason is that the poor fit between the built environment and the needs and expectations of the occupants may lead to dissatisfaction, health issues and productivity losses.

Keywords: *Building Occupants; Expectations; Green Building; Indoor Environment Quality; Acceptance.*

1. INTRODUCTION

The buildings, where people live, work, and protect people from nature's extremes, yet they also affect human health and environment in countless ways. The increasing consensus on climate change has resulted in escalating demands on the public to make better environmental choices in building construction. It is widely recognized that the current environmental crisis is a human problem and solutions depend on major changes in human attitudes, expectations and actions (Cole, 2010). The term 'green design' has been used fairly consistently over the past decade to emphasize such environmental performance of buildings fit with human expectations and actions. Further, Green Building (GB) has emerged as a new building philosophy, encouraging the use of more environmentally friendly materials, the implementation of techniques to save resources and reduce waste consumption, and the improvement of indoor environmental quality, among others in order to mitigate the impact of buildings along their life cycle (Thormark, 2006 cited Lacouture *et al*., 2008). Lacouture *et al*., (2008) further verified that the green building design would result in environmental, financial, economic, and social benefits. Green building occupants despite an increasing interest in the green building investment.

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Many researchers suggest that green building users were more forgiving of their building, which has important implications to green building design and evaluation. It has been previously argued that in order for green buildings to perform effectively in the context of a low-carbon future, a shift is required from conceptualizing the occupant as a passive recipient, to the inhabitant who may play a more active role in achieving comfort and satisfaction (Cole, 2010). It is encouraging to see green building users' capability and potentiality to balance the good features against the bad to reach their overall comfort when they are provided with control over the physical environment.

However, there were no studies more focusing on green buildings and their impact on occupants expectations. Much of the emphasis to date in green building development has been on optimizing energy and resource efficiency. Very little was known about user perception and satisfaction in green buildings (Lau *et al*., 2013). The demand and willingness of clients eventually determines the development of sustainable or green buildings (Hakkinen & Belloni, 2011). Therefore, this study is expected to identify occupants' expectations of green buildings and to convince its importance for acceptance of green buildings.

2. LITERATURE REVIEW

2.1. GREEN BUILDINGS

The indoor environment is where people spend 90% of their time (Kosonen and Tan, 2004). Hence, the occupant exposure to microbial, chemical and building-physical factors in indoor environments can lead to a series of health symptoms ranging from discomfort to clinical disease (EPA, 1995 cited Prakash, 2005). Further, this is incorporated in the human right to a healthy indoor environment as formulated in the WHO 1985 Constitution (Kosonen and Tan, 2004). Consequently, enhancing the quality of indoor environment highly concerns in recent years.

Thormark, (2006 cited Lacouture *et al*., 2008) verified that GB has emerged as a new building philosophy, encouraging the use of more environmentally friendly materials, and implementation of techniques to save resources and specially the improvement of indoor environmental quality, among others. Henceforth, GB practices are perceived by many construction industry professionals to be part of the solution to problems regarding indoor environment of buildings (Hashim *et al*., 2011). Green, or sustainable building, is the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition (EPA GB, 2008 cited Edwin *et al*., 2009). It offers an opportunity to create environmentally efficient buildings by using an integrated approach of design so that the negative impact of building on the environment and occupants is reduced (Ali *et al*., 2009 cited Hikmat *et al*., 2009).

As a study by Cheng (2007) mentioned that the concept of GB has applied in most of the countries as to reduce the impact of buildings on environment and human health. As Cheng further stated that Green Building" is called "Environmental Co-Habitual Architecture" in Japan, "Ecological Building" or "Sustainable Building" in Europe and "Green Building in North American countries. Many fashionable terms such as "Green consumption", "Green living", "Green illumination" have been broadly used. In Taiwan, currently, "Green" has been used as a symbol of environmental protection in the country. According to studies by Lacouture *et al*. (2008) and Karkanias *et al*. (2010), other benefits of bioclimatic or green buildings include lower energy and operational costs, market advantages for the building developer, higher indoor environmental quality and therefore living quality or higher productivity and lower long-term exposure to environmental or health endangering factors thus, it reduces health cost. Consequently, a recent trend toward increased concern about the impacts of buildings on the larger environment has led many building design professionals to design so-called "sustainable architecture" or "green buildings" (Levin, 1995).

2.2. *MOVING GREEN FROM NON-GREEN*

Under the category of Indoor Environmental Quality (IEQ) in the LEED checklist, IEQ comprises of indoor air quality (IAQ), including, environment tobacco smoke, Carbon dioxide monitoring, indoor chemical and pollutant source, thermal comfort, and daylight and views. According to a study by Levin (1995), among the other indoor environmental factors that must be considered are the quality of thermal, light, acoustic, privacy, security, and functional suitability.

Green Building Council showed that many of its members believed that sustainable or green building design would become a more common practice once the human benefits had been identified (Heerwagen, 2000 cited Lacouture *et al*., 2008). Noticeably, human benefits should become a hot spot of research on green buildings; occupant comfort and satisfaction which lay the foundation for a healthy and productive building, therefore, should be investigated (Lau *et al*., 2013).

Other benefits of GBs related to indoor environmental quality improvements are the reduction on health costs and the increase on employees' productivity (Ross & Lopez-Alcala, 2006 cited Lacouture *et al*., 2008) through their perceived satisfaction towards work areas (Ries *et al*., 2006 cited Lacouture *et al*., 2008). While a considerable amount of this engagement is directed at technical performance metrics such as energy use, greenhouse gas emissions, water use, etc necessary to guide positive decision-making and action, interest is also growing with respect to understanding the quality of experience that buildings afford their users (Cole, 2010). It is widely believed that occupants prefer a high degree of adaptive opportunities, as can be provided within naturally ventilated (NV) buildings as opposed to centrally controlled air conditioned (AC) designs. Many studies have found occupants are more favourably disposed to green buildings than their conventional energy-intensive predecessors (Leaman & Bordass, 2007 cited Deuble & Dear, 2012). It is widely believed that green buildings are more comfortable than conventional buildings; thereby making them more satisfying and productive workplaces, there is little empirical evidence to support this belief (Paul & Taylor, 2007).

2.3. *OCCUPANTS' EXPECTATIONS OF GREEN BUILDINGS*

Numerous studies have explored how building users perceive the indoor environment and which conditions are considered to be comfortable (Frontczak & Wargocki, 2010). For all actors involved with planning, developing and managing buildings, the environmental impact relating to energy use and the quality of the indoor environment are both aspects of major concern. However, many studies stated that high quality indoor environment is the major expectation of building occupants as it is directly affected on their health, well-being and the productivity. Much of the emphasis to date in green building development has been on optimizing energy and resource efficiency. However, green buildings need to do more than effectively use natural resources within economic means (Lau *et al*., 2013).

It is crucial that a reduction in the environmental impact of a building is not achieved through compromising the indoor environment. They must also support the comfort and well-being of their occupants. Very little was known about user perception and satisfaction in green buildings (Lau *et al*., 2013). The environmental impact relating to energy use and the qualities of the indoor environment are two of the most significant environmental aspects relating to buildings. To some extent these are interconnected since for example lower energy use for heating, which normally means less environmental impact, may cause discomfort for the users. It is thus crucial that a reduction in the environmental impact of a building is not achieved by lowering the quality of the indoor environment (Malmqvist, & Glaumann, 2006, 2009). In standard sealed buildings, heating, ventilation and air-conditioning (HVAC) systems are often sized and operated to maintain indoor conditions within a narrow range of temperatures and humidity. In many places, comfort expectations have evolved to leave little margin for error in this regard Borgeson & Brager, 2011). Hence, to ensure continued growth in the adoption of green building technologies it is important to ensure that customer needs are being addressed and that claims of performance are warranted; this means evaluating the performance and life-cycle costs of new green buildings as they come on line. The particular import to corporate customers in green buildings is the indoor environmental quality (usually measured in terms of occupant comfort) of a building because there is evidence that links comfort to satisfaction and productivity (Paul & Taylor, 2007). Building users will often employ a wide range of passive cooling strategies and adaptive opportunities available to them expecting their own comfort conditions to suit their needs (Deuble & Dear 2012).

2.4. INDOOR ENVIRONMENTAL QUALITY IN GREEN BUILDINGS

The indoor environment is where people spend 90% of their time (Kosonen and Tan, 2004). Hence, the occupant exposure to microbial, chemical and building-physical factors in indoor environments can lead to a series of health symptoms ranging from discomfort to clinical disease (EPA, 1995 cited Prakash, 2005) Further, this is incorporated in the human right to a healthy indoor environment as formulated in the WHO 1985 Constitution (Kosonen and Tan, 2004). Consequently, enhancing the quality of indoor environment highly concerns in recent years. The term Indoor Environmental quality (IEQ) is referring to "the environmental qualities within a building, used especially in relation to the health and comfort of building occupants" (Hobday, 2011). Hence, IEQ refers to all aspects of the indoor environment that affect the health and well-being of such occupants (Levin, 1995). According to a studies by Prakash (2005), Portman *et al*. (2006 cited Lee *et al*., 2009) and Lee (2010), IEQ is one of five categories of the LEED (Leadership in Energy and Environmental Design) building assessment system, developed by the Green Building Council of the United States of America including sustainable site, energy and atmosphere, water efficiency, materials and resources, and indoor environmental quality.

Under the category of IEQ in the LEED checklist, IEQ comprises of indoor air quality (IAQ), including, environment tobacco smoke, Carbon dioxide monitoring, indoor chemical and pollutant source, thermal comfort, and daylight and views. According to a study by Levin (1995), among the other indoor environmental factors that must be considered are the quality of thermal, light, acoustic, privacy, security, and functional suitability. Henceforth, IEQ generally encompasses factors such as temperature, humidity, ventilation, indoor air quality, day lighting and lighting quality, thermal comfort and access to views.

Green building parameters to ensure occupants' IEQ expectations

Once the evaluation and assessment of environmental impact of a building is carried out before it is built and when only the representation of the building is available, environmental impacts from that building could be prevented. Hence, IEQ is a major concern in developing such green assessment tools due to its considerable impact on wellbeing of the building occupants. Thus, most of green assessment tools specially LEED Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) and Green Star techniques have developed considering the IEQ as a major criteria towards sustainable buildings (Boonstra and Pettersen, 2003; McKay, 2007).

According to the Table 1, IEQ is a major concern in developing such green assessment tools due to its considerable impact on wellbeing of the building occupants. Hence, many IEQ parameters have concerned in these green assessment tools to fulfil IEQ requirements in green buildings. These parameters can be applied in order to control temperature and humidity such as, room temperature settings, zone and system control, using low emitting materials etc while sound insulation, absorption materials, equipment noise controlling strategies are applied to ensure acoustic quality in green buildings. Operable windows, air intake, fresh air and ventilation rates can be applied as the suitable parameters for ventilation quality. As the occupants are highly expected, IAQ can be ensured by adapting many green parameters including CO_2 and VOC monitoring and controlling, control of smoking, air change effectiveness, pollutant source controlling and construction IAQ management plan. Further, many parameters can be applied in order to maintain and improve the lighting quality and thermal comfort in green buildings. As most of occupants are expecting quality indoor environment while working in green buildings, the properly controlled IEQ factors ultimately help to execute the expectations of green building occupants.

Table 1: IEQ parameters in green buildings (Boonstra and Pettersen, 2003; Haapio, 2008; Wallhagen, 2010; GBCSL, 2010)

IEQ factor	LEED	BREEAM	Green Star	CASBEE	GREEN^{SL}®
Temperature and humidity	Controllability of systems	Local temperature control		Room temperature setting Variable loads and following-up control Zoned control Temperature and humidity control	Low - Emitting Materials Indoor Chemical & Pollutant Source Control
Acoustic	Controllability of systems	Noise	Internal noise levels	Background noise Equipment noise Sound insulation of openings Sound insulation of partition walls Sound absorption	Controllability of Systems
Ventilation	Environmental tobacco smoke control Co2 monitoring Ventilation efficiency	Operable windows Air intake Fresh air	Ventilation rates	Ventilation rate Natural ventilation performance Consideration for outside air intake Air supply planning	Monitoring Increased Ventilation
Indoor Air Quality	Indoor chemical and pollutant source control Minimum IAQ performance Construction IAQ management plan	Smoking Clean carpets	Air change effectiveness CO_2 and VOC monitoring and control Hazardous materials	Type of A/C CO_2 monitoring Control of smoking	Minimum IAQ Performance Smoke (ETS) Control Outdoor Air Delivery Construction IAQ Management Plan
Day Lighting and Lighting Quality	Low-emitting materials Day lighting	80% adequately day light Window antiglare Ballets Illuminance levels Independent lighting control	Daylight Daylight glare control High frequency ballets Electric lighting levels	Daylight factor Openings by orientation Daylight devices Glare from light fixtures Daylight control Illuminance level Uniformity ratio of illuminance Lighting controllability	Daylight and Views
Thermal Comfort	Thermal comfort	Thermal comfort	Thermal comfort	-	Thermal Comfort,
Access to Views	Views	Desks location	External views	-	Daylight and Views

2.5. OCCUPANTS' ACCEPTANCE OF GREEN BUILDINGS IN TERMS OF IEQ EXPECTATIONS

Occupant acceptance of an indoor environment in green buildings depends on a number of environmental parameters. A number of studies have attempted to understand the quantitative relationship between occupant overall satisfaction and the building's performance on individual IEQ factors which has the most significant effect on occupant satisfaction (Kim & Dear, 2011). Hence, four basic components, namely thermal comfort, indoor air quality (IAQ), aural and visual comforts are identified for determining an acceptable IEQ (Frontczak and Wargocki., 2011 cited Lee *et al*, 2011). Compared to past work environments, the design of a modern work environment must anticipate high levels of spatial and technological change by providing responsive thermal and air quality delivery systems, as well as flexible technology infrastructures. However, the current standards and guidelines for indoor environments were predominantly developed based on experiments involving human subjects in environmental chamber conditions without consideration of these modern office variables (Loftness *et al*., 2009 cited Lee *et al*., 2009).

Furthermore, the design of high performance, green buildings promise to provide a better and healthier environment for occupants (Kamaruzzaman *et al*., 2010). Typical benefits of sustainable or green buildings include savings from operating costs and the increased bottom line through higher employee satisfaction and job performance due to the better quality of indoor environment (Kats *et al*., 2003 cited Lee *et al*., 2009). The demand from clients, the satisfaction from tenants, and the higher productivity from occupants due to GB are possible means to motivate the business stakeholders. A better understanding of the needs and expectations of the business stakeholders will bridge the gap between government and the market which make the GB more preferable to conventional buildings. Construction clients are demanding assurance of their buildings' long-term economic and environmental performance and costs. The problem for the best environmentally friendly buildings is that the environmental attributes are often invisible and only appreciated once the building is occupied and in use (Bartlett & Howard, 2000).

According to Edwards (1998), the benefits of bioclimatic or green buildings include lower energy and operational costs, market advantages for the building developer, higher indoor environmental quality and therefore living quality or higher productivity the inhabitants and lower long-term exposure to environmental or health endangering factors. Green buildings also have indirect benefits and advantages compared to conventional ones: they establish a psychologically and mentally more pleasant indoor environment, due to the utilization of natural lighting and ventilation (Karkanias *et al.*, 2010). Accordingly, green building users are more forgiving of their green building, which work best with ‘green' occupants. Nonetheless, it amplifies how occupant attitudes and expectations play an important role in the way green buildings are designed, built and received. Psychological dimensions of occupant adaptation, such as attitudes, expectation and control are important to consider in green building design. However, future studies across a broader sample of buildings are needed to understand how occupants' pro environmental attitudes influence their tolerance of green buildings. Given the urgency to mitigate global warming, it has become apparent that people's attitudes, and the behaviours they entail, can be shifted. Whilst buildings take years to build or months to retrofit, the path to altering people's expectations of the built environment presents another, potentially more accessible strategy to moving buildings towards more green from non-green buildings (Deuble & Dear 2012).

3. SUMMARY

The increasing consensus on climate change has resulted in escalating demands on the public to make better environmental choices in building construction. It is widely recognized that the current environmental crisis is a human problem and solutions depend on major changes in human attitudes, expectations and actions. Hence, it emerges the importance of facilitating high quality indoor environment within buildings. Consequently, many tools and concepts have been developed to determine criteria for healthy and comfortable buildings with high quality indoor environment. Green building concept has emerged as a new building philosophy to provide better and healthier indoor environment for building occupants. Hence, the modern practice extended and complemented the conventional building construction process to achieve sustainable or high performance building. There is also more potential to change the existing buildings to be more ‘green', as the quality of built environment is a major expectation of building occupants. The occupants have been favourably disposed to green buildings from their conventional environments. It is due to the certainty of reaching their expectations specially to obtain comfortable working environment. It implies that the occupants' expectations are significance for the acceptance of any green building specially in moving from their typical working environments. The reason is that the poor fit between the built environment and the needs and expectations of the occupants may lead to dissatisfaction, health issues and productivity losses. Henceforth, occupants' attitudes and expectations play an important role in the way green buildings are designed, built and received and its acceptance.

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