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Influences of human behaviour on energy efficiency in commercial buildings

Nurul Sakina Mokhtar Azizi

Dedicated to my dearest Babah and Mama for their unconditional love, and to my endlessly supportive siblings Angah & Apan
Abstract

Green building was introduced to reduce energy consumption and minimise the adverse impact to the environment. This research attempts to understand the behaviour of building occupants and its implication towards energy saving. With better understanding of the building occupants’ behaviour, building management strategies can be efficiently improved. A comparative case study approach was adopted, along with mixed method for data collection and analysis. Three buildings in Malaysia and five buildings in New Zealand were selected as the research case study.

The analysis shows that occupants in the green buildings practice better energy saving than those in the conventional buildings. Better energy management strategies have been implemented in the green buildings as compared to the conventional buildings. These have been proven to encourage the building occupants to save energy. Although results showed that the energy management strategies and the design features in green buildings promote occupants to save energy, yet these did not motivate the building occupants to save energy.

This study has contributed to the existing body of knowledge by providing an understanding of the relationship between occupants’ behaviour and buildings energy efficiency. As a result, energy management strategies can be developed in order to increase the occupants’ level of practice in saving energy. This research has also provided useful information on the occupants’ level of interaction with the building control system. Findings revealed that green building design is not the only contributing factor in energy reduction. The need for the building occupants to practice green behaviour is equally important. This is possible through engagement of occupants’ behavioural modifications.
ACKNOWLEDGEMENTS

The writing of this PhD thesis was a journey that provided a valuable learning experience with many challenges. The past 4.5 years have nurtured my personal growth in many ways.

Firstly, and above all, I praise God, the almighty for providing me this opportunity and granting me the capability to proceed successfully. This thesis appears in its current form due to the assistance and guidance of various parties. I would therefore like to offer my sincere thanks to all of them.

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I would also like to express my appreciation to Associate Professor Dr Adi Che Irfan who provided me with the initial contacts for me to start off doing the data collection in Malaysia for this research. Not forgetting, my profound thanks to all the participants who participated in this research for their valuable time.
I am grateful to all my friends and colleagues at the research office, especially Dr Phanida Phukoetphim, Dr Sandeeka Manakkara, Dr Subeh Chowdury, Dr Stephan Hassold, Dr Alice Yan Chang, Dr Ting Ting, Dr Bo Li, Dr Temitope, Har Einur, Dr Khairil Izam, Zulkfli Sapeciay, Dr Pham Xuan Hoa, with whom we have shared many discussions on the research, and for their continuous encouragement. This PhD journey had been such an emotional roller coaster, you guys at the office made the learning environment exciting and fun. Not forgetting all my friends outside the office, Norliza Julmohamad, Aini Shamsi, Alifdalino Sulaiman, Imelda Saran, Agkilah Maniam, Hemyza Budin, Sharidah Azuar, Nabilah Ismail, Syazwa, Dr Yana Mohtar, Nawwarzawani Dr Norsaremah Salleh, Diyana Fazkhurazi, Sue Yahya, Nurul Husna, Halim Embong, Amir Razlan, Fadzlina Yahya, Ili Liyana Azman; thank you for being there with me through ups and downs. I also thank Jo Adams, for proof-reading my thesis and her assistance in checking grammar, and making the thesis look more consistent.

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* in cases where the PhD candidate was the lead author of the work that the candidate wrote the text.

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Parts of Sections 8.1, 8.2, 8.3, 8.4, 8.5 in Chapter 8 "An analysis of the differences in motivation between occupants in green and conventional buildings" and Section 9.2 were extracted from this co-authored work:


| Nature of contribution by PhD candidate | Data collection, data analysis, and paper writing |
| Extent of contribution by PhD candidate (%) | 80 |

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Adopting green buildings is believed to reduce environmental impact and provide a healthier environment for occupants (WGBC, 2009; Kubba, 2010). The emergence of green buildings has been due to the adverse impact on the environment of conventional buildings which have contributed to approximately 30 to 40 per cent of global energy usage (UN, 2007). While implementation of green buildings is required for energy reduction, the building occupants also have a role to play in reducing energy consumption. Users of buildings impact on the energy efficiency performance of green buildings (Bordass et al., 2001; Browne and Frame, 1999; Cole and Steigner, 1999; Hes, 2005; Menezes et al., 2012). Green behaviours are actions that building occupants take to reduce energy consumption in a building (Browne and Frame, 1999; Cole and Steigner, 1999; Roisin, 2013) and these behaviours are the primary focus of this thesis.

Successful energy performance of green buildings can be achieved by reducing energy consumption through changes in human behaviour. Studies by Cole and Steigner (1999) and Steinberg et al., (2009) have shown that the integration of energy saving behaviours has not been given sufficient focus in green buildings. The Energy Efficiency Conservation Authority (EECA, 2012) in New Zealand, as well as other organisations in developed countries, such as CarbonTrust, the United Kingdom (2010); Energy Star, the United States (2012); and international guidelines such as the International Standards Organisation (ISO, 2011), encourage energy saving behaviour as a way to reduce energy consumption in office buildings. Although concerns have been raised, there is limited research on understanding the
current levels of practice in energy saving behaviours in buildings. An important question that needs to be asked is: In what ways can building occupants be encouraged to practice energy saving behaviour? Previous studies showed that there are contradictory findings as to whether green building occupants’ practice better energy saving behaviour than conventional building occupants’ (Lynam, 2007; Steigner et al., 2009; Tajabadi, 2010). Given that occupants’ behaviour is highly likely to be influenced by how the buildings are managed, this raises the question whether there are differences between energy management in green and conventional buildings. Therefore, the energy management strategies in green and conventional buildings are compared in this thesis.

This thesis is focused on understanding the relationship between buildings and their occupants, in order to achieve greater energy reduction in buildings. The overall aim of this thesis is to improve energy management strategies in buildings using cases from Malaysia and New Zealand. This study is done across two different cultures, with two different populations. There are limited studies that investigate occupants’ thermal adaptation in different climate region (Zhu, Ouyang, Cao, Zhou, & Yu, 2015). For instance, van Hoof & Hensen (2007) speculated that countries of moderate climate with air temperature above 20°C are more suitable to adopt the adaptive thermal comfort standard than those with the colder climate. Yu, Cao, Cui, Ouyang, & Zhu (2013), a study in China between two different climate (northern vs southern region) showed that people from the colder climate are found to be more tolerant of discomfort in feeling cold than those who are from the warmer climate. Another study on comparison between two different climates (China vs Denmark) by (Yu, Simone, Levorato, Zhu, & Olesen, 2014) also indicated that occupants in Denmark where the climate is colder were more tolerant of discomfort. However, neither of these studies allowed the building occupants to exercise any coping mechanism in response to thermal discomfort. They were only allowed sedentary activities such as reading, writing, and surfing the internet.
The occupants were not allowed to adjust their clothing in which they were given specific clothing during the conduct of the study. Thus, these restrictions can affect occupants’ level of tolerance to thermal discomfort. By allowing these behavioural adjustments can reduce their discomfort level. To date, researchers have emphasised the importance of having continuous research in understanding the relationship between buildings and the occupants (Baird, 2015; Humphreys, 1995). Therefore an analysis of occupants’ responses in thermal discomfort in different climates (Malaysia vs New Zealand) is necessary to gain a better understanding in designing buildings. This thesis is structured into four stages. The next section describes the development of the thesis according to the stages depicted in Figure 1.1.
Energy Management Strategies

Office appliances, lightings, heating ventilation air-conditioning

Computer usage behaviour

Risks associated in implementation of green buildings

Energy Management Strategies

Conventional building

Strategies practices

STAGE 1

Development of energy management framework

STAGE 2

Energy saving behaviour

STAGE 3

Occupants response to thermal discomfort

STAGE 4

Motivational factors to encourage energy saving behaviour

Figure 1. 1 Overall thesis stage
1.2 Overall thesis stages

The evolution of this thesis as depicted in Figure 1.1 is described in detail in this section. This thesis is a study based on a series of published and unpublished research papers. It follows the University of Auckland PhD Guidelines (UoA, 2014) in which the PhD candidate is the lead or sole author of the publications, and where the introductory and concluding chapters of a thesis are included in addition to the research papers.

1.2.1 Stage 1: 1A Risks associated in the implementation of green buildings.

Stage 1 of this thesis consists of two parts: 1A and 1B. The first stage (1A), as shown in Figure 1.1, begins with an exploration of the risks associated with implementing green buildings. The various risks were categorized into three broad phases of a building project: the (1) design phase; (2) construction phase; and (3) operational phase.

The motivation for exploring the risks associated with the implementation of green buildings was to better understand the challenges and barriers in constructing green buildings. There have been many cases reporting that green buildings are not successful in achieving their expected energy efficiency performance (Marsh, 2009; Howe and Gerrad, 2010).

Previous studies have identified various risks in green building implementation (Ashuri, 2010; Marsh, 2009), but the main identified risks were unknown. This led to the question of what are the risks associated with implementing green buildings? Therefore, the objective of this study in Stage 1A was to identify the risks associated in implementing green buildings in the three phases of a building project (design phase, construction phase and operational phase). The categorisation of the risks provides a better structure to understand in which
phase of a building project most risks lie and could help in the understanding of energy efficiency improvements.

1.2.2 Stage 1: 1B Energy management strategies to achieve energy efficiency performance

The categorisation of the risks in the phases of a building project in Stage 1A allowed a more focused approach to the study and a consequential reduction in the scope of the research. Risks involved during the operational stage of a building project were chosen as the next focus of the study in Stage 1B. This is because ensuring energy efficient performance during the operational stage has commonly been reported as the main risk in green buildings. A majority of 50\% out from the literature showed that risks during the operational stage are essential in ensuring successful performance of green buildings. The actual energy consumption of green buildings is often different than the predicted energy consumption (Ashuri, 2010; Bordass et al., 2001; Cohen et al., 2007; Howe and Gerrad, 2010; NAO, 2002; Sawyer et al., 2008; Scofield, 2009; Wedding, 2008). The main reason for this discrepancy has been found to be due to facility managers who do not operate the building as intended, and occupants behaving differently from expected (Andrews et al., 2010; Bordass et al., 2001; Cole and Steigner, 1999; Kubba, 2010; Reiss, 2005). Several studies indicated that 50\% of the total energy consumption of the building are influenced by the various occupants behaviour (Bourgeois, Reinhart, & Macdonald, 2006; Cushman-Roisin & Dreissigacker, 2009; WBCSD, 2009). Therefore, understanding the impact of variation in occupants behaviours on energy use is essential to achieve an optimum energy reduction. The occupants vital role during operational of the building led to the research question of how can buildings be managed to save energy?
Hence, the research at Stage 1B introduced a framework for energy management strategies to ensure energy efficient performance in buildings. The motivation for introducing an energy management strategy framework was driven by the lack of operational and maintenance performance-rating tools that are specifically for green buildings. Operational and maintenance performance rating tools such as the *Leadership in Energy and Environmental Design Existing Building Operational and Maintenance (LEED-EBOM) Guideline* (USGBC, 2009), or the *Building Research Establishment Environment Assessment Method-In Use Guideline* in the UK (BREEAM, 2011), do exist but needed investigation into their relevance to the case study buildings. The available guidelines for conventional office buildings in New Zealand and in Malaysia were not comprehensive, and the effectiveness of the guidelines was unknown. Therefore, the research objective in Stage 1B of this thesis identified strategies to achieve energy efficient performance and test the implementation in the selected case study buildings.

1.2.3 Stage 2: 2A Overall energy saving behaviour practice

Understanding the energy management strategies in Stage 1B showed a difference in how energy is managed between green and conventional buildings. Findings from the case studies showed that an energy management framework can assist operators to improve energy efficiency performance. A section of the energy management framework that is targeted specifically at encouraging energy saving behaviour was taken as the focus of the study in the next part of this study (Stage 2). Occupants’ behaviour in reducing energy usage was chosen as the focus of the study because that behaviour appeared to have been given less focus in terms of the contribution to improving energy efficiency performance in green office buildings compared to the building system (Cole and Steigner, 1999; Levine, 2007; Lopes et
al., 2012; Steinberg et al., 2009). As shown in Figure 1.1, Stage 2 consisted of two parts; 2A and 2B.

The research in Stage 2A investigated energy saving behaviours that reduce the energy consumption of office appliances and lighting; and heating, ventilation and air-conditioning (HVAC). A total of 17 listed of behaviours that were believed to reduce energy usage were examined and compared between occupants in the green and conventional buildings. The comparative study of the occupants’ level of practice in reducing energy usage in buildings was conducted to investigate whether green building occupants practiced better energy saving behaviour than the conventional building occupants.

The motivation for this comparative study was driven by the contradictory findings in the previous studies which showed inconclusive evidence in regards to whether working in green buildings encouraged occupants to save energy more than those occupants in conventional buildings (Kato et al., 2010; Lynam, 2007; Steinberg et al., 2010; Tajabadi, 2010). Given that these studies investigated different behaviours in energy saving, it was difficult to draw an affirmative conclusion. In addition, there were behaviours in saving energy that were not included in the green buildings studied. A more comprehensive list of behaviours in saving energy were investigated which led to the question of what is the overall level of practice in reducing energy usage by building occupants in green and conventional buildings? Therefore, the research objective in Stage 2A case studied the overall level of practice in energy saving behaviour; comparing occupants in the green with those in the conventional buildings.
1.2.4 Stage 2: 2B Energy saving behaviour and computer usage

Stage 2A led to the conclusion that, overall, the green building occupants’ practiced better energy saving behaviours than occupants in the conventional buildings. However, the findings in Stage 2A only provided an overview practice of the occupants’ behaviour. In order to gain a better analysis of the occupants’ behaviour, the scope of the energy saving behaviours was reduced to specifically focus on computer usage since findings from the building case studies in both countries showed that energy saving practices is observed most in computer use. This led to the question; do occupants in green buildings practice better energy saving behaviour in computer usage than occupants in conventional buildings? This necessitated an examination of the relationship between the management strategies practiced with the behaviours in the building case studies to gain a better understanding of the situation.

1.2.5 Stage 3: Occupants responses to thermal discomfort

Stage 2B led to the conclusion that there are significantly more occupants in the green buildings that practice computer use energy saving behaviour than occupants in the conventional buildings. Stage 2B also led to an understanding of what strategies were successful in encouraging energy saving behaviour among building occupants.

Another theme of energy saving behaviour was examined in Stage 3 of this study: that of thermal discomfort; that is, what do occupants do when they feel too hot or too cold in buildings? Occupants’ responses to thermal discomfort in the buildings were examined to see whether they adopted actions that consumed less energy in buildings; and what actions they took that provided healthier benefits to the occupants. There are three coping mechanisms that occupants engage in when facing thermal discomfort, namely: (1) environmental adjustment; (2) personal adjustment; and (3) psychological adjustment (Brager and de Dear, 1998; Heerwagen and Diamond, 1992).
The reason for investigating occupants’ responses to thermal discomfort was due to the many studies that have found high levels of discomfort issues in green buildings, where occupants have reported finding it too cold during the winter and too hot during the summer (Abbaszadeh, 2006; Baird, 2010; Leaman and Bordass, 2007, Paul and Taylor, 2008). These studies have found that occupants’ responses to thermal discomfort increased the energy consumption of the building. It is important to investigate occupants’ responses to thermal discomfort since energy savings can be achieved by adapting more behavioural and psychological modifications and by efficiently adjusting the environmental control systems. Behavioural modifications reduce energy consumption in buildings, and also create healthier personal actions by the occupants since there is more muscle movement (Heewargen and Diamond, 1992). However, there is a limited understanding of the level of practice of these thermal discomfort coping mechanisms when examining green and conventional buildings. Green building design features such as the spacious common room and access view to the natural environment are known to reduce occupants stress level,(Haynes, 2007; Joye, 2007; McCunn & Gifford, 2012; Miller, Pogue, Gough, & Davis, 2009) but there are uncertainties as to whether it influences occupants behaviour response in thermal discomfort (Gauthier & Shipworth, 2015; Moezzi & Goins, 2011). There are two school of thoughts where the perception of working in green buildings can either encourage occupants to save energy (Deuble & de Dear, 2012), or create a rebound effect where occupants adopt poor energy saving behaviour(Bourrelle, 2014; Sorrell, Dimitropoulos, & Sommerville, 2009). Therefore, this led to the question, what do occupants do in response to thermal discomfort and are there significant differences in the behaviour of occupants between green and conventional buildings?
Since occupants’ responses to thermal discomfort have energy implications for the energy efficiency performance of green buildings, Stage 2B examined the differences between green and conventional buildings in how occupants respond to thermal discomfort. The adaptive thermal comfort guidelines (i.e., International Standard ASHRAE 55-2004 and European Standard EN 15251) propose that buildings should be designed in a way that provides a wider opportunity for occupants to adopt behavioural adaptations (Nicol et al., 2012). Therefore the research objective in Stage 3 examined what people do when they are too hot or too cold, and whether there are significant differences between green and conventional buildings in the behaviour of occupants.

1.2.6 Stage 4: Motivational factors to encourage energy saving behaviour practice

Stage 3 of this thesis led to an understanding of the differences in occupants’ responses to discomfort in the green and conventional buildings. The findings in Stage 3 indicated that the design attributes (i.e., the views of the natural environment outside the building, and common spaces) in green and conventional buildings encouraged occupants to demonstrate green behaviour by engaging in personal adaptations such as walking around in the building when feeling cold. The occupants in the green buildings were also found to be less likely to adjust the environmental control systems, demonstrating that the green building occupants cope with discomfort better than the occupants in the conventional buildings. The level of the occupants’ interaction with the environmental control systems provides useful information to model energy use in buildings. A suggestion for improvement was to also have a hybrid control system, since results from the case studies showed that the manually operated windows are not being opened or closed properly. These findings in Stage 3 indicated that there is a relationship between how occupants behave with the building type. Therefore in the
next part of the thesis, in Stage 4, the focus became on whether occupants’ motivations to practice energy saving behaviour in the green buildings are different to occupants in the conventional buildings.

The findings from previous stages (stage 2 and 3) are consistent with several earlier studies (Tajabadi, 2010; Steinberg et al., 2010) that working in green buildings encourage occupants to save energy. A better understanding on the relationship between the management strategies practiced in the building case studies with the occupants’ behaviour was achieved. However, there is little understanding on how does the difference in the building management strategies, as well as the perception of working in green building give impact on the occupants’ motivation to save energy. Therefore, the research question in Stage 4 of this thesis is; are green building occupants more motivated to save energy than conventional building occupants? Several earlier studies showed that the green building occupants are motivated to save energy than the conventional building occupants due to the difference in their concern for the environment (Deuble & de Dear, 2012; Lynam, 2007).

The practice of the facility management in green buildings showing leadership by being proactive in communicating concern for the environment (McCunn and Gifford; 2012; Mokhtar Azizi et al., 2012; Li et al., 2013) raises the question whether does this create a social norm among the building occupants through a collective attitude of wanting to be example to others. Other studies showed that the facility management assumed the building occupants will more likely save energy by informing on the energy costs (Mokhtar Azizi et al., 2013). Therefore, Stage 4 adds to the debate about the energy saving motivation.

The research objective at Stage 4 was to examine whether the building occupants’ motivation to save energy differs across the different building types. The findings in Stage 4 led to the understanding that the motivation to save energy was not different between building
occupants in the green and conventional buildings. The overall aim of the thesis, which was to improve energy management strategies in buildings, was achieved by examining the occupants’ level of practice in reducing energy usage and the impact it has on their motivation to save energy. The results of this study lead to conclusions and recommendations about what particular strategies are potentially effective and assist in improving occupant behaviour.

1.3 Research questions and objectives

The overall aim of this study was to improve energy management strategies in buildings using cases from Malaysia and New Zealand. There were a total of six research objectives and research questions below relating to the thesis stages described above, as presented in Table 1.1. The research objectives for Stage 1 of this thesis aimed for the development of an energy management framework. The research objectives in Stages 2, 3, and 4 were used to identify whether the energy management strategies implemented in the green and conventional buildings were effective.

Table 1.1 Research questions and objectives

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<td>Stage 1</td>
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<td>What are the risks associated with implementing green buildings? To investigate the risks associated in implementing green buildings in three stages of a project: (1) design stage; (2) construction stage; (3) operational stage</td>
<td>3: Risks associated with the implementation of green buildings</td>
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<tr>
<td></td>
<td>1B</td>
<td>How are the buildings managed in order to save energy? To identify the energy management strategies used in green and conventional buildings in Malaysia and New Zealand</td>
<td>4: Management practices to achieve energy</td>
</tr>
</tbody>
</table>
1.4 Overview of thesis methodology

A sequential, exploratory, mixed method approach was used to achieve the research objectives in this study (Babbie, 1990; Creswell, 2003; Mc Murray et al., 2004). In order to examine the energy management strategies in green and conventional buildings, a case study of the building types in two different countries was used. A total of eight buildings were used as case study buildings. Two green buildings and one conventional building were selected in Malaysia; and three green buildings and two conventional buildings in New Zealand. New Zealand case study buildings were chosen because the country is known for its green image and high awareness of energy efficiency issues amongst the general population (Brown and Stone, 2007; Smith, 2008). The New Zealand government encourages the implementation of
green buildings and the private sector voluntarily builds green buildings. In Malaysia, the government has an interest in implementing green buildings and provides contractors with tax exemptions to encourage green building implementation due to the lack of voluntarily participation in constructing green buildings. Furthermore, energy efficiency awareness amongst the population in Malaysia is generally poor (Kumar, 2012; Saidi, 2014; Tajabadi, 2010). Both countries New Zealand and Malaysia have green buildings, but the different level of awareness about energy efficiency in each country enabled the researcher to draw different conclusions and investigate different strategies regarding the encouragement of energy saving behaviour.

Case study buildings were selected to compare energy efficiency practices and outcomes between green and conventional buildings. A case study methodology is suitable for this study because it allows researchers to use multiple sources of evidence within a real-life context (Yin, 2002). A detailed explanation of the methods used can be found in Chapter 2.

Table 1.2 presents the overview of the research methodology used to achieve each of the objectives in this thesis. The research undertaken in Stage 1 used a qualitative research method, in which content analysis was used to extract relevant information to assess the energy management strategies implemented. The research objectives in Stage 1 were also achieved through discussions with the construction industry, architects, and building managers of the buildings. The research objectives in Stages 2, 3, and 4 used a quantitative method. Data was collected using questionnaires as the instrument to collect the relevant data from the building occupants in the case study buildings.
Table 1.2 Research methods

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<th>Data sources</th>
<th>Research method</th>
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|        | To investigate the risks associated in implementing green buildings in three stages of a project: (1) design stage; (2) construction stage (3) operational stage | • Literature  
• Discussion with practitioners | • Literature review  
• Participation in conferences and seminars  
• Preliminary discussions with the construction industry, building managers  
• Observation at site visit in New Zealand and Malaysia case study | QUALITATIVE METHODS |
| Stage 1| To investigate the energy management systems used in green and conventional buildings in Malaysia and New Zealand | • Case studies  
• Drawing plan  
• Active and passive designs of energy efficiency  
• Complaint log report  
• Design energy index  
• Actual energy index  
• Energy data for the last 3 years  
• Energy reports of case studies  
• Discussion with building managers of case studies  
• Discussion with Architects of case studies | • Observations at case study site visits to New Zealand and Malaysia  
• Discussions from case study building managers and architects | |
|        | To investigate the overall energy saving behaviour in green and conventional buildings in Malaysia and New Zealand | • Literature  
• Survey questionnaire data  
• Discussion with building managers  
• Energy report of case studies | • Uploaded questionnaire survey online on organization website  
• Distributed hard copy questionnaire survey to occupants through building managers of each case study building  
• Discussion with building managers | QUANTITATIVE METHODS |
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<th>Stage</th>
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<tr>
<td>Stage 4</td>
<td>To investigate occupants’ motivation to practice energy saving behavior between green and conventional buildings in Malaysia and New Zealand</td>
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</table>

### 1.5 Thesis structure

The format of this doctoral thesis is a thesis with publications following the University of Auckland PhD guidelines (UoA, 2014). Hence, the chapters of the thesis are extracted from published and unpublished research papers. This doctoral thesis is comprised of a total of nine chapters. Chapter 1 is the introduction of the thesis; followed by chapter 2, research methodology. Chapters 3 to 8 are extracted from the published and unpublished papers. There are a total of eight journal papers and three conference papers. Three of the journal papers have been published. The remaining five journal papers have been submitted for review. The last chapter of this thesis is the conclusion.
Chapter 1 Introduction

The introduction of this thesis describes the background of this study, the research problems and objectives and the overview methodology used in this study.

Chapter 2 Research methodology

This chapter describes the research methodology used to achieve the research objectives of this study, along with methods of data collection and analysis tools.

Chapter 3 Risks associated with the implementation of green buildings

The risks associated in implementation of green buildings were categorized in to the three phases in a project: the (1) design phase; (2) construction phase; and (3) operational phase. Chapter 3 is based on extracts from the papers listed.

Extracted from:

Chapter 4 Management practice to achieve energy efficiency performance

Identifies from the literature strategies to achieve energy efficient performance and examines energy management strategies using case study buildings in New Zealand and Malaysia. Chapter 4 is based on extracts from the papers listed.

EXTRACTED FROM:


Chapter 5 Overall energy saving behaviour practices

Chapter 5 presents the investigation of the overall level of practice in reducing energy usage in green and conventional buildings. A total of 17 energy saving behaviours were assessed in the study. The study provided an overview of understanding of the general practices of the occupants in the green buildings when compared with those in the conventional buildings. The New Zealand case studies were taken as part of the analysis in this chapter which is based on extracts from the paper below.

EXTRACTED FROM:

**Chapter 6 Energy saving behaviour and computer usage**

Chapter 6 presents the findings from the investigation of the occupants’ energy saving behaviour in computer usages in green and conventional buildings. The Malaysian and New Zealand case studies have been utilized together to draw out the effective strategies for future recommendation. The following are the papers that Chapter 6 is based on.

**EXTRACTED FROM:**


**Chapter 7 Occupants response to thermal discomfort**

Chapter 7 discusses the differences in occupants’ responses to thermal discomfort between the green and conventional buildings in New Zealand and Malaysia.


Chapter 8 Motivational factors to encourage energy saving behaviour

Chapter 8 investigates whether occupants in the green buildings are more motivated to save energy than occupants in the conventional buildings.

EXTRACTED FROM:


Chapter 9 Conclusions

Chapter 9 ends the thesis by providing conclusions to the research objectives and research questions.
CHAPTER 2: RESEARCH METHODOLOGY

2.1 Choice of research method

The research methods used in this study were a combination of qualitative and quantitative techniques. These techniques are commonly adopted in social science research (Easterby-Smith et al., 2012) and are also referred to as “mixed method” research (Creswell, 2003, McMuray et al., 2004). The strength in choosing a mixed method research methodology is that it can also be used as a technique for the triangulation of data, in order to establish reliability and validity of the findings (Mc Murray et al., 2004, Tashakkori & Teddlie, 2003).

Both research methods were chosen according to the nature of the research questions and objectives of the study (Bryman, 2008).

The qualitative techniques were chosen for Stage 1 of the study as, according to Easterby-Smith et al., (2012), qualitative methods enable more flexibility in drawing out relevant data and provide the opportunity to observe ‘real life’ situations. The research objectives in Stage 1 required the researcher to observe the situations within the case study buildings, as well as have discussions with the construction industry and building managers, in order to gain in-depth insights into the issues regarding the implementation of green buildings and the management practices to reduce energy usage in buildings. Quantitative techniques were chosen for Stages 2, 3, and 4 of this study because those techniques can lend themselves to the statistical analysis of results which are useful in understanding the building occupants’ behaviour trend (Easterby-Smith et al., 2012).
2.1.1 Consideration of the research questions

A total of six research questions were investigated in this study. The research questions were comprised primarily of ‘what’ and ‘how’ questions. Quantitative methods are typically suited to answer ‘what’ questions, while ‘how’ questions are best answered using qualitative methods (Yin, 2004). The research questions were:

1. What are the risks associated with implementing green buildings?
2. How are the buildings managed to save energy?
3. What are the overall levels of energy saving behaviour practices between green and conventional buildings?
4. Do occupants in green buildings practice better energy saving behaviour in computer usage than occupants in conventional buildings?
5. What do occupants do in response to thermal discomfort and are there significant differences in the behaviour between occupants of green and conventional buildings?
6. Are green building occupants more motivated to save energy than conventional building occupants?

2.1.2 Motivation for adopting a mixed method approach for this study

Case studies were selected to compare energy efficiency practices and outcomes between green buildings and conventional buildings. The case study methodology is suitable for this study because it allows researchers to use multiple evidence sources within real life contexts (Yin, 2002, p. 78), in order to test the theory of energy management measures practiced by facilities management. A description of the case study buildings is provided in section 2.2.1. This study adopted a case study approach. In order to investigate the case studies, mixed methods were adopted, which can provide data to gain in-depth answers to a research
question (Tashakkori & Teddlie, 2003). The study employed the qualitative method of content analysis, including a systematic review or evaluation of printed documents and electronic materials describing and quantifying phenomena (Bowen 2009; Sandelowski, 1993; Wamboldt 1992). The study also adopted a quantitative research method in which a questionnaire survey was designed to capture the occupants’ behaviour and perceptions in practicing energy saving behaviour.

### 2.2 Research design

Given that mixed methods were chosen as part of the research methodology of this study, the data sources used in this are tabulated in Table 2.2.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Sources</th>
<th>Research Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the risks associated with implementing green buildings?</td>
<td>• Literature  &lt;br&gt; • Discussion with construction industry</td>
<td>• Literature review  &lt;br&gt; • Participation in conferences and seminars  &lt;br&gt; • Preliminary discussions with the construction industry and building managers  &lt;br&gt; • Observation at site visit to New Zealand and Malaysian case studies</td>
</tr>
<tr>
<td>How are the buildings managed to save energy?</td>
<td>• Literature  &lt;br&gt; • Government guidelines  &lt;br&gt; • Non-government organisations (Green Building Council) publications  &lt;br&gt; • Case studies  &lt;br&gt; • Drawing plan  &lt;br&gt; • Active and passive designs on energy efficiency  &lt;br&gt; • Complaint log report  &lt;br&gt; • Design energy index  &lt;br&gt; • Actual energy index  &lt;br&gt; • Energy data for the</td>
<td>• Literature review  &lt;br&gt; • Participate in conferences and seminars  &lt;br&gt; • Content analysis  &lt;br&gt; • Observation at site visit to New Zealand and Malaysian case studies  &lt;br&gt; • Qualitative analysis of discussions from building managers and architects from case studies</td>
</tr>
<tr>
<td>What is the overall level of practice in reducing energy usage by building occupants in green and conventional buildings?</td>
<td>Literature</td>
<td>Uploaded questionnaire survey online on organisation website</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Survey questionnaire data</td>
<td>Distributed hardcopy questionnaire survey to occupants through building managers of each case study building</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantitative data analysis using basic statistical methods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Do occupants in green buildings practice better energy saving behaviour in computer usage than occupants in conventional buildings?</th>
<th>Literature</th>
<th>Uploaded questionnaire survey online on organisations’ websites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survey questionnaire data</td>
<td>Distributed hardcopy questionnaire survey to occupants through building managers of each case study building</td>
</tr>
<tr>
<td></td>
<td>Discussion with building managers</td>
<td>Quantitative data analysis using basic statistical methods</td>
</tr>
<tr>
<td></td>
<td>Energy report of case studies</td>
<td>Qualitative analysis of discussion with building managers from case studies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparison and convergence of analysis results from content analysis method and quantitative analysis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What do occupants do in response to thermal discomfort and are there significant differences in the behaviour of occupants between green and conventional buildings?</th>
<th>Literature</th>
<th>Uploaded questionnaire survey online on organisations’ websites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survey questionnaire data</td>
<td>Distributed hardcopy questionnaire survey to occupants through building managers of each case study building</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantitative data analysis using basic statistical methods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Are green building occupants more motivated to save energy than conventional building occupants?</th>
<th>Literature</th>
<th>Uploaded questionnaire survey online on organisation website</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survey questionnaire data</td>
<td>Distributed hardcopy questionnaire survey to occupants through building managers of each case study building</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantitative data analysis using basic statistical methods</td>
</tr>
</tbody>
</table>

Figure 2.1 depicts the research processes that have been carried out in this thesis. As shown, the study consisted of two phases of research methods: the first phase adopting qualitative methods; and the second, qualitative methods. Creswell (2003) described this research strategy as a sequential exploratory strategy in which different research methods are applied.
at different stages of the research. This method enabled the research to gain in-depth insight which linked the different stages of the study.

**Figure 2.1 Research process.**

- **Start of PhD**
- Literature Review on Influences of human behaviour impact on energy performance
- Identification of research gap and developed research questions
- Conceptual framework identified
- Identification of Case studies
- Develop Research Framework
- Data collection from Case Studies
- Design Questionnaires for Occupants
- Pilot Survey
- Are questions valid?
- **Quantitative Phase**
  - Data Collection from occupants
- **Qualitative Phase**
  - Discussion with building managers and architects
  - Document Analysis
- Data Processing and Analysis
- THESIS WRITTING
- END
2.2.1 Case study selection

A case study approach was used in this study because, according to Yin (2002), it allows the researcher to utilise multiple evidence sources to gain a better understanding of the real life context. Furthermore, case studies are best adopted when the research questions are in the form of “how” and “what”. These justifications enabled the researcher to choose case studies as the approach to collect multiple datasets using both qualitative and quantitative methods.

The overall aim of this study was to compare the energy management strategies between green and conventional buildings. Both New Zealand (NZ) and Malaysia have initiated the implementation of green buildings since the year 2004. Although the implementation of green buildings began in the same year in both countries, New Zealand is better known than Malaysia for its green image, and awareness of green issues tends to be high amongst the general NZ population (Brown & Stone, 2007; Smith, 2008). The New Zealand Ministry for the Environment has recognised that energy efficiency is an important aspect of sustainability that needs to be addressed (EECA, 2010). The Malaysian government also acknowledges the importance of energy conservation (Ibrahim & Hilmie, 2007), but it has been reported that general building occupants’ awareness of energy efficiency in Malaysia is poor (Tajabadi, 2010; Kumar, 2012; Saidi, 2014). Thus New Zealand was used as the case study location to compare the relative differences with the Malaysian case studies to learn about differences in the management strategies used in buildings to save energy.
The occupancy rate in the New Zealand building case studies are relatively lower than the Malaysia building case studies. There is a range of a 100 to 400 building occupants in the New Zealand building case studies, while in Malaysia a range of 300 to 800 building occupants. A comparison of the building case studies of low occupancy with higher occupancy can provide useful implications to understand the common and differences in the management practice in energy efficiency.

2.2.1.1 Justification to the selection of case studies from New Zealand and Malaysia

The climate and culture is significantly different in New Zealand compared to Malaysia. This study purposely selected countries with different climates to understand the suitability of designing buildings with a high opportunity for behaviour adaptation which inconsequently can reduce energy use. Earlier studies have suggested that building occupants from the colder climate are more tolerant of discomfort than those from the warmer climate (van Hoof & Hensen, 2007; Yu, Cao, Cui, Ouyang, & Zhu, 2013; Yu, Simone, Levorato, Zhu, & Olesen, 2014; Zhu, Ouyang, Cao, Zhou, & Yu, 2015). However, these studies limited the occupants for only sedentary activities such as reading and surfing the internet. Furthermore, they required the occupants to wear specific clothing during the conduct of the survey. Therefore, an analysis of the behaviours by allowing the building occupants to engage various coping mechanisms in response to thermal discomfort can provide a more realistic scenario of the situation.

The cultural differences between countries are suggested to have an impact on their energy saving practices (Cordano, Welcomer, Scherer, Pradenas, & Parada, 2010; Kaiser & Biel, 2000). Several cross-cultural studies examined the antecedents of predicting energy saving practice through analysis of their values, beliefs and norm (Milfont, Duckitt, & Cameron, 2006). However, the contexts of the management in energy efficiency practice were not
incorporated in their studies. Therefore, the levels of energy saving practices reported are unclear. The diverse cultural input in this study can provide a better understanding on whether or not there are differences in their behaviour.

2.2.1.1 New Zealand

Five educational buildings at The University of Auckland campus (located in central Auckland, NZ) were chosen as they are buildings with modern facilities and have occupants with high computer usage. The Thomas Building (TB), Owen G Glenn Building (OGGB), and Population Health Complex (PHC) were identified as green buildings with the design intent of being energy efficient. The Faculty of Engineering (FoE) and Old Choral Hall (OCH) buildings were randomly selected as conventional buildings without specific energy efficient design.

Case study 1: Thomas Building (TB) – green building

The extension of the Thomas Building, a four storey building, was built in 2011 with the design intention that it would be a green building certified by GreenStar New Zealand. The area of the building is 4,958m², with an estimated population of 160 occupants. The design was intended to gain a NZGreenStar rating of between 4 star to 5 star. Energy efficient features in the building incorporated a double glazed tinted low E with a double skin facade. The outer glazing, with a fritted dot pattern, provides 30 per cent shading. Access for natural ventilation is provided through inoperable window louvres. Most areas in the building have occupancy sensors. The building also adopts the variable air volume (VAV) system, which is energy efficient compared to a typical air-conditioning system.
Case study 2: Owen Glenn Building (OGGB) – green building

The Owen G. Glenn Building, a seven storey building, was completed in 2007. The area of the building is 74,000m² with an estimated population of 400 occupants. The main energy efficient features incorporated in the building are highly glazed windows to optimise natural daylight, with layered facades to provide solar shading. Occupancy sensors and automatic building control systems are connected with the Energy Management System.

Case study 3: Population Health Complex (PHC) – green building

The Population Health Complex, a four storey building, was designed to have 40 per cent less energy use than conventional buildings. The area of the building is 11,338m² with an estimated population of 300 occupants. The building includes a climate responsive façade and an atrium to minimise solar gain and is insulated to reduce heat loss. The atrium is combined with motorized windows for better daylight and natural ventilation. The building has a layered facade comprised of fins, columns, and overhangs to reduce solar gain and air conditioning usage. The soffit of the structural concrete floor system is exposed to reduce night time cooling in winter and encourage pre-cooling in summer. Occupancy sensors control lighting and air-conditioning systems. Energy efficient light bulbs T5 fluorescent tubes have been installed and chilled beam systems were also used in the building. The building is also thermally insulated around the walls and roof area.

Case study 4: Old Choral Hall (OCH) – conventional building

The Old Choral Hall (OCH) building is a four storey building completed in 1872. The total estimated population in the building is 100 occupants. This building has been identified as a New Zealand historic building (Jones, 2001). No energy efficient design was incorporated at
the time it was built. As the building is protected under the Historic Places Act 1993, there is limited ability to incorporate significant changes into the building (McClean, 2012; MfE, 2004).

**Case study 5: Faculty of Engineering (FoE) – conventional building**

The Faculty of Engineering (FoE) building has been reported to have no energy efficient features in it. It was built in 1969 and is a 12 storey building with an estimated 300 occupants. In 2003 the building was refurbished where an atrium was built with a large common room area including a cafeteria on the lower floor. The building provides a 250-seat lecture theatre. At the end of the building, a long glass-enclosed colonnade has been designed to create a transparent effect, as well as to allow natural daylight into the building.

**2.2.1.2 Malaysia**

Three case studies were selected to compare energy efficiency practices and outcomes between a Green Building Index (GBI)-certified green building, a non-certified building with ‘green’ features, and a conventional building. Office buildings were chosen as they represent well used buildings that have large numbers of occupants with high computer usage. The Low Energy Building (LEO) was identified as a Green Building Index-certified green building. The Perbadanan Putrajaya (PPJ) was identified as a non-certified green building with the design intent of being energy efficient. The Ministry of Health (MoH) building was identified as a conventional building with no specific energy saving elements.
Case study 1: Low Energy Office (LEO) Building – Green Building Index-certified building

The LEO building was built as the first government energy efficient building in 2004 to house the Ministry of Energy, Green Technology and Water. It is situated in Putrajaya, Kuala Lumpur, a city that is envisaged to become a sustainable city with a master plan concept theme of “City in a Garden and the Intelligent City”. The LEO building won the ASEAN Best Practice Energy Efficient Building award in 2006 and received a Platinum certificate awarded by the Green Building Index (GBI) in 2011. The main energy efficient features are that it adopts a variable air volume (VAV) system; which is energy efficient as compared to a typical air-conditioning system. The atrium is naturally ventilated and has large access to natural daylight through a skylight. Occupancy and photo sensors are installed where necessary in the building. Solar photo-voltaic panels are installed on the roof of the building to provide renewable energy for a water wall feature in the atrium. The building has a double roof to provide additional shading and the windows incorporate low emission glazing. A spray mist system which emits water particles is installed at the sliding doors to provide cooling, natural ventilation.

Case study 2: The Perbadanan Complex, Putrajaya (PPJ) – green (non-certified)

The PPJ building, situated in Putrajaya and built in 2008, is known for its contemporary traditional Islamic architecture. It was also designed to incorporate energy efficiency features. The PPJ won an ASEAN Energy Award in 2008; however did not apply for green certification. The main energy efficient features are that it adopts a variable air volume (VAV) system. The building is highly glazed with double-tempered green glass, with no emission-producing glazing. The building consists of floating meeting rooms which are naturally ventilated; occupancy and photo sensors are installed where necessary. A plant irrigation system is installed which is controlled by an individual rain sensor.
Case study 3- The Ministry of Health (MoH) building, Putrajaya – conventional building

The MoH building was built in 2008, and is adjacent to the PPJ building. The building was designed to be a contemporary building which emphasises transparency and dynamism in forms. Even though the building has double glazing installed with a low thermal emissivity layer, which is known as a green material, it is still considered to be a conventional building. Discussions with the MoH architect and report analysis of the façade building assessment revealed that the building requires constant artificial lighting instead of optimising daylight usage. The building has low visible light transmittance and high indoor reflectance which causes the façade to look dark and has a ‘mirroring’ effect when viewed from interior. Thus in view of the report, together with the architects’ opinion, it is considered it as a conventional building.

2.3 Data collection in the qualitative phase

The following section describes how the data were collected for the qualitative component of the study. Three methods of data collection were used: (1) observation; (2) discussion with the practitioners; and (3) document analysis. These methods of data collection are considered appropriate for qualitative studies (Morehouse, 1994; Silverman, 2010). The first phase of the study consisted of two stages: 1A and 1B (See Chapter 1, Table 1.2). In Stage 1A, the data were collected using observation, discussion with practitioners and document analysis. In Stage 1B, the data were collected from the selected case studies using the same methods of data collection.
2.3.1 Discussion with practitioners

The main purpose of the first stage of this study was to understand the real life contextual issues when implementing green buildings. The objectives in stage 1A of the research were used to investigate the risks associated with implementing green buildings in three stages of a project: the (1) design stage; (2) construction stage; and (3) operational stage. Therefore, informal interviews with the practitioners were conducted in stage 1A to retrieve relevant data.

A total of 10 participants in New Zealand and 10 in Malaysia were interviewed in order to understand the issues involved when implementing green buildings. Table 2.2 indicates the profile of the participants in New Zealand and Malaysia. The participants were initially contacted through email with a brief explanation about the research project. Upon agreement, the researcher requested an appointment that best suited their schedule. The discussions ranged from between 30 minutes to one hour’s duration Additional notes were also taken by the researcher during the informal discussions. All the participants were met face-to-face and discussions were audio recorded upon their agreement. However, one participant was interviewed by telephone, because the participant is based in the United States and it was more economical to conduct a telephone interview; site visits were not deemed appropriate at the initial stage of this study.

Table 2.2 Profiles of the interviewees in New Zealand and Malaysia

<table>
<thead>
<tr>
<th>Participant Code</th>
<th>Organization</th>
<th>Research Trip</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Fletcher Construction</td>
<td>June- October 2010</td>
<td>New Zealand</td>
</tr>
<tr>
<td>P2</td>
<td>BECA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>NZGBC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>P4</td>
<td>Architectus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>Ecube Engineering Consultant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P6</td>
<td>Arent Fox Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P7</td>
<td>Energy Manager Coordinator, University of Auckland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P8</td>
<td>Sustainable Coordinator University of Auckland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P9</td>
<td>Building manager of Landcare Research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P10</td>
<td>Building manager of the Population Health Complex (PHC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P11</td>
<td>Town Planner, Putrajaya</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P12</td>
<td>Building manager of Diamond Building, Putrajaya</td>
<td></td>
<td>November 2010 Malaysia</td>
</tr>
<tr>
<td>P13</td>
<td>Building manager of the Low Energy Building, Putrajaya (LEO)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The findings led to the selection of the case studies in New Zealand and in Malaysia which are used in Stage 1B of this thesis. A total of five participants from New Zealand and six from Malaysia were involved in Stage 1B of the study, consisting of building managers and architects of the buildings. A discussion with the relevant participants was conducted to understand the management practices implemented in the buildings to save energy. The architects for the case study buildings in New Zealand were not contacted because the documents provided by the building managers were sufficient to extract relevant information.
pertaining to the design of the buildings. The case study buildings in Malaysia required the researcher to conduct personal interviews with the architects to retrieve relevant information about the building design since this information was not accessible to the building managers of the case study. Observations within the case study buildings were conducted in both countries in conjunction with the discussions with the participants.

Table 2.3 Participants involved in selected case study buildings

<table>
<thead>
<tr>
<th>Participant Code</th>
<th>Case study buildings</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>P9</td>
<td>Building manager PHC</td>
<td>New Zealand</td>
</tr>
<tr>
<td>P10</td>
<td>Building manager OGGB</td>
<td></td>
</tr>
<tr>
<td>P11</td>
<td>Building manager TB</td>
<td></td>
</tr>
<tr>
<td>P13</td>
<td>Building manager FoE</td>
<td></td>
</tr>
<tr>
<td>P12</td>
<td>Building manager LEO</td>
<td></td>
</tr>
<tr>
<td>P14</td>
<td>Architect LEO</td>
<td></td>
</tr>
<tr>
<td>P15</td>
<td>Building manager PPJ</td>
<td>Malaysia</td>
</tr>
<tr>
<td>P16</td>
<td>Architect PPJ Building</td>
<td></td>
</tr>
<tr>
<td>P17</td>
<td>Building manager MoH</td>
<td></td>
</tr>
<tr>
<td>P18</td>
<td>Architect MoH</td>
<td></td>
</tr>
</tbody>
</table>

2.3.2 Document analysis

This study utilised a content analysis research method, that of a systematic review or evaluation of printed documents and electronic materials describing and quantifying phenomena (Bowen, 2009; Sandelowski, 1993; Wamboldt, 1992). The documents for each building were assessed against energy management strategies which were developed based
on the relevant literature. The documentation related to the energy performance of the case study sites in Malaysia and in New Zealand is summarized in Table 2.4.

Table 2.4 Supporting documentation acquired for case study assessment

<table>
<thead>
<tr>
<th>Documents</th>
<th>New Zealand</th>
<th>Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TB</td>
<td>PHC</td>
</tr>
<tr>
<td>Drawing plan</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Active and Passive Design on Energy Efficiency</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Complaint log report</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Design energy performance</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Actual energy performance</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Energy data for the last three years</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Energy report</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Actual energy consumption and estimated energy consumption at the design stage was compared with the Building Energy Index (BEI) identified from the literature to assess the energy efficiency performance of these buildings. The BEI is expressed in units of kWh/m²/year which is derived from the total energy consumption of the building in a year with the gross floor area of the building in square metres (Chan, 2009; Monts & Blissett, 1982). The BEI values identified from the literature are referred as the energy benchmark to measure energy efficiency performance of the building case studies. In this study, two energy benchmarks were identified for the Malaysia building case studies which were 200kWh/m²/year (ASEAN region building energy index) and 150 kWh/m²/year (MS1525 energy efficiency code). The building case studies in New Zealand are unique as it functions as a combination of accommodating offices and research laboratories. Therefore, historical
energy performance was used to assess the buildings energy performance since there was no appropriate energy benchmark available. Information on the active and passive designs relevant to energy efficiency and the building’s drawing plan were used to understand the characteristics of the building. Complaint log reports, energy data for the last three years, and energy reports were used to assess the extent of facilities management input. Neither of the case study buildings in New Zealand had complaint log reports. Also, the design energy performance of the buildings was unable to be retrieved, since these buildings did not have an estimate of energy consumption during the design stage. The green buildings were selected based on the initial design intention of the buildings, in that they were intended to be energy efficient through the incorporation of energy efficient design features.

As shown in Table 2.4, some of the case studies in New Zealand and in Malaysia were missing information. These documents were not able to be retrieved because the information required permission from other authorized managers within the organisation which was unable to be obtained within the allotted timeframe of the research. There were cases in which the information was not available, such as the energy reports and complaint log reports which were not available in the case study buildings. Other missing information was also not available during the discussion session with the case study building representatives. The discussion with the relevant participants representing the case study buildings supplemented the missing documents to gain a better understanding of the situation. The discussions helped achieve a better understanding of how the buildings worked in practice. Each case study was investigated in terms of practices recommended for efficient energy management.

The researcher participated in several conferences, workshops and meetings to facilitate a better understanding of the research study. Table 2.5 depicts the list of conferences, workshops and meetings held during the course of this study. The researcher attended a total
of four international conferences; three as a presenter and one as a participant. The researcher presented several parts of the findings of this thesis. The opportunity to present at conferences allowed the researcher to gain valuable insights regarding the research and suggestions for improvement from the construction building industry and practitioners. During the conference participation, the researcher was able to gain a better understanding of the current research problems in the field and the diversity solutions being provided. Notes and articles were gathered during participation at the workshops and meetings.

Table 2.5 Details of conferences, workshops, and meetings attended

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
<th>Date</th>
<th>Location</th>
<th>Nature of Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>International Sustainable Building Conference SB10</td>
<td>Sustainable Building</td>
<td>26-28 May 2010</td>
<td>Wellington, New Zealand</td>
</tr>
<tr>
<td></td>
<td>International Conference on Sustainability Engineering and Science, Transition to sustainability, Sustainable Society New Zealand</td>
<td>The Sustainability Society- a technical interest group of IPENZ</td>
<td>30 November 2010</td>
<td>Auckland, New Zealand</td>
</tr>
<tr>
<td></td>
<td>Meeting with industry practitioners</td>
<td>Academics from University of Auckland</td>
<td>2011</td>
<td>Auckland, New Zealand</td>
</tr>
<tr>
<td></td>
<td>BRANZ visiting</td>
<td>University of Auckland</td>
<td>28 Feb 2011</td>
<td>Auckland, New Zealand</td>
</tr>
<tr>
<td></td>
<td>Built Environment Research Symposium</td>
<td>Massey University, Albany</td>
<td>23 September 2011</td>
<td>Auckland, New Zealand</td>
</tr>
<tr>
<td></td>
<td>Workshop for PhD Students in Construction Management</td>
<td>University of Auckland</td>
<td>27 September 2011</td>
<td>Auckland, New Zealand</td>
</tr>
<tr>
<td></td>
<td>Meeting with industry practitioners in Malaysia</td>
<td>Town Planning Department, Putrajaya Malaysia Building Manager of Diamond Building, Putrajaya</td>
<td>2012</td>
<td>Kuala Lumpur, Malaysia</td>
</tr>
</tbody>
</table>
2.3.3 Data analysis

The study adopted a combination of approaches to analyse the data. In the first phase of the research, the discussions with the practitioners that were audio recorded were transcribed using MS Word software. Subsequently, the transcription word files were imported into NVivo software for coding purposes. The coding was based on the research objective in Stage 1A of the study, which was to categorize the risks associated in the three stages of a building project (the design, construction and operational stages). This process of coding the data into its relevant categories is called a constant comparative analysis (Maykut & Morehouse, 1994). Another analytic technique used in this process was pattern matching, where similar patterns in the data across sources were identified (Yin, 2009). The data analysis exercise and comparisons with the existing literature enabled the researcher to identify which stage of the building project contains the most risks.

In the next stage of the research, 1B, the data were collected from the selected case study buildings. A similar analytical technique was conducted for processing the data collected from the discussions between the relevant participants listed in Table 2.4. The constant comparative analysis technique recommended by Maykut and Morehouse (1994) was used to
identify the current practices of the management in each building to save energy. These data were then compared with the theoretical framework of management strategies to achieve energy efficient performances in buildings which were developed based on recommendations from a variety of existing international guidelines. The energy efficiency performance of the case study buildings was assessed using the relevant national standard Building Energy Index for each country. For the Malaysian case study buildings the Malaysian Standard Index Building Energy Efficiency 1515 was used as the Building Energy Index for energy efficient performance. However, the New Zealand case study buildings were a mixed office and research function building, therefore no appropriate Building Energy Index was available during the course of this research study. Hence the energy performance was assessed based on the increases and decreases in the historical energy data. Cross-case synthesis recommended by Yin (2009) was used between the different case study building types (i.e., green and conventional buildings) to assess the buildings’ management strategies in reducing energy consumption.

2.3.4 Reliability and validity

Following the suggestion by Maxwell (2005), the reliability and validity of the data were ensured through the collection of multiple sources of evidence which were triangulated using interview data obtained from expert validators, participant observations and analysis of documents relevant to the case study buildings. These techniques are commonly applied in social science research to reduce errors and bias in studies and to provide credibility to the results obtained (Yin, 2009).

Given that the building case studies in New Zealand are university buildings, a greater number of occupants working as academicians are more likely to have higher degree
qualification (i.e PhD degree) than the occupants in the office building case studies in Malaysia. Earlier studies showed that those with higher academic qualification are more likely concerned about the environment (Ostman & Parker, 1987). However, being more concerned about the environment does not necessarily translate into behaviour (Gifford & Nilsson, 2014; Kollmuss & Agyeman, 2002). Therefore, it is unlikely that there is a bias validity issue of using a university and an office building.

2.4 Data collection in the quantitative phase

The remaining stages of this thesis adopted a quantitative research method. The following section describes how the researcher determined the sample size and analytical techniques used in the research. The data were collected using questionnaires which were surveys disseminated through online websites and hard copies. The nature of the research objectives in this stage of the study required the researcher to obtain representative data on the case study building occupants’ behaviour. This technique is supported by Creswell (2003), in which surveys are recommended as the appropriate tool to collect data that quantifies a description of trends, attitudes, and opinions of a population. Representative data in this study are judged by obtaining an acceptable response rate to represents the whole occupants for each of the building case studies. A minimum response rate of 27% to 30% is targeted in the survey following a former research conducted by the Centre of the Built Environment (CBE)(Zagerus, Huizenga, Arens, & Lehrer, 2004).
The design of the questionnaire survey had undergone several corrections by the researcher’s supervisors and research team members. The wording of the sentences, format and layout of the thesis were provided during the process of designing the questionnaire. A pilot test was conducted on the questionnaire to provide feedback on its readability. This initial pilot study of the questionnaire was conducted in a small conventional building using 12 occupants. This test was conducted for logic and understanding of the questionnaire and modifications were made.

The questionnaire was based on the literature. The questionnaire was structured into four sections. The first section gathered the respondents’ demographic profile. The second section of the questionnaire examined the respondents’ energy saving practice in their workplace, while the third section examined their responses in thermal discomfort. The last section of the questionnaire examined their awareness on energy efficiency as well as their suggestions on their preference of strategies to encourage them to reduce energy use.

Invitations to participate in this study were sent through an email and followed up by a phone call to the building managers. Only the conventional OCH building in New Zealand had no on site building manager. The conventional OCH building in New Zealand is occupied by the International Relations office. Therefore, the head of the International Relations Office was contacted to seek consent to invite the subordinate staff to participate in this study.

The authorized managers in each of the case study buildings in New Zealand and Malaysia then distributed an online survey to the occupants in the buildings by uploading it onto the building website. The researcher then sent a follow up email requesting the authorized manager to circulate the website link to the occupants in the building after two weeks. Hard copies were also provided to the authorized manager for respondents who wished to fill in the questionnaire manually. In order to increase the response rate, the researcher was given
access to the case study buildings to invite participation in the research face-to-face. Both hardcopies and the website link were given to interested participants.

Some of the challenges faced in obtaining responses from the occupants in the buildings included that the researcher found it problematic to distribute the questionnaires face-to-face to the occupants in the green PHC building in New Zealand because most of the spaces required access cards to gain entry the office areas, and not many of the staff loitered in the common area spaces. Although the green TB building in New Zealand also required an access card to enter most of the office spaces there were many building occupants who used the common area spaces, therefore it was easier to get responses from that building. As for the green OGGB building in New Zealand, building occupants were much more accessible since entry to the office spaces did not require an access card for the building. Due to the low response rate obtained in the green PHC building, the researcher decided to discount that case study building and use only the other two green (TB and OGGB) buildings in New Zealand.

Similar difficulties were faced in obtaining data from the building occupants in the Malaysian case study buildings. Although the researcher was given permission to invite the occupants to take part in the research study, the researcher was not given access to the office areas due to security reasons. Fortunately, the occupants in the case study buildings in Malaysia frequently loitered in the common areas which were accessible to the researchers, so they could then approach the building occupants.

2.4.1 Sample Population

Table 2.6 shows the analysis of the response rate in each building in New Zealand, while Table 2.7 shows the response rates in Malaysia. The building managers estimated that there
.000 were 960 people in the four selected case study buildings in New Zealand, while 1640 people in the three case study buildings in Malaysia.

Table 2.6 Response Rate (New Zealand)

<table>
<thead>
<tr>
<th>Type</th>
<th>Total Population</th>
<th>Sample Size</th>
<th>Total Respondents Received</th>
<th>Response rate</th>
<th>Name of Building</th>
<th>Population</th>
<th>Sample Size</th>
<th>Respondents received</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Building</td>
<td>400</td>
<td>196</td>
<td>113</td>
<td>58%</td>
<td>FoE</td>
<td>300</td>
<td>169</td>
<td>80</td>
<td>47%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OCH</td>
<td>100</td>
<td>80</td>
<td>33</td>
<td>41%</td>
</tr>
<tr>
<td>Green Buildings</td>
<td>700</td>
<td>248</td>
<td>157</td>
<td>63%</td>
<td>TB</td>
<td>300</td>
<td>169</td>
<td>68</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OGGB</td>
<td>400</td>
<td>196</td>
<td>89</td>
<td>45%</td>
</tr>
</tbody>
</table>

Table 2.7 Response Rate (Malaysia)

<table>
<thead>
<tr>
<th>Type</th>
<th>Total Population</th>
<th>Sample Size</th>
<th>Total Respondents Received</th>
<th>Response rate</th>
<th>Name of Building</th>
<th>Population</th>
<th>Sample Size</th>
<th>Respondents received</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Building</td>
<td>500</td>
<td>217</td>
<td>61</td>
<td>28%</td>
<td>MoH</td>
<td>500</td>
<td>217</td>
<td>61</td>
<td>28%</td>
</tr>
<tr>
<td>Green Buildings</td>
<td>1140</td>
<td>288</td>
<td>206</td>
<td>72%</td>
<td>PPJ</td>
<td>800</td>
<td>260</td>
<td>110</td>
<td>42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LEO</td>
<td>340</td>
<td>181</td>
<td>96</td>
<td>53%</td>
</tr>
</tbody>
</table>

The determination of the sample size of the population for this study used the “Sample Size Determination Table” recommended by Krejcie and Morgon (1970) and Bartlett et al., (2001). With reference to the “Sample Size Determination Table”, the recommended sample size for the population of each building is as tabulated in Table2.6 and Table 2.7. Response rate of more than 30% was achieved for all the buildings to represent the occupants for each individual building. However, only the conventional (MoH) building achieved a lesser response rate of 28% due to constraint of time during the data collection period.

The occupation of the respondents in the New Zealand building case studies are depicted in Figure 2.2, while the Malaysia building case studies are shown in Figure 2.3. The results in
Figure 2.2 showed that almost 50% of the occupants in the New Zealand building case studies are working as lecturers, while results in Figure 2.3 showed that occupants worked as executive levels. The minimum qualification to be an academic set by the University of Auckland is to at least to hold a PhD degree, while the minimum qualification to work as an executive level in the Malaysia building case studies are with a degree. The postgraduate students in the building case studies in New Zealand all have their personal workstation in the buildings. The staff profile website for each of the building case studies reported that neither of the occupants in the Malaysia building case studies attained a PhD degree. This demonstrates that the occupants in the New Zealand building case studies have a higher academic background than the occupants in the Malaysia building case studies. Many previous studies have reported that occupants with higher academic background are more likely to be concerned about the environment (Gifford & Nilsson, 2014). Hence, the results suggests that occupants in the New Zealand building case studies are more likely concerned about the environment than those in the Malaysia building case studies. The impact of the differences in their academic background on their energy saving practice is further discussed in Chapter 6 of this thesis.
Figure 2. Respondents occupation (New Zealand case study buildings)

Figure 2. 3 Occupants occupation (Malaysia case study buildings)
50% of the respondents from both of the building case studies in New Zealand and in Malaysia are between the ages of 31 to 40. The profile of the age of the occupants for the Malaysia building case studies are shown in Figure 2.4, while occupants for the New Zealand building case studies are shown in Figure 2.5.

![Figure 2.4 Occupants age (Malaysia building case studies)](image1)

![Figure 2.5 Occupants age (New Zealand building case studies)](image2)

There are more female respondents in the New Zealand green buildings (Figure 2.7) than those in the Malaysia green buildings (Figure 2.6). As for the conventional building, more female respondents are seen in the Malaysia conventional building compared to the New Zealand conventional buildings. The difference in gender influences how occupants respond in thermal discomfort. Earlier studies suggest that on average females tend to feel colder a lot more than males (Rupp, Vásquez, & Lamberts, 2015). Studies have also shown that females tend to be more concerned about the environment (Gifford & Nilsson, 2014). However, the limitation of this thesis does not examine the impact of the differences in the gender. Further research will be carried out to examine the relationship between the occupants’ gender and their behaviour to gain more insight of the analysis.
2.4.2 Data analysis

SPSS Statistics 22 software was used to analyse the statistical relevance of the research. Several statistical tests were used in analysing the data obtained from the building occupants. Among the statistical analysis used in Stages 2 to 4 were mean, mode, frequency description, crosstab analysis, and the Man-Whitney U test.

In Stage 2A of the study the building occupants from both the green and conventional buildings in New Zealand were asked about their level of practice of a total of 17 energy saving behaviours. The mean value was then used to represent the overall level of practice of each of the energy saving behaviours. This statistical analysis allowed the behaviours to be ranked in ascending order.

Weighting scores were assigned to each level of practice in reducing energy usage on the list of the 17 behaviours. A maximum score of ‘5’ was assigned for respondents who claimed to
always practice the behaviour, while a minimum score of ‘0’ was assigned for respondents who claimed to never practice the behaviour. Therefore, every respondent would have their own total score to represent their overall level of practice in reducing energy usage. The categories of scores are as presented in Table 2.9. These analytical techniques enabled the researcher to draw comparisons of the occupants’ levels of practice in reducing energy usage between the two types of buildings (i.e., green and conventional).

<table>
<thead>
<tr>
<th>Level of Practice</th>
<th>Range of Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>63 to 85</td>
</tr>
<tr>
<td>Often</td>
<td>55 to 62</td>
</tr>
<tr>
<td>Sometimes</td>
<td>47 to 55</td>
</tr>
<tr>
<td>Rarely</td>
<td>41 to 46</td>
</tr>
<tr>
<td>Never</td>
<td>0 to 40</td>
</tr>
</tbody>
</table>

The mode values were the most commonly calculated statistical descriptors used in Stages 2B, 3 and 4 of this thesis, as derived from the frequency distributions. Other relevant statistical analyses used in these stages of the study were crosstab analysis and the Man-Whitney U test.

The Man-Whitney U test was used to identify the significant difference in the occupants’ responses between the two building types. For instance in Stage 2 it was used to investigate
which of the energy saving behaviours were significantly different between the buildings; and in Stage 3 the aim was to identify which of the coping mechanisms in response to thermal discomfort were significantly different between the two buildings. In Stage 4 the aim was to identify which of the motivational factors were significantly different between the building types. The $p$ values of the data that were less than 0.05 were considered as significantly different (Pallent, 2007).

Due to the limitation of the Man-Whitney U test, in that it only determines whether the variables are significantly different or not, the frequency distribution and crosstab analysis of the data allowed the researcher to ascertain the occupants of which building types practice the most energy saving behaviours, coping mechanisms, and have the highest motivation to save energy. At these stages, the mode values of the data were obtained to achieve better representation of the occupants’ level of practice in reducing energy usage.

2.4.3 Reliability and validity

Reliability is defined as the consistency of the measurement data, while validity is defined as the credibility of the data (Roberts et al., 2006). According to Cronbach (1951), the reliability of quantitative data is determined by the Cronbach’s alpha coefficient which can be obtained through statistical analysis. This method in measuring reliability is commonly applied in quantitative research (Roberts et al., 2006). Each of the questions in the questionnaire instrument obtained a value of more than 0.70, which indicates that there is an acceptable level of internal consistency between the responses; demonstrating that the data are reliable (George & Mallery, 2003; Gliem & Gliem, 2003). A Cronbach’s alpha coefficient of 0.741 was obtained through the test which shows that 74.1% of the observed score is true and the
remaining 25.9% is due to error. These percentages show an acceptable level of reliability of the data.

The validity of data is ensured by obtaining a high response rate from the determined sample size of the population (Barlett et al., 2001). The study achieved a response rate of over 70%; therefore, the data retrieved from the building occupants are sufficient to represent the building types.

Given that the building case studies in New Zealand are university buildings, a greater number of occupants working as academicians are more likely to have a higher degree qualification (i.e PhD degree) than the occupants in the office building case studies in Malaysia. Earlier studies showed that those with higher academic qualification are more likely concerned about the environment (Ostman & Parker, 1987). However, being more concerned about the environment does not necessarily translate into behaviour (Gifford & Nilsson, 2014; Kollmuss & Agyeman, 2002). Therefore, the bias validity issue of using a university and an office building is reduced.

There is a potential for bias given that there is a lack of documents, different documents and how people answer the surveys and interviews. People may be telling what the researcher wants to hear (Kanuk & Berenson, 1975). Therefore, among the strategies used to reduce the bias is by remaining the respondents as anonymous (Kanuk & Berenson, 1975). The respondents were not required to provide their personal contact information. In order to reduce the bias for the interpretation of the content from the different documents, terms that were similar were categorised into the same category following the rule of coding as proposed by Mayring (2008). Another strategy to reduce bias was by supplementing the data from the interviewees to avoid a one-sided judgement on the interpretation of the content analysis (Bryman, 2006; Creswell, 2007).
2.5 Ethical Consideration

This research obtained approval from the University of Auckland Human Participants Ethics Committee on 11th April 2012 with the reference number 7930 (see Appendix A). To ensure that the research was conducted in an ethical manner, the Committee required the researcher to inform the participants about the purpose of the research study, the objectives, and the process of the data collection. All this information was provided in the Participant Information Sheet which was given to the authorized manager in each case study building. Upon agreement to participate in the research, the authorized manager was required to sign the Consent Form agreeing to the terms stated in the Participant Information Sheet. The authorized manager then distributed the Participant Information Sheet to the building occupants in each of the case study buildings. Interested participants were given the consent forms prior to answering the questionnaire. A sample of the Participant Information Sheet to the authorized manager and building occupants, together with the Consent Forms, are attached in Appendix B
3.1 Introduction

Green Building Councils from all over the world have developed rating tool systems that can be used as a guideline to profile buildings that are designed either as ‘green’ or non-green. There are a number of existing rating tool systems, such as the Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom, the Building Environmental Performance Assessment (BEPAC) in Canada, the Leadership in Energy and Environmental Design (LEED) in the United States, Green Star in New Zealand and Australia, the Green Building Index (GBI) in Malaysia and the GBTool that is applicable worldwide. Each of the assessment rating tools shares common categories of what they assess. The categories are: (i) Energy Efficiency, (ii) Water Efficiency, (iii) Materials, (iv) Indoor Environmental Quality, and (v) Sustainable Site Planning and Management. Each category has been assigned its own weighting set by the Green Building Council in the respective countries. In general, the greater the weighting of a category, the more criteria are required. Thus a wider coverage of the scope of the categories will require more criteria to be obtained in order to achieve a higher level of certificate. Having more criteria such as in the “GBTool” rating system, makes it difficult to comply with since some of the criteria may not
apply to the country’s climate conditions and economy. Building environmental systems must reflect national, regional, and local differences if they are to be accepted and used (Crawley et al., 2001; Todd & Geissler, 1999). This is the reason why some stakeholders would prefer to use a local sustainable rating tool as it has been tailored to suit the country’s climate conditions and economy.

There is an increasing trend in implementing green buildings in the world. The World Green Building (WGBC, 2015) council reported that there are 62 countries that have more than 60% of green projects. The implementation of green building has increased from 20% to 30% within 3 years since 2012.

3.2 Drivers to implement green buildings

The current market trends show that there is an increase in the number of green buildings being implemented. In the United States, the rate of growth in the numbers of ‘green’ buildings has been rapidly increasing, with numbers doubling nearly every two years (Fuerst, 2009). In Germany, Lutzkendorf and Lorenz (2006) have stated that increasingly, great interest is being shown in sustainability and green buildings by key players, for example: (i) increasingly, companies and corporations aim to demonstrate their contribution to sustainable development by using self-occupied property assets as an example of best practice and leadership in sustainability; (ii) property valuation professionals, rating agencies and banks are now beginning to integrate aspects of a building’s sustainability into property valuation and risk assessment processes; and (iii) suppliers and auditors of socially responsible investment products increasingly require proof of the economic, environmental, and social advantages of these products (e.g., sustainable property funds or real estate investment trusts). In Switzerland, sustainable real estate has become progressively more of interest to investors.
The author observed that the drivers for this growing trend are due to: (i) the implementation of new government policies that will help to promote or perhaps mandate eco-friendly features; (ii) stakeholders perceiving that green buildings will deliver higher profits and increasing awareness that green buildings tend to be more economical to operate; and (iii) an increasing level of awareness due to multiple research studies on the performance of green buildings. Each of these driving factors is explained in the following sections.

3.2.1 Implementation of new eco-friendly government policies

The impact of pressure on the global ecosystem is driving governments in many countries worldwide to place a high value on the concept of sustainability (Yang & Lim, 2008). Accordingly, the European Commission is encouraging each member state to take a leading role in the area of implementing principles of sustainable development in the property and construction sectors (Lutzkendorf & Lorenz, 2006). For instance, the government in Germany provides incentives to promote sustainable development, such as introduction of tax credit schemes and regulatory mechanisms, as well as assisting with the implementation of other economic instruments (e.g., favourable banking and insurance products, and advantageous interest and insurance rates) that support sustainable development in property and construction (Lutzkendorf & Lorenz, 2006). Similarly, in the United Kingdom the government offers the industry lower taxes on sustainable properties to promote energy efficiency (Matters, 2009).
3.2.2  

Cost-benefits and financial advantages of green buildings

There are three types of stakeholders that are involved in the implementation of green buildings: developers, owner-occupier and tenants. Developers who participate in the implementation of green building for commercial and residential buildings are driven by the profit that they are able to make through selling properties with eco-labelling (Fuerst, 2009). Thus developers are looking for a good return on their investment over either a short- or long term period. In other words, they are interested in expanding their business. The owner-occupier and the tenant are interested in the low operating costs of the green building. Studies carried out by McGraw Hill Construction (2006) and Grimley (2007) reported that building occupiers are willing to pay for the additional costs of green buildings through higher rents, provided that in return they will receive the benefits of reduced operating costs, improved productivity, an improved image for the occupiers and owners, and reduced operating and regulatory risks. In brief, the stakeholders are driven by cost-benefit and cost implications.

3.2.3  

Research on green building performance

Through research and publications, the level of awareness of the benefits of green buildings has been increasing for more than 10 years. The research carried out by Heewagen (2000) and Heewagen and Wise (1998) outlined the benefits of green buildings and promoted awareness of sustainable development amongst key stakeholders. Another study by Yang and Yang (2009) highlighted the mutual benefits of sustainable housing which also contributed to the level of awareness. A study by Seewald (2009) suggested that the relevant authorities use computer software to measure the benefits of green buildings and this also made a contribution to promote the level of awareness. More recent research by Baird (2010) studying occupants’ level of comfort helped to emphasise the benefits of green buildings.
The abovementioned drivers have contributed to the growth in implementation of green buildings. However, there are also risks in green buildings that need to be mitigated in order to accelerate the growth. Knowing the significant need for green buildings, it is essential to explain the types of risks involved in their design, construction management, operation and maintenance. The next section focuses on explaining the types of risks involved in the design, construction, operation and maintenance of green buildings.

3.3 Risks associated in the implementation of green buildings

Understanding the risks and the suitable approaches to manage and mitigate them would accelerate the growth of green buildings. This section explores some of the major risks related to green building projects. The risks will be discussed in detail in all three stages of a green building implementation: the (1) design stage (2) construction stage, and (3) maintenance and operation stage.

3.3.1 Design stage

During the design stage, the major concern is designing a building within a budget constraint. Risks lie in the level of design effectiveness in meeting green building requirements. The building must be designed in a way that incorporates and supports green building characteristics as well being user-friendly. The designers are responsible for incorporating these characteristics into the design considerations while keeping to the allocated budget. Three risks in this stage are identified below.
3.3.1.1 Financial risk

A study by Colliver (2007) classified financial risk at the design stage as a soft cost that is associated with designing, permitting and certifying the project, and includes any delay cost. The expensive soft cost can be a barrier to implementing green buildings (Cupido, Baetz, Pujari, & Chidiac, 2010). In a report by Marsh (2009), the cost of the green building certification process is listed as a risk to the growth of implementing green buildings. This is in line with a report by Hanatani (2009) which maintains that the cost of the green building certification process is expensive. That report claimed that the estimated soft costs for applying green certification ranged approximately between USD$40,000 to USD$200,000, depending on the size of the project. This could impede the implementation growth of green buildings. Hanatani (2009) and Marsh (2009) suggested that a reduction of the cost of certification process could accelerate the growth of green buildings.

Another issue in relation to financial risk is a lack of knowledge about and experience in green building, resulting in incorrect perceptions that can lead to a decision not to go green. A study by Richardson and Lynes (2007) stated that perceptions of high initial capital costs and a long payback time to recuperate the initial cost are risks to the growth of green building. Another study by Cupido et al., (2010) found that there was a general perception that green buildings cost more than conventional buildings. These perceptions can influence decisions against going green. This perception contradicts other research carried out by Bordass (2000), Hydes and Creech (2000), Intrachooto and Arons (2002), and Scofield, (2002) which claim that green buildings do not necessarily result in higher initial capital costs for design and construction. Two studies by Abidin (2009), and Yang and Skitmore (2003) stated that this perception is considered to be a result of the first cost mentality, which means that there is a fear of investing in potentially high cost areas when there are uncertain returns on the investment.
3.3.1.2 Standard of care and legal risks

Standard of care and legal risks are identified as occurring in the design stage. Specific issues associated with standard of care and legal risks are as follows:

- Not attaining the level of Green Certification expected by owner, tenant, or other third party. When the sustainable building expert certifies the building below the expectation of the client upon the completion of the project, the issues of liability for this failure must be indicated clearly in the contract prior to the construction of the project.

- The challenge of determining an appropriate standard of care as green building expertise continues to evolve. Until the appropriate standard of care and legal risk has been legally determined, the consequences of risk at the design stage will continue to occur.

- Evolving building codes with the potential for application of a strict liability standard. Until an appropriate green building code is established, the risk at this stage is unavoidable.

- Untested contract language (Elovitz, 2010). The contract document must clearly express where the liability lies in terms of the designers, builders and clients. Often there is a blurred area in allocating the faults when it comes to failure in achieving the expected level of certification and building performance.

3.3.1.3 Regulatory risk

A report by Marsh (2009) identified that the shift in government priorities, such as maintaining green regulations but removing tax incentives and subsidies, is one of the risks in
implementing green buildings. Removal of tax incentives and subsidies contributes to the barriers to implementing green buildings. A study by Ashuri (2010) maintained that tax and regulatory incentives are not uniform and tend to change from state to state, and over time. Based on that study, the non-uniformity and instability of the tax and regulatory incentives can be considered as risks towards accelerating the growth of green buildings. It was further added that the dates of expiration of the incentives were uncertain, which would affect stakeholders’ decision making processes when implementing green buildings; possibly influencing them to postpone or cancel the implementation of the project.

3.3.2 Construction stage

There are multiple risks in the construction of green buildings. The risks are explained in the next sections.

3.3.2.1 Inexperienced consultants and contractors

A report by Marsh (2009) identified that lack of experienced consultants and contractors with respect to green projects results in delays in the schedule of the project. Another study by Ashuri (2010) found that contractors may lack of the skills to properly implement green-oriented technology. As a result this could hinder the technology’s effectiveness. Ashuri also stated that possible unforeseen conditions when retrofitting existing buildings to become green are a common risk identified during the construction stage. This reason supports the significant need to have experienced consultants and contractors involved when constructing green buildings. These risks eventuate upon the selection of inexperienced and insufficiently
knowledgeable consultants and contractors. It is essential to choose sufficiently experienced consultants and contractors with a good track record in implementing green buildings.

3.3.2.2 Financial risk

Financial risk is a risk during the construction stage, as the cash flow during that stage is critical in implementing green buildings. A study by Marsh (2009) identified that the credit capacity of the contractors is listed as one of the risks faced by them in creating green buildings. Ashiru (2010) and Marsh (2009) both stated that fluctuations in the price of green materials are also a risk. New green materials on the market incur high costs which require contractors to have a strong credit capacity. The clients are also faced with this risk.

3.3.2.3 Limited availability of green materials

A study by Tredrea and Mehrtrens (2008) found that the availability of green materials in the market is a risk during the construction stage. This is a challenge to contractors as sourcing materials become difficult. The consultants are then faced with the challenge of auditing the work of the contractor to ensure compliance. These risks hinder the growth of the implementation of green buildings.

3.3.3 Operational stage

The risk associated with this stage is the performance of the green building; it is expected to reduce the operational costs due to being more energy efficient, and also to increase productivity due to a better living indoor environment.
3.3.3.1 Performance risk

According to the report by Marsh (2009), the building performance risk is rated as one of the greatest risks in the growth of the implementation of green buildings. Ashuri (2010) stated that the building performance of a green building has a significant influence on the decision making process about whether to implement green buildings that will affect the market position. A number of studies have been carried out to show that green buildings are underperforming. For example, some of the LEED rated buildings use more energy than the design intended (Newsham & Birt, 2009). A similar study by Gabe (2008) was conducted on a building that was designed to be an energy saving building, but when operational it turned out that the building used twice the amount of energy as expected. Another study by Bordass et al., (2001) also found that the green buildings were using more energy than expected. In a report by Turner and Frankel (2008), some of the LEED rated buildings were found to have a high level of energy usage.

Based on the above studies, this author identified that the primary reason for inefficient green building energy performance is mainly due to the actions of the occupants and facility managers of the building. Malfunction of technologies and systems in the buildings is identified as the reason for a building’s inefficient energy performance. Another reason identified is that the benchmark or estimated energy use is inappropriate for buildings that involve high energy usage (for example, a research building that houses a laboratory). More investigation is needed to examine the reasons for the variations in energy building performance in order to help improve future modelling and benchmarking. Furthermore, there is a need to calibrate user needs with building design in order to optimize building performance.
Table 3.1 tabulates the frequencies of the reported risks from the literature to depict a clearer picture. Out from the 23 literature reviewed, risks occurring during the maintenance and operational stage is reported the most frequently with 52% being the highest percentage. This indicates that the building performance is a critical issue that is worthwhile to address. The discussion from the practioneers in New Zealand (Table 2.3 Chapter 2) led to a clearer understanding that risks occurring at each building stage are important, but emphasised that it is essential that greater measures are taken during the maintenance and operational stage.

Table 3.1 Frequencies of reported risks

<table>
<thead>
<tr>
<th>No</th>
<th>Literature</th>
<th>Design stage</th>
<th>Construction stage</th>
<th>Maintenance and operation stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Abidin (2009)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ashuri (2010)</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Bordass (2000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Bordass et al., (2001)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Colliver (2007)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Cupido, Baetz, Pujari, &amp; Chidiac (2010)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Elovitz (2010)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Fuerst (2009)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Gabe (2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Hanatani (2009)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Hydes and Creech (2000)</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>12</td>
<td>Intrachooto and Arons (2002)</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>14</td>
<td>Marsh (2009)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>15</td>
<td>Matters (2009)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Newsham &amp; Birt (2009)</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>18</td>
<td>Richardson and Lynes (2007)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Scofield, (2002)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Scott and DuBose (2008),</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>21</td>
<td>Tredrea and Mehtrrens (2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Turner and Frankel (2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Yang and Skitmore (2003)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9/23</td>
<td>3/23</td>
<td>12/23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>39%</td>
<td>13%</td>
<td>52%</td>
</tr>
</tbody>
</table>
Participants from the construction industry (P1 and P2) in New Zealand and participant P13 in Malaysia agreed that some of the failures during the building performance occurred due to a failure during the construction stage. An example of a construction default was the double glazing window instalment where it was due to lack of expertise installing the windows. The glazings of the facades on the green (PPJ) building were reported to frequently break. Figure 3.1 shows approximately 10 glasses break in a year. The arrow pointed in Figure 3.2 shows a shaped butterfly form crack where it had initiated.

![Figure 3.1 Frequency of glass breakage](image)

Figure 3.1 Frequency of glass breakage
The participants from the designers (P3, P4, P5) in New Zealand as well as from Malaysia (P11, P14, P16) raised concern that there is a challenge in designing buildings to ensure that its performance is as expected. Often, the designers do not get feedback on how the buildings are performing which inconsequentially cause the designers to make a lot of assumptions especially in predicting the buildings’ energy use. The participants recommended that research in the existing green buildings during the operational stage would be of great benefit to aid the designers in improving the quality of the building design. Input from the designers perspective together with the discussion from the building managers showed that it is crucial to examine the operational stages of the buildings to ensure that energy efficiency is maintained.
3.4 Conclusion

In conclusion, this chapter reviewed research studies on the risks to the growth of the implementation of green buildings. The author has attempted to outline and discuss the risks during three phases of a building project (the design phase, construction phase and maintenance and operation phase). In the design stage, three risks were discussed: financial risk, standard of care/ legal risk and regulatory risk. At the construction stage, three risks were highlighted: inexperience of consultants and contractors, financial risk, and limited availability of green building materials. Lastly, in the maintenance and operation stage, only the performance risk was discussed. The findings in this chapter showed that the main risk associated with implementation in green buildings is the performance risk which is ensuring energy efficiency performance of a building. The following chapter in this thesis attempts to mitigate the performance risk through the development of an energy management framework which aims to assist facility managers ensure energy efficient performance in a building.
CHAPTER 4: MANAGEMENT PRACTICES TO ACHIEVE ENERGY EFFICIENCY PERFORMANCE

This chapter has been extracted from:


4.1 Introduction

The growing need to reduce energy consumption has encouraged the implementation of green buildings worldwide (Fullbrook, Jackson, & Finlay, 2006; UNFCC, 2007; WGBC, 2009). A green building is best described as a building that is designed, constructed and operated to be resource efficient (Kubba, 2010; Wedding, 2008; Zigenfus, 2008). Howe and Gerrad (2010) and Wener and Carmalt (2006) found that the majority of green buildings are not energy efficient. Turner (2008) showed that 20 to 34 per cent of supposedly ‘green’ buildings consumed more energy than its counter conventional parts Andrews et al., (2010) and Bordass et al., (2001), suspects that green buildings become less efficient when facility managers do not operate the building as intended, and because occupants sometimes behave differently than expected. How the facility management manages energy plays an important role in achieving energy efficient performance.
In New Zealand, green buildings began being constructed from 2004, including the Vero Building which won the National EnergyWise Award in 2005 (Ministry of Environment, 2005). Since the introduction of the GreenStar NZ rating tool in 2007, the numbers of green buildings have increased to 55 buildings to date (NZGBC, 2011b) with three certified buildings on university campuses (NZGBC, 2011a). The Malaysian government have also expressed interest in greater implementation of green buildings (Esa et al., 2011; Razak, 2011). The increasing trend of implementing green buildings necessitates the need to have an operational building guideline to avoid inefficient operation of green (Gabe, 2008; Ministry of Environment, 2005).

This raises the question: what energy management strategies should be taken to ensure buildings’ energy efficient performance? In New Zealand, standard energy management guidelines to inform building operators on how to achieve energy efficiency have been produced by the Energy Efficiency Conservation Authority (EECA), New Zealand (2012). Although the guidelines exist, there have not been studies to investigate the effectiveness of the guidelines in achieving optimum energy performance.

In Malaysia, the closest corresponding guideline to refer to is the Green Building Index rating tool. The Green Building Index (GBI) for existing non-residential buildings (i.e., commercial buildings) is a rating tool used in Malaysia to assess a building’s impact on the environment, with energy efficiency scoring the highest (a maximum 35 points out of the total 100 points) (GBI, 2011). The GBI tool was developed to evaluate the building design, but not how energy is managed operationally in the building. Despite the lack of focus on energy management, there are still strategies listed in the rating tool which can be developed for further improvement.
In summary, the available references for ensuring energy efficient performances in buildings in New Zealand and Malaysia can be developed to create a more comprehensive framework. Guidelines in other developed countries such as those produced by the Carbon Trust in the United Kingdom (UK) (2010) and Energy Star in the United States (US) (2011), and the International Standard Organisation’s *ISO 50001:2011 Energy Management System* (2011), all have similar features to the EECA guidelines. New Zealand and Malaysia lack operational and maintenance performance rating tools that are specifically for green buildings, such as the LEED Existing Building Operational and Maintenance (LEED-EBOM) guideline (USGBC, 2009); or the Building Research Establishment Environmental Assessment Method-In Use (BREEAM In Use) guideline in the United Kingdom (BREEAM, 2011).

The objective of this study was to identify strategies to achieve energy efficient performance in buildings and test the implementation of these strategies in case studies from New Zealand and Malaysia.

### 4.2 Energy management strategies

From the literature, energy management strategies were identified that were considered as relevant to a commercial office building’s planning phase and the operational ‘reviewing and monitoring’ phase. The energy management strategies were tested in the New Zealand case studies for relevance and use.
4.2.1 Energy policy

According to the energy management guidelines developed by the EECA, New Zealand (EECA, 2012), Energy Star in the US (Energy Star, 2011) and Carbon Trust in the UK (CarbonTrust, 2010) a good energy plan consists of an energy policy, which is a written document stating how the organisation will meet an energy target and continue to improve energy efficiency over time. An energy policy consists of long and short term objectives as part of the organisation’s commitment to achieve energy efficiency. Determining an appropriate energy efficiency target is important and needs to be included in an energy plan (BRECSU, 2000; EC, 2003; EECA, 2012; Energy Star, 2012; Myeda, Kamaruzzaman, & Pitt, 2011; OSISOft, 2007). The target enables facility management to make comparisons between the target and the actual energy consumed. An energy benchmark, commonly known as the Building Energy Index (BEI), is calculated as the total energy used in a building for one year in kilowatt hours divided by the gross floor area of the building in square metres (Chan, 2009; Monts & Blissett, 1982), expressed as kWh/m²/year. Another BEI which can be formulated is simply derived from data on historical energy performance (Energy Star 2012). Hence, a range of BEI gives operators more choices to help them decide how much effort should be put into reducing energy consumption, since certain costs are involved if energy targets are set at an ambitious level.

Kato et al., (2010) and Bond (2011) have reported that many four star certified buildings do not perform at a two star level. According to The National Australian Built Environment Rating System (NABERS), with the two star rating the building is considered as performing below average, while a four star rating demonstrates good performance (Nabers, 2014).
The energy efficient BEI for office buildings in New Zealand suggested in GreenStar NZ is 105kWh/m² (GreenStar, 2009). While in Australia, the National Built Environment Rating System (NABERS, 2011) suggests that the energy efficient benchmark is approximately 170kWh/m²/year. These BEI values are debatable since the values are only averages of a range of buildings and variables such as weather are not normalized (Newsham, Mancini, & Birt, 2009; Scofield, 2009). The process differs from the United States’ Energy Star Portfolio Manager which consists of energy data that has been normalized for weather and several other important building and operational characteristics, thus allowing building comparisons to be made (Energy Star, 2011). A similar tool called The Carbon Trust’s Energy Consumption Guide (ECON19) benchmark is used in the UK (Action Energy, 2003). Both of these tools have been used for energy performance studies (Leaman & Bordass, 2001; Turner & Frankel, 2008). In New Zealand, there is no similar database yet but the importance has been recognised and a database is currently being developed through research at the University of Lincoln (McDonagh, 2010).

4.2.2 Facility management

Leaman and Bordass (2001) identified that an active facility management team, including a proactive help desk to deal with complaints, is an important mechanism for making energy savings. They emphasise that it is very important that occupants’ complaints are taken seriously. Hinks (2000) described that the management process by the operators should be proactive rather than reactive; thus pre-planned and proactive maintenance works should consider both clients’ satisfaction and service performance.

Energy use cannot be managed if it is not measured (Hinks, 2000). Energy management guidelines (CarbonTrust, 2010) show the importance of having an energy management
system (EMS) installed to measure and track energy consumption in the building. An EMS consists of computer-aided tools which enable the monitoring and controlling of energy using systems. There are different types of EMS available in the market, with different levels of detail of energy measurement. Energy Star (Energy Star, 2012) suggests that it is important to have an effective EMS as it allows for the development of energy control strategies and retrieval of the data needed to do diagnostics to identify energy waste. A better assessment of energy waste helps facilities management to identify opportunities to conserve energy.

Energy management guidelines developed by the Carbon Trust (UK) (2010), Energy Star (US) (2012), the EECA (NZ) (2012) and the NZGBC (2011c) mention the testing, commissioning and updating of energy schedules. According to the Carbon Trust (UK) (2010) and LEED-EBOM (2009), best practice management has detailed schedules for the operation of all of the plant, instruments and controls. Scheduling for only some of the plant and control systems is considered not effective. According to LEED-EBOM (2009), scheduling techniques must include an occupancy schedule, equipment run-time schedule, set points for all HVAC equipment, and lighting levels. Examples of scheduling strategies include setting timers to turn off the HVAC at least one hour before the end of the working day (EECA, 2011a), and setting the temperature of cooling systems to a higher degree (the temperature advised is between 20 to 24 ºC). These operating scheduling strategies must be regularly reviewed (NZGBC, 2011c). The Energy Star guidelines (2012) suggest that the exterior lighting schedule should be changed throughout the year according to the season. Occupancy or motion sensor sensitivity and time-delay settings should be customized to the requirement of each individual space (Energy Star, 2012).

Intervention studies using antecedent tools (i.e., information posters (EECA, 2011b) and/or reminder labels (Reab, Dillon, & Levy, 1987)) and consequent tools (i.e., feedback or
comparative feedback on energy usage) (Abrahamse, Steg, Vlek, & Rothengatter, 2005; EECA, 2011b) are suggested as being effective in facilitating energy saving behaviour. Steinburg and Landis (2010) discovered that occupants expressed high interest in helping to save energy, provided they understood more about the energy efficiency features in the building. The occupants in the study learned to manually dim the lights when there was sufficient natural daylight to help reduce energy. The Carbon Trust (2010) and EMP NZGBC (2011c) have emphasised the importance of communication in an organisation so that employees and stakeholders are aware of energy savings progress. Armitage (2010) and Brown (2009) have advised that interactive and direct education, such as building inductions and workshops, is a more effective way of communicating with staff than distributing a building manual.

It is important to note that environmental knowledge alone does not predicate pro-environmental behaviour (I Ajzen & Ferrand, 1999; Diekmann & Preisendoerfer, 1992; Kempton, Boster, & Hartley, 1995; Kollmuss & Agyeman, 2002; Rajecki, 1982). Barriers to behaviour change are complex because behaviour is dependent on both internal (individual, psychological and social) (GreenStar, 2009) and external factors (institutional, economic, social and cultural) (Kollmuss & Agyeman, 2002). The effectiveness of interventions needs to be evaluated in different contexts and cultures, because behaviours and needs vary (Ajzen, 1991).

4.2.3 Achieving energy efficiency

Energy management guidelines (CarbonTrust, 2010; EECA, 2012; Energy Star, 2011; NZGBC, 2011c) mention efficient appliances as an important strategy in energy efficiency management. An LCD flat screen display computer monitor uses one third less energy as
compared to an old CRT monitor (EECA, 2010a). Laptops are 50 to 80 per cent more efficient than conventional PCs and monitors (EECA, 2010a). Other electrical equipment (e.g., copiers, printers, scanners and fax machines) should be selected based on the Energy Star label which is currently an international mark of energy efficiency for electrical appliances (EECA, 2010a). Energy saving and sleep routines for the computer equipment should be enabled (NZGBC, 2011c).

To avoid modifications by the occupants, guidelines such as the Energy Management Plan (EMP) for green buildings have been developed by the New Zealand Green Building Council (NZGBC, 2011c) which require tenants to gain approval from the building owner to bring any electronic appliances (e.g., radiators, fans, toasters, and similar small appliances) into the building. Similarly the Green Lease Guide, Australia (Investa Property Group, 2007) and Good Practice Guide, United Kingdom (Langley & Stevenson, 2007), have been developed by government agencies and request that tenants only purchase energy efficient office equipment.

Buildings may apply for green certifications, such as the GreenStar NZ rating system, where certification requires a continuous commitment to maintaining energy efficient performance and is assessed every three years to ensure that performance is adequate. Energy schemes demonstrate good practice, and achieve recognised standards (CarbonTrust, 2010). Endorsement of the efforts of the energy management staff involved make those staff motivated and feel appreciated, and the organisation can thereby foster an internal culture of continuous commitment to energy efficiency. Recognition through an external audit may encourage occupants to improve energy efficiency performance. A study by (Tajabadi, 2010) reported that occupants in a certified green building practiced more energy conservation behaviours as compared to occupants in conventional buildings. Another study by (Armitage,
2010) surveyed 31 certified green buildings in Australia, and discovered that 60 per cent of the respondents believed that the image of working in a green building motivated occupants to be more environmentally friendly.

Energy management guidelines (e.g., EECA (EECA, 2010b) and Energy Star (Energy Star, 2012)) emphasise the importance of engaging the cooperation of all levels of staff in buildings. Some of the recommendations provided by Energy Star include rewarding occupants through formal acknowledgements and certificates, salary increases and cash bonuses, and appreciation gifts such as coffee mugs or energy programme shirts (Energy Star, 2012). EECA recommend donating the money saved through energy efficiency measures to charity (EECA, 2010b). Hence, many forms of recognition can be used to sustain the support and momentum for energy management initiatives.

4.2.4 Reviewing, reporting and maintenance

Sub-meters of the building systems’ energy use must be monitored to track energy consumption of the major building uses and other end-use applications (GBI, 2011; GreenStar, 2009). Monitoring involves the process of data collection (i.e., energy consumption figures, energy costs, floor area, temperature variations), analysis and interpretation of the data to identify where energy can be reduced, and production of a report for reference purposes (CarbonTrust, 2010; EECA, 2010c). The sub-meters are not the only thing that should be monitored. As suggested in the NZGBC Energy Management Plan, quarterly surveys of after-hours energy use around the building should be carried out to identify lights, plant items and equipment that are left on unnecessarily (NZGBC, 2011c). A study by Leaman and Bordass (2001) on 16 energy efficient buildings in the UK identified
that constant review of actual performance against objectives during occupation is crucial in maintaining energy efficiency performance.

A report reflecting energy efficiency performance can show energy savings over a period of time, starting from the building’s existing historical Building Energy Index (BEI) baseline (GBI, 2011). A report compiles and summarises the BEI measure on an annual basis, including monthly energy bills. A complete energy report contains reasons for any energy increase and recommended plans for further improvement in energy efficiency (Energy Star, 2011; Marteinsson, 2003; Teicholz, 2001; Toro, 1995; USGBC, 2009). The LEED-EBOM rating tool (2009) suggests that proper documentation is encouraged to promote the continuity of information on energy efficient operating strategies and to provide a foundation for training and system analysis. According to energy management guidelines (CarbonTrust, 2010; EECA, 2012; Energy Star, 2011), monitoring should be carried out on a regular basis.

Implementing improvements to ensure that buildings’ major energy using systems are repaired, operated, and maintained effectively is important to optimize energy performance (GBI, 2011). The operations management team should provide a documented plan for a facility maintenance budget (inclusive of staffing and outsourced contracts) (GBI, 2011). Energy management guidelines (CarbonTrust, 2010; EECA, 2012; Energy Star, 2011; USGBC, 2009) emphasise that best practice energy management should remedy any defaults and that remedial work should not be constrained by budgets. Maintenance and re-calibration of building services advised by EMP NZGBC are to be carried out regularly (NZGBC, 2011c).

A key measure mentioned as part of core maintenance by the Carbon Trust, Energy Trust, and EECA, is that lighting diffusers and shades should be cleaned or maintained on a regular schedule. Windows and blinds also need to be cleaned regularly (NZGBC, 2011c). The EMS
should be regularly checked to ensure it is operated in the most effective and efficient manner (Armitage, 2010; Bordass, Cohen, et al., 2001). All sensors (i.e., room and duct thermostats, humidistats, pressure sensors, temperature sensors) and meters need to be checked regularly and calibrated with the EMS.

The *Energy Management Plan* (EMP) guidelines developed by the NZGBC suggest that fine tuning of the control systems must be done during the first year of operation (NZGBC, 2011c). The Carbon Trust (2010) suggest that this fine tuning of control systems should be done more than once a year. Energy Star (Energy Star, 2011) advise that some of the controls may require outside expertise with specialized skills or equipment. The NZGBC’s *Energy Management Plan* suggests that a performance clause may be added into a contract with the contractor to ensure that this maintenance work is implemented (NZGBC, 2011c).

In summary, a total of 19 factors were identified as contributing to energy efficiency. The major factors that should be monitored in terms of facilities management are summarised in Table 4.1. The factors were further categorised into four phases: the planning, operational, reviewing, and monitoring phases. Each phase consists of elements that are suggested as being important. Elements included in the planning phase were energy policy, facility management, and achieving energy efficiency. Three factors were identified under the heading of energy policy; seven were identified under facility management and four general factors were identified as being important in achieving energy efficiency. The remaining five factors were identified as being relevant to the operational, reviewing, and monitoring phase.
<table>
<thead>
<tr>
<th>Item</th>
<th>Phase</th>
<th>Major Factor</th>
<th>Sub-factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Planning Phase</td>
<td>Energy Policy</td>
<td>A written document stating how the organisation will meet an energy target and continue to improve energy efficiency over time</td>
</tr>
<tr>
<td>2</td>
<td>Planning Phase</td>
<td></td>
<td>Long- and short-term objectives of the organisation’s commitment to achieve energy efficiency</td>
</tr>
<tr>
<td>3</td>
<td>Planning Phase</td>
<td></td>
<td>A proper energy efficiency target</td>
</tr>
<tr>
<td>4</td>
<td>Facility Management</td>
<td></td>
<td>Provide for a designated building maintenance office that is fully equipped with facilities</td>
</tr>
<tr>
<td>5</td>
<td>Facility Management</td>
<td></td>
<td>An active facility management team whereby there exists a pro-active help desk to deal with complaints</td>
</tr>
<tr>
<td>6</td>
<td>Facility Management</td>
<td></td>
<td>Energy management system (EMS) installed to measure and track energy consumption in the building</td>
</tr>
<tr>
<td>7</td>
<td>Facility Management</td>
<td></td>
<td>An effective EMS for the development of control strategies and for detail retrieval of data needed to identify energy waste.</td>
</tr>
<tr>
<td>8</td>
<td>Facility Management</td>
<td></td>
<td>Testing, commissioning and updating of energy schedule</td>
</tr>
<tr>
<td>9</td>
<td>Facility Management</td>
<td></td>
<td>Intervention studies using antecedent tools (i.e. information posters / reminder labels and consequent tools (i.e., feedback or comparative feedback on energy usage)</td>
</tr>
<tr>
<td>10</td>
<td>Facility Management</td>
<td></td>
<td>Provide training and skills for management staff on a broad range of sustainable building operations topics.</td>
</tr>
<tr>
<td>11</td>
<td>Achieving Efficiency</td>
<td></td>
<td>Mainly uses energy efficient office equipment</td>
</tr>
<tr>
<td>12</td>
<td>Achieving Efficiency</td>
<td></td>
<td>Request tenants to only purchase energy efficient office equipment</td>
</tr>
<tr>
<td>13</td>
<td>Achieving Efficiency</td>
<td></td>
<td>Applied for an external energy audit assessment/ competition</td>
</tr>
<tr>
<td>14</td>
<td>Achieving Efficiency</td>
<td></td>
<td>Provide internal recognition</td>
</tr>
<tr>
<td>15</td>
<td>Operational, Reviewing, and Monitoring Phase</td>
<td></td>
<td>Monitor sub-metering of building systems to track energy consumption of major building uses and other end use applications</td>
</tr>
<tr>
<td>16</td>
<td>Operational, Reviewing, and Monitoring Phase</td>
<td></td>
<td>A report to reflect energy efficiency performance to show energy savings over a period of time from existing building historical BEI baseline</td>
</tr>
<tr>
<td>17</td>
<td>Operational, Reviewing, and Monitoring Phase</td>
<td></td>
<td>Report provide reasons on the energy increase and recommendations plans for further improvement in energy efficiency</td>
</tr>
<tr>
<td>18</td>
<td>Operational, Reviewing, and Monitoring Phase</td>
<td></td>
<td>Ensure the building’s major energy using systems are repaired, operated, and maintained effectively</td>
</tr>
<tr>
<td>19</td>
<td>Operational, Reviewing, and Monitoring Phase</td>
<td></td>
<td>Provide evidence of documented plan for facility maintenance and preventive maintenance budget</td>
</tr>
</tbody>
</table>
4.3 Assessment of the green building index (GBI) tool in Malaysia

The Green Building Index (GBI) for existing non-residential buildings (i.e., commercial buildings) is a rating tool used in Malaysia to assess a building’s impact on the environment with Energy Efficiency as the highest rated item (35 points out of a total of 100 points) (GBI, 2011). The GBI tool was developed to evaluate the building design, but not how energy is managed during the operational phase of the building. Despite the lack of focus on energy management, there are still strategies listed in the rating tool which can be developed for further improvement. Therefore, the GBI tool is used in this study as the basis for developing a more comprehensive framework. The strategies are categorised into three phases: the (1) Planning phase; (2) Reviewing and reporting phase; (3) maintaining phase.

4.3.1 Planning phase

4.3.1.1 Energy policy

The GBI tool (GBI, 2011), lists developing a commissioning or ongoing commissioning plan for the building’s major energy using systems” as one of the criteria to consider in maximising energy efficiency performance. However, the GBI tool does not describe clearly what an energy plan should look like. According to energy management guidelines developed by EECA (EECA, 2012), Energy Star (Energy Star, 2011), and the CarbonTrust (CarbonTrust, 2010), a good energy plan consists of an energy policy, which is a written document stating how the organisation will meet an energy target and continue to improve its energy efficiency in the future. An energy policy consists of the long and short term objectives of the organisation’s commitment to achieving energy efficiency.
4.3.1.2 Setting an appropriate Energy Target – The Building’s Energy Benchmark

Determining an appropriate energy efficiency target is important and should be included in an energy plan (BRECSU, 2000; EC, 2003; EECA, 2012; Energy Star, 2012; Myeda, Kamaruzzaman, & Pitt, 2011; OSISOft, 2007). It enables the facility management to compare the targets with the actual energy consumed. An energy benchmark commonly known as the Building Energy Index (BEI) is calculated as the total energy used in a building for one year in kilowatts hours divided by gross floor area of the building in square metres (Chan, 2009; Monts & Blissett, 1982), expressed as kWh/m$^2$/year. Target BEI values vary across organizations concerned with energy efficiency. Under the GBI tool (GBI, 2011), a range of BEI values are listed, ranging from <90 kWh/m$^2$/year to <150 kWh/m$^2$/year; with intervals of 10 kWh/m$^2$/year. The maximum value of the BEI of 150 kWh/m$^2$/year in the GBI tool was developed based on the Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings MS 1525 Guideline (MS1525, 2007), which is the latest available figure. It was set as the benchmark for energy efficient buildings. Another BEI value for a typical office building, which was developed by the Malaysia Energy Centre (MEC) for office buildings, has a value of 200 to 250 kWh/m$^2$/year (Chan, 2009). The Association of South East Asian Nations (ASEAN) calculated a BEI of 200 kWh/m$^2$/year for a typical office building (Chan, 2009). These BEI values are somewhat debatable since the values are only averages of a range of buildings, and variables such as the weather are not normalized (Newsham, Mancini, & Birt, 2009; Scofield, 2009). This differs from the US’s Energy Star Portfolio Manager which consists of energy data that has been normalized for weather and several other important building and operational characteristics, thus allowing comparisons to be made on a level playing field (Energy Star, 2011). A similar tool called The Carbon Trusts Energy Consumption Guide (ECON19) benchmark is used in the UK (Action Energy, 2003). Both of these tools have been used for energy performance studies.
(Leaman & Bordass, 2001; Turner & Frankel, 2008). In Malaysia, there is no similar database, but development of this type of portfolio in the Malaysian context would help make the energy management framework more comprehensive. Another BEI which can be taken is simply from historical performance of energy data (Energy Star 2012). Hence, a range of BEI gives operators more choices to decide how much effort should be placed to reduce energy consumption since certain costs would be involved if energy targets are set at an ambitious level.

4.3.1.3 Facility management team support

The GBI tool states that there is a need to provide for a designated building maintenance office that is fully equipped with facilities (including tools and instrumentation) and inventory storage. However, an office equipped with complete facilities is not sufficient in itself to achieve energy efficiency performance. Leaman and Bordass (2001) identified that a diligent facility management team with a proactive help desk to deal with complaints is an important agent. They emphasise that it is very important that occupants’ complaints are taken seriously. Hinks (2000) described that the operational management process should be more proactive than reactive. Proactive maintenance work should consider clients’ satisfaction as being of prime importance, alongside service performance.

4.3.1.4 An effective energy management system

Energy cannot be managed if it is not measured (Hinks, 2000). The GBI tool (GBI, 2011) emphasises the importance of having an energy management system (EMS) installed to measure and track energy consumption in the building. Other energy management guidelines supports this strategy (CarbonTrust, 2010). An EMS consists of computer-aided tools which
enable the tasks of monitoring and controlling energy using systems. There are many different types of EMSs available in the market such as Honeywell (Honeywell), Energex (Energex), Lonix (Lonix), amongst others. Each of the systems has a different level of capacity in terms of how much detail about energy use can be measured. Energy Star (Energy Star, 2012) suggests that it is important to have an effective EMS, as it makes more control strategies available and typically retrieves most of the data needed to carry out diagnostics to identify energy waste. Therefore, with an effective EMS a better assessment of energy waste can assist the facilities management team to identify opportunities to conserve energy.

4.3.1.5 Apply scheduling during testing and commissioning building, and regularly update

The GBI rating tool states: “update the building operating plan as necessary to reflect any changes in the occupancy schedule, equipment runtime schedule, design set points and lighting levels”. Energy management guidelines by the Carbon Trust (2010), Energy Star (2012), and EECA (2012) have mentioned this aspect especially in controlling lighting and heating, ventilation, and air conditioning (HVAC) energy usage. The GBI tool can be improved by including guidance on what measurements a building’s operating plan should have. According to the Carbon Trust (UK) (2010), and LEED-EBOM (2009), a best practice management has detailed schedules for all plant operations, instrumentations and controls. Scheduling for only some of the plant and control systems is considered a poor building operating plan. According to LEED-EBOM (2009), scheduling techniques must, at a minimum, include occupancy and equipment run-time schedules, set points for all the HVAC equipment, and lighting levels. Examples of scheduling strategies include setting timing operations to turn off the HVAC at least one hour before the end of the working day (EECA, 2011a), setting the temperature of cooling systems to a higher degree (i.e., 24°C in Malaysia
is determined to be an energy efficient measure (Energy Centre, 2011), and in New Zealand, the temperature advised is between 20 to 24 ºC). The Energy Star guideline (2012) suggests that the exterior lighting schedule should be changed throughout the year according to season. Occupancy or motion sensors sensitivity and time-delay settings should be customized to the requirement of each individual space (Energy Star, 2012).

4.3.1.6 *Provide sufficient education on energy efficiency to all occupants*

According to the GBI tool, training for management staff should be provided on a broad range of sustainable building operation topics including energy efficiency, and building, equipment, and system operations and maintenance. Results from intervention studies using antecedent tools (e.g., information posters (EECA, 2011b) and reminder labels (Reab, Dillon, & Levy, 1987)) and consequent tools (e.g., feedback or comparative feedback on energy usage) (Abrahamse, Steg, Vlek, & Rothengatter, 2005; EECA, 2011b) suggest that they are effective in facilitating energy saving behaviour, but these are not mentioned in the GBI tool. The Carbon Trust (2010) also emphasises the importance communication in an organisation, so that employees and stakeholders are aware of the progress made in energy savings; thus it recommends that achievements and reports are announced to all employees. It is important to note that environmental knowledge alone does not predicate pro-environmental behaviour (Ajzen & Ferrand, 1999; Diekmann & Preisendoerfer, 1992; Kempton, Boster, & Hartley, 1995; Kollmuss & Agyeman, 2002; Rajecki, 1982). Barriers to behaviour change are complex because behaviour is dependent on internal (individual, psychological, social) and external factors (institutional, economic, social & cultural) (Kollmuss & Agyeman, 2002). The effectiveness of the intervention studies needs to be planned for different context and cultures because behaviour and need vary.
4.3.1.7 Procurement of energy efficient electrical appliances

The GBI tool does not mention purchasing energy efficient electrical office equipment as an important part of increasing energy efficiency (GBI, 2011). Energy management guidelines (CarbonTrust, 2010; EECA, 2012; Energy Star, 2011) point out that this as an important strategy in energy efficiency management. An LCD flat screen display computer monitor uses one third less energy as compared to an old CRT monitor (EECA, 2010a). Usage of laptops are 50 to 80 per cent more efficient than conventional PC and monitor (EECA, 2010a). Other electrical equipment (i.e. copiers, printers, scanners and fax machines) should be selected based on the Energy Star label which is currently an international mark of energy efficiency electrical appliances (EECA, 2010a). To avoid modifications by the occupants, guidelines such as Energy Management Plan (EMP) for green building were developed by New Zealand Green Building Council (NZGBC, 2011) where it requires tenants to gain approval from building owner to bring any electronic appliances (i.e. radiators, fans, toasters, and etc.) into the building. Similarly the Green Lease Guide, Australia (Investa Property Group, 2007) and Good Practice Guide, United Kingdom (Langley & Stevenson, 2007), were developed by government agencies requesting tenants to only purchase energy efficient office equipment.

4.3.1.8 Apply for an external energy audit

Under the GBI tool, the certification must be re-assessed every three years to ensure GBI rating performance. In addition to this effort, the organisation can enter into an energy efficiency building competition such as ASEAN building competition. Organisations can also apply for an independent energy audit party such as GREENTECH in Malaysia. Suggested by Carbon Trust Energy Management Guideline (CarbonTrust, 2010), entering into
additional energy schemes demonstrates good practice, and achieve recognised standards. This endorsement of the efforts of energy management staff involved would make staff feel motivated and appreciated. Thus, a continuous commitment culture within the organisation is instigated.

4.3.1.9 Provide internal recognition

Energy management guidelines (i.e. EECA (EECA, 2010b) and Energy Star(Energy Star, 2012)) emphasise that it is important to engage cooperation from all level of staffs in the building. This strategy is not mentioned under the GBI tool. Some of the recommendations provided by Energy Star guideline were rewarding occupants through formal acknowledgements and certificates, salary increases and cash bonuses, appreciation gifts such as coffee mugs or energy program shirts. EECA recommended donating the money saved to charity. Hence, many forms of recognition can be used to sustain support and momentum for energy management initiatives.

4.3.2 Reviewing and reporting

4.3.2.1 Monitoring

Under the GBI rating tool (GBI, 2011), sub-meters of the building systems must be monitored to track energy consumption of major building uses and other end-use applications. Monitoring involves the process of data collection (i.e. energy consumption figures, energy costs, floor area, temperature variations), analysis and interpretation of the data to identify where energy can be reduced, and produce a report- for reference purpose (CarbonTrust, 2010; EECA, 2010c). A comprehensive study by Leaman and Bordass (2001)
on 16 energy efficient buildings identified that constant review of actual performance against objectives during occupation is crucial in maintaining energy efficiency performance.

4.3.2.2 Reporting

An energy report required by the GBI tool (GBI, 2011) must demonstrate energy savings over the last three years when compared with the building’s existing historical BEI baseline. It is also a requirement to submit a compilation and summary of BEI consumption on an annual basis, including monthly energy bills. A complete energy report should not just contain information on previous historical data on energy savings; it should also contain reasons for any energy increase, and recommendations and plans for further improvements in energy efficiency (Energy Star, 2011; Marteinsson, 2003; Teicholz, 2001; Toro, 1995; USGBC, 2009). The LEED-EBOM rating tool (2009) suggests that proper documentation is encouraged to promote continuity of information about energy efficient operating strategies and to provide a foundation for training and system analysis. According to energy management guidelines (CarbonTrust, 2010; EECA, 2012; Energy Star, 2011), a report on the monitoring process should be carried out on regular basis and circulated to a variety of audiences, not just within the organisation. Hence, it would be better for an energy management framework to use this as an additional strategy to achieve greater energy efficiency performance.

4.3.2.3 Maintenance

The GBI tool states that improvements should be implemented to ensure that a building’s major energy using systems are repaired, operated, and maintained effectively to optimize performance. The GBI tool also requires a building’s operations management to provide
evidence of a documented plan for the facility maintenance budget (inclusive of staffing and outsourced contracts). However, it does not guide operators on how to conduct this measurement. Myeda, et al., (2011) observed a lack of standard guidelines and monitoring of maintenance approaches in Malaysia. Energy management guidelines (CarbonTrust, 2010; EECA, 2012; Energy Star, 2011; USGBC, 2009) emphasise that a best practice energy management will quickly remedy any defaults and that remedial work should not be constrained by budgets. Among key maintenance measures mentioned by the Carbon Trust, Energy Trust and EECA is that lighting diffusers and shades must be cleaned or maintained on a regular schedule. The EMS should be regularly checked to ensure it is operated in the most effective and efficient manner (Armitage, 2010; Bordass, et al., 2001). All sensors (e.g., room and duct thermostats, humidistats, pressure sensors, and temperature sensors) and meters should be regularly checked and calibrated with the EMS. The Carbon Trust (2010) suggests that these fine tuning control systems should be carried out more than once a year. Energy Star (Energy Star, 2011) advises that some of the controls may require calling on outside expertise for their specialized skills or equipment.

Table 4.2 depicts the recommended elements for an energy management framework that is used to test in the case studies.

<table>
<thead>
<tr>
<th>Item</th>
<th>Energy Management Measures</th>
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<tbody>
<tr>
<td>1</td>
<td>Implement improvements to ensure building’s major energy using systems are repaired, operated and maintained effectively to optimize energy performance.</td>
</tr>
<tr>
<td>2</td>
<td>Develop a commissioning plan, or have an ongoing plan in place, for the building’s major energy-using systems.</td>
</tr>
<tr>
<td>3</td>
<td>Provide training for management staff to build awareness and skills in a broad range of sustainable building operations topics, including energy efficiency and building, equipment and systems operations</td>
</tr>
</tbody>
</table>
and maintenance

4. Update the building operating plan as necessary to reflect any changes in the occupancy schedule, equipment runtime schedule, design set points and lighting levels.

5. Use an Energy Management System to monitor and trend log building system performance for HVAC system efficiency, including parameters for plant sequencing, etc.

6. Monitor sub-metering of building systems to track energy consumption of major building uses and other end use applications.

7. Submit a compilation and summarisation of the BEI consumption on an annual basis, including monthly energy bills.

8. Provide for a designated building maintenance office that is fully equipped with facilities (including tools and instrumentation) and inventory storage.

9. Provide evidence of a documented plan for at least 3-yearly facility maintenance and preventive maintenance budget (inclusive of staffing and outsourced contracts).

10. Demonstrate energy savings over the last 3 years from the existing building historical BEI baseline.

11. Set room temperatures at 24C.

12. Apply scheduling of equipment during the testing and commissioning of a building.

13. Apply for an external energy audit assessment and/or enter competitions.

14. Continuously ensure building control systems are fine tuned to maintain the efficiency of the system.

15. Always incorporate reminders for staff and/or circulate circulars on energy efficiency information.

16. Distribute reminder labels to switch off lights and computers.

17. Update occupants on energy consumption of building from time to time.

18. Primarily use Energy Efficiency certified office equipment and networked printers; that is, computers with LCD screens, or laptops. Do not allow computers with CRT screens. Equip computers with software that automatically reduce energy consumption during idle periods.

19. Provide internal recognition.

Note: Items 1 - 10 highlighted in grey show measures adopted from the Malaysian GBI tool. Items 11 – 19 are measures adopted from the literature.
4.4 Results and Discussion: New Zealand

4.4.1 Energy Policy

The University of Auckland (UoA) is party to the Universitas 21 Agenda (U21), which is a formal type of commitment to encourage activities that contribute to a sustainable future. This indicates that the university have a formal written document to show their commitment to conserving energy. The scope of the commitment to being a sustainable university not only focuses on energy, but also focusses on reducing water usage and waste. The university acknowledges the need to set goals, both long and short term and accordingly developed an eight year strategic plan for the period from 2005 to 2012. The plan includes three objectives to achieve more efficient use of resources. The first objective, to encourage efficient and environmentally sustainable use of the nation resources, is to be achieved through continuous high quality learning and research outcomes, equity of access and innovation. The second objective is to include sustainability elements in improving the university’s physical environment and infrastructure. The last objective is to continuously improve the understanding of the concept of sustainable management of resources in terms of what is appropriate for the university’s activities, and develop policies and practices that improve efficiency in resource utilisation and minimise environmental impact. In addition to the U21 statement, an environmental policy was established which stated that UoA is committed to conserving energy. The environmental policy attempts to conserve energy by committing the university to being environmentally responsible in the areas of the natural environment; development, design and management of the built environment; and resource conservation. Under the heading of the responsibility to the natural environment; it states that the university will undertake the conservation and economic use of utilities such as electricity, steam and gas; and that university will ensure high quality of air and light is achieved and maintained.
Under development, design and management the policy states that buildings and facilities are designed to enhance natural lighting and ventilation; and in terms of resource conservation, it states that the university supports efficient use of buildings, equipment, resources, materials, and utilities. At the time of this study, the practice of all three case study buildings was to compare the energy consumption index to the previous year's energy consumption data. To date, in New Zealand there is no appropriate energy consumption index that can be used as the reference for energy efficiency benchmarking. The case study buildings are unique, as the building functions are a combination of accommodating offices and research laboratories. An appropriate benchmark that standardises function, local condition, and weather is necessary for buildings on a university campus. The building managers reported that it would be beneficial if there were energy benchmarks available that could be used as targets. Their current practice is just to compare yearly historical data without reference to any external energy targets. Improvements to energy policy, incorporating rating indices, would improve the energy policy focus for these buildings.

4.4.2 Facility management

At the time of this study, each of the three green case study buildings (TB, OGGB, and PHC) had a building maintenance office equipped with facilities, as did one of the conventional case study buildings (FoE). Only the conventional OCH building did not have an on-site building manager for energy usage matters, or a building maintenance office. The energy management system showing the ongoing record of energy usage was accessible online for all four case studies (the TB, OGGB, PHC, and FoE).

The University of Auckland (UoA) is aware on the importance of having an active facility management team. This demonstrated by the UoA environmental policy, where it states the importance of having specific objectives for implementation on an ongoing basis. The
objectives included establishing a dedicated senior staff position to provide leadership and direction. In 1998, the University of Auckland was the first university in New Zealand to appoint an Energy Manager responsible for all the buildings in the university. The university has also stated that there must be a committee to oversee the implementation of the environmental policy.

In all four case studies (TB, OGGB, PHC, and FoE) there is an assigned building manager responsible for providing reasons for current changes in energy use as compared to previous years. Each building manager reports back to the Energy Manager, a central coordinator on energy related matters for all the buildings in University of Auckland. Frequent meetings are held to understand and discuss how energy can further be reduced, with the Sustainable Coordinator responsible for all the environmental conservation activities at the UoA.

The UoA have utilised an Energy Management System (EMS) since the 1980s. The UoA uses an EMS which has the ability to compile together all the energy data from all the buildings. The EMSs track energy consumption of each building at an interval of 30 minutes daily; thus allowing building managers to identify energy waste by observing the current energy trends and comparing them to the average baseline of what the building should be consuming. The EMS also allows the lighting, building services, plant and temperature to be remotely controlled. As a potential improvement of the EMS, the building managers recommended installing additional sub-meters per floor. As a result, a detailed energy breakdown of energy consumption changes could then be obtained and possible reasons for the changes more accurately ascertained. The building managers acknowledged that it is important to have an effective EMS to measure and manage energy consumption in order to achieve better energy efficiency performance. At the time of writing, the efficiency of the EMS was being upgraded.
In all five of the case studies, each building was found to be subject to a detailed scheduling of energy allocation. Air-conditioning is scheduled to switch off an hour before the end of office hours ends; temperatures are set at between 20ºC to 24ºC and are regularly reviewed according to occupancy density in the building. Lighting systems are also scheduled to switch off after hours.

The University of Auckland environmental policy acknowledges that it is important to have a mechanism for dissemination of information. The building managers in all four case studies mentioned that they distributed reminders for staff about energy efficiency behaviours and other energy efficiency information. They sent out emails reminding staff to switch off appliances and lights in empty rooms, to power down personal computers and manually turn off monitors when leaving at night, and to ensure that equipment are turned off when not in use. Staff were also advised to inform the facilities management of faulty or energy wasting equipment. Staff and others occupying the building can easily access a list of energy saving actions they can take along with updates and progress of activities to reduce energy. For the Thomas Building, a building manual was prepared before the occupants moved into the building. The building manual documented the energy efficient design of the building and provided instructions for occupants to help save energy. For example, occupants were advised to turn off the lights, although an occupancy sensor is installed. Sensor lights are turned off after 15 minutes, but occupants can reduce this time by turning lights off when they leave an area. Occupants were also encouraged to switch off computers when they finish for the day, although computers and equipment have been programmed to automatically shut down at the end of the day after a certain time period. No documentation for occupants was prepared for the other case study buildings. The level of effectiveness in providing additional knowledge to occupants on the energy efficient design features of the building, as well as instructions to help reduce energy, is undocumented. From the Thomas building manager’s
observations there were still appliances and lights left on when not in use, despite providing the additional information in the manual about energy saving.

A knowledge sharing portal is available within the organisation. The facilities management team brainstorm strategies to reduce energy consumption. Some of the ideas proposed were: to have a monitoring screen that displays real time energy consumption and information on green features; a cost-benefit study documenting the benefits of intervention tools versus the cost of implementation; and a centralised booking system for weekends, where energy savings can be made as the numbers of buildings to operate is reduced. The building managers in the case studies acknowledged that internal recognition is important to gain support from staff in the organisation. Emails are used to show appreciation to those involved in helping to save energy. Building managers suggested other improvements, including having an energy competition between floors. The building managers speculated that this strategy may encourage more staff in the building to help save energy.

4.4.3 Achieving energy efficiency

Green technologies are technologies that are designed to reduce buildings’ energy consumption. To optimize utilisation of daylight and reduce heat gain in the buildings’ thermal envelope, the buildings use a combination of double glazing of windows with a low emissivity layer, and automated louvers together with wind speed sensors. The automated louvers installed in the PHC, which have an intelligent ability to automatically close and open depending on the wind speed, have had a technology interface issue. In summer the weather conditions can cause the building to become quite hot. Occupants in the building wanted the windows to be opened, however the automatic feature of the technology closed the windows when the wind speed reached a certain threshold. The automatic feature of the louvers was
dismantled as a result. An increase in the sophistication of this technology may provide more comfortable conditions for the occupants in the building via an automated system. Building managers in the three green building case studies also mentioned that the daylight sensors could be improved. They reported that the artificial lights have to be manually switched on when natural daylight is insufficient. In addition, the occupancy sensors sometimes failed to detect occupants in the building because the timer for the lights is controlled by the EMS, which overrides the sensors. The building managers recommended improvements to the flexibility of the system so that the switches can be better controlled in response to occupants’ lighting needs. Variable Air Volume is a cooling technology that is more energy efficient when compared to conventional air-conditioning systems. The TB uses a Variable Air Volume (VAV) system to reduce the air flow rate and fan energy consumption. The building manager in the TB reported that manual fine tuning of the system had to be done to maintain the temperature between the 19°C to 25°C range and recommend improvements to assist in maintaining desired temperatures. This is not an uncommon problem, as these findings are consistent with a study by Armitage (2010) in Australia and by Gabe (2008) in New Zealand, where occupants complained about a lack in stability of the temperature. There is a need to improve the Variable Air Volume technology to achieve better quality ventilation as well as better energy performance.

The key energy saving feature across all five case studies buildings was the use of energy efficient office appliances. The university has procured energy efficient LCD computer monitors and installed software in computers which generates automatic energy saving features when in idle mode. Another area of improvement is to reduce the number of desktop computers and replace them with laptops. Other electrical appliances such as printers, copiers, scanners, and refrigerator are Energy Star labelled. The building managers did mention that while occupants are not encouraged to bring their own electrical appliances into
the building, they still do so. For example, personal fans are mostly brought into the OGGB and PHC buildings because occupants often complain that it is quite hot during the summer. In the TB, occupants mostly had personal heaters as they complained it was too cold during the winter. This shows that although the NZGBC Guidelines state that heaters and fans are not allowed into the building, it shows that the guidelines must be reconsidered to increase occupants’ levels of comfort.

The University of Auckland was interested in applying for an external energy audit and the TB intended to apply for a green star rating by the New Zealand Green Building Council (NZGBC). They aimed to achieve a five star rating, which demonstrates “New Zealand Excellence”. Unfortunately it was reported that, due to budget constraints, the application did not proceed. As for the PHC and OGGB, during the time they were built there was no green rating tool available in New Zealand. An assessment of the likelihood of obtaining the certificates is necessary to aid decision makers when determining whether to approve the budget for an external energy audit. Although the buildings did not get an individual energy audit assessment, the University of Auckland did enter an energy management competition in 2009. The UoA was awarded the Energy Management Award by the Energy Efficiency and Conservation Authority (EECA). The EECA commented that the energy saving campaign for staff and students in 2008 was innovative, and that the UoA has a well-grounded energy management programme that provides an opportunity for continuous improvement.

4.4.4 Reviewing, reporting and maintenance

The University of Auckland conducts careful monitoring and management of its energy use. Monitoring energy use enabled the building managers to become aware of unusual energy use patterns. For example, energy usage for lighting after office hours was identified to be
high when it was expected to be low. This was suspected to be due to cleaners working in the building at night. In response to this issue, the facilities management team instructed the cleaners to work during daytime to save energy. The building manager also identified energy waste by making observations when walking around in the building. Some of the minor issues reported were: that the automatic light control systems were not accurate, resulting in lights being switched off manually; and, as described earlier, minor technology interface problems such as the timer feature in the EMS overriding the motion sensors. Observations by the building manager in the PHC also highlighted occupant behaviours such as windows being left open while the air-conditioning or heating was on.

The University of Auckland environmental policy states that the University must have an established reporting procedure on energy use, thus it is aware on the importance of having sound documentation of energy use information. In discussions, the Energy Manager explained that a full report on the energy data of each of the buildings is sent out to the assigned building manager. The building manager then reports on the reasons for any changes in energy use as compared to previous years. The environmental policy also contains a requirement for regular reviews. A meeting between the facility team management members is conducted using the full energy report as the tool for discussion.

The case study buildings each had an archive of energy data. The most recent energy data available at the time of the study is shown in Table 4.3. A consistent pattern of energy saving was not demonstrated for the green buildings (TB, OGGB, and PHC). Energy data in all three green case study buildings showed an increase in energy use from the previous year. In 2012, when compared to the previous year the PHC had an increase in energy consumption of 4 per cent; the TB had an energy increase of 57 per cent, while the OGGB showed an increase of
11 per cent. Energy data in both the conventional building case studies (the FoE and OCH) showed a decrease from the previous year.

<table>
<thead>
<tr>
<th>Building</th>
<th>Green Buildings</th>
<th>Conventional Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TB</td>
<td>OGGB</td>
</tr>
<tr>
<td>Actual Energy Performance (2011)</td>
<td>239,892.98 kWh</td>
<td>3,589,548 kWh</td>
</tr>
<tr>
<td>(2012)</td>
<td>376,631.98 kWh</td>
<td>3,955,666 kWh</td>
</tr>
<tr>
<td>Difference from last year</td>
<td>136,739.00 kWh (57%)</td>
<td>366,118 kWh (11%)</td>
</tr>
</tbody>
</table>

Opportunities to improve the design of the building to encourage energy saving behaviour were identified in the case studies through observations made by the building managers. For example, the lighting in each separate toilet in the PHC was linked to the lighting in each of the others, thus a sticky label was placed on the switch instructing that it was not to be turned off for the convenience of others that may be using the toilet. Thus the lights in all the toilet cubicles had to remain turned on until the EMS turned the lights off at the end of the day. There were other issues to do with the lighting, such as only one person working in an open plan area in the PHC which lit up the whole room. A shortage of manually controlled light switches has been identified as a persisting issue in green buildings (Bordass, Leaman, & Ruyssevelt, 2001). In the TB, the design of the open plan area followed the New Zealand Green Building Council light switch design guidelines and so controlling lighting was not a particular weakness. However, there were still some areas in the TB, such as in storage rooms, where lights were on continuously until the end of the day because there was no manual switch. Providing more manual light switches for building users allows occupants to take the necessary actions to turn the lights off when not in use. Another design improvement
that could potentially save energy was identified in the PHC, where the lights in the atrium were connected with the lights in the car park. Energy could have been saved if more manual light switches were provided for each space, allowing the atrium lights to be switched on during the day when there is insufficient natural daylight, without having the lights in the car park switched on as well.

Information about what occupants like and dislike about the building control systems is important feedback for building designers and facility managers. For example, in the PHC occupants did not fully utilize the windows in areas that had natural ventilation access with no air-conditioning, mainly because of the noise made by the venetian blinds when the wind blew through them. Cole and Steigner (1999) have emphasised that occupants need to use the building control systems appropriately in order to achieve optimum energy efficiency. The case studies identified improvements that could be made to the design of the building to increase the comfort levels of the occupants. A more comfortable environment for the occupants may reduce the occupants’ use of personal modifications in the building. For example, the majority of occupants in the TB used their own personal heater in the building because the building temperature was too cold as the window louvres did not operate efficiently. In addition, windows in some areas of the PHC were designed to not open, causing the rooms to be quite hot, so a fan and sitting mounting heater was installed to improve occupants’ comfort. Brown (2009) suggests that if the majority of the occupants have fans or heaters, it indicates that there is probably a design failure which does not meet the needs of occupants. Personal modifications lead to increased energy consumption. To be able to accurately predict energy consumption at the design stage requires an in-depth understanding of occupants’ behaviour and needs. Post-occupancy evaluation studies have shown that some green buildings had low scores for users’ experience of comfort, health, and productivity (Abbaszadeh, 2006; Baird, 2010; Leaman & Bordass, 2007) Discomfort
experienced by occupants can impact on the energy performance of the building as they attempt to correct the situation with their own modifications. Findings from the case studies have shown that there is room for improvement to achieve optimum energy efficiency through energy efficient technologies, building design and changes in human behaviour.

The energy reports indicated that the major energy using systems in the UoA buildings are repaired, operated and maintained effectively. Careful retrofitting, rationalisation of equipment and measures to improve energy efficiency began at the university in 2008. For example, T12 generation light fittings were replaced with energy efficient lights bulbs similar to the T5 generation light fittings installed in the three case study buildings. This led to a 8.4 per cent reduction in energy usage per student as compared to 1980. The UoA is also aware of the need for a clearly documented plan for facility maintenance and a preventive maintenance budget. A long term 10 year planning programme has been developed for the maintenance of all the university’s buildings. In 2011 a policy was developed to consider life cycle operating and maintenance expenditure in the design of new buildings. The architects and engineers are required to demonstrate that the operating and maintenance costs are minimised over the life cycle of a building.

4.5 Results and discussion: Malaysia

4.5.1 Energy management measures

Elements of a good energy management framework identified from the literature are summarised in Table 4.4. An energy management framework provides operators with guidance for continuous improvement in building energy performance. Each case study building was subsequently investigated in terms of identifying practices that were absent in the energy management approach. The next sections specifically address items 2, 6, 7, 10, 13, and 15 to 19.
<table>
<thead>
<tr>
<th>Item</th>
<th>Energy Management Measures</th>
<th>LEO</th>
<th>PPJ</th>
<th>MoH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Implement improvements to ensure building’s major energy using systems are repaired, operated and maintained effectively to optimize energy performance.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>Develop a commissioning plan, or have an ongoing plan in place, for the building’s major energy-using systems.</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Provide training for management staff to build awareness and skills in a broad range of sustainable building operations topics, including energy efficiency and building, equipment and systems operations and maintenance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>Update the building operating plan as necessary to reflect any changes in the occupancy schedule, equipment runtime schedule, design set points and lighting levels.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5</td>
<td>Use an Energy Management System to monitor and trend log building system performance for HVAC system efficiency, including parameters for plant sequencing, etc.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6</td>
<td>Monitor sub-metering of building systems to track energy consumption of major building uses and other end use applications.</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>Submit a compilation and summarisation of the BEI consumption on an annual basis, including monthly energy bills.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>Provide for a designated building maintenance office that is fully equipped with facilities (including tools and instrumentation) and inventory storage.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>9</td>
<td>Provide evidence of a documented plan for at least 3-yearly facility maintenance and preventive maintenance budget (inclusive of staffing and outsourced contracts).</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>10</td>
<td>Demonstrate energy savings over the last 3 years from the existing building historical BEI baseline.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>11</td>
<td>Set room temperatures at 24°C.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>12</td>
<td>Apply scheduling of equipment during the testing and commissioning of a building.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>13</td>
<td>Apply for an external energy audit assessment and/or enter competitions.</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>14</td>
<td>Continuously ensure building control systems are fine tuned to maintain the efficiency of the system.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>15</td>
<td>Always incorporate reminders for staff and/or circulate circulars on energy efficiency information.</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>16</td>
<td>Distribute reminder labels to switch off lights and computers.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>17</td>
<td>Update occupants on energy consumption of building from time to time</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>18</td>
<td>Primarily use energy efficient certified office equipment and networked printers; that is, computers with LCD screens, or laptops. Do not allow computers with CRT screens. Equip computers with software that automatically reduce energy consumption during idle periods.</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>19</td>
<td>Provide internal recognition.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td><strong>Total Score</strong></td>
<td>17/19 (89%)</td>
<td>13/19 (68%)</td>
<td>10/19 (52%)</td>
</tr>
</tbody>
</table>

Note: Items 1 - 10 highlighted in grey show measures adopted from the Malaysian GBI tool. Items 11 – 19 are measures adopted from the literature.
4.5.1.1 Item 2: Develop a commissioning plan, or have an ongoing plan in place, for the building’s major energy-using systems.

Neither the PPJ nor the MoH building has an ongoing commissioning plan for the building’s major energy using systems. The PPJ energy report did not present an energy consumption benchmark or future target, an energy management strategy for future demand mitigation, or a policy committing to short or long term goals for energy efficiency. The MoH building lacked an energy report altogether. Hinks (2000) similarly observed that facility management relies on reactive actions based on clients’ or users’ complaints. The managers prefer to carry out reactive maintenance works rather than proactive works. A proactive approach in achieving optimum client satisfaction and service performance is believed to be an important strategy in achieving optimal energy efficiency performance (Hinks, 2000; Lateef, 2009).

The LEO energy report did contain an energy benchmark/ target that they wished to achieve for the following year. It contained energy management strategies for the facility management team to implement to assist in achieving the target. The document also had an energy policy committing the building as a showcase of an energy efficiency, with an energy consumption target of 100 kWh/m²/year.

4.5.1.2 Item 6: Monitor sub-metering of building systems to track energy consumption of major building uses and other end use applications.

The EMS installed in the LEO building monitors the sub-meters of energy usage by lighting, cooling, and plugload. Data review by the LEO facility management team led to several corrective actions to reduce energy consumption. For example, the utility power system (UPS) for the computers consumed more energy (5kWh/m²/year) when a power failure occurred at the distribution board. It was identified that a potential energy saving could be
achieved (8.8 kWh/m²/year) if the computers have a direct supply from the mains power, since power failure is less likely to occur as compared to using power from the distribution board. In another instance, lighting in the lobby areas of the lifts and toilets was found to be unnecessarily left on. The facilities management decided that those areas could be de-lamped at a minimum light level. The findings from LEO confirm Leaman and Bordass’ (2011) observation that constant monitoring of actual performance against objectives is important.

The PPJ and the MoH building do not have sufficient sub-meters or systems to enable sector assessment, which precluded thorough analysis of energy performance. In the PPJ building, not all the lighting or plugload systems are connected to the EMS. The PPJ architect reported that the limited installation of the system was due to budget constraints imposed during the design stage. The purchase of the complete EMS package was claimed to be too costly. The EMS in the MoH building does not separate lighting and plugload energy use. Therefore it is difficult to identify and assess where energy is consumed and energy waste occurs. Although the design of the MoH building incorporated some energy efficient measures, the architect indicated they were not the focus of the design. Therefore, allocating a budget to install an effective EMS was not given priority.

An effective EMS is a prerequisite in order to conduct a thorough energy audit such as in the LEO building. This finding supports the suggestion that an effective EMS makes more energy control strategies available and retrieves most of the data needed to carry out diagnostics to identify greater energy conservation opportunities (CarbonTrust, 2010; EECA, 2010c; Energy Star, 2012). The case study results indicate that the adoption of an effective EMS is still not widespread. Therefore, a cost benefit analysis of installing an effective EMS may convince practitioners more and increase the EMS adoption rate (Morrow & Rondinelli, 2002).
4.5.1.3 *Items 7 and 10: Reporting.*

A compilation and summary of the BEI consumption on an annual basis (item 7) and demonstration of energy savings over the last three years from the existing historical BEI baseline (item 10) should be part of an energy report. According to the energy data retrieved from the MoH building, energy was not saved over the last three years (Figure 4.1). Figure 4.2 depicts the energy consumption per occupant in the MoH building. Unfortunately, reasons for the changes in energy usage were not documented. The building manager of the MoH building surmised that the overall energy consumption increase since the baseline was due to an increase in the number of occupants between 2008 and 2010 as the building was not fully occupied in 2008.

![Figure 4.1 Energy Consumption Index of the MoH Building in kWh/ m²/year](image)

*Figure 4.1 Energy Consumption Index of the MoH Building in kWh/ m²/year*
Figure 4.2 Energy consumption for the MoH building in kWh per occupant

The PPJ building had incomplete historical energy data which precluded thorough analysis. In the case of LEO building, it too did not demonstrate energy saving within the last three years from 2011 (Figure 4.3). The first three years from 2006 to 2008 had an energy increase of 13%, and the following three years from 2009 to 2011 with an energy increase of 4%. Figure 4.4 depicts the energy consumption per occupant in the LEO building. The energy report for LEO contained reasons of energy increment/decrement as well as recommendations for future energy saving. However, the energy report available was only produced in year 2005 to submit for a building competition programme and in 2011 to apply for green certification under GBI. Energy reports should be done more regularly (i.e. yearly basis) to quickly identify potential energy wastes. For example, a suggestion to delamp some of the lights with minimum light level where necessary was done in year 2011 to save a total of 49,056kWh/yr (MYR11,049/ year). This saving could have been achieved if it was identified earlier. The same energy waste since 2005 were reported again in 2011 where computers and electrical equipments were observed left on after office hours. The findings
from case studies shows that energy report together with historical energy data enables to capture a better understanding of energy usage. For further improvement it is recommended that the energy report is produced more regularly and circulated to a variety of audiences. It is also recommended that comprehensive energy reports should be accessible to public for education purpose.

![Energy Consumption Index of the LEO building in kWh/m²/year](image)

**Figure 4.** Energy consumption index of the LEO building in kWh/m²/year
4.5.1.4 **Item13: Applied for an external energy audit assessment.**

The LEO building demonstrated an ongoing commitment to energy conservation by participating in multiple third party energy schemes. The LEO building was first entered into a best practice competition for buildings with the 2006 ASEAN Energy Award. In 2010, an energy audit by an external agency (GreenTech) was requested for the LEO building. Consequently, in 2011 GBI green certification for the LEO building was applied for. PPJ had only been entered in one competition, which was the ASEAN Energy Awards in 2008; the same competition that the LEO building had entered in 2006. As for the MoH building, it did not participate in any assessment programmes.

The advantage of applying for an energy audit such as GreenTech is that it enables the identification of the wasting of energy that requires special assessments beyond the typical EMS applications. For example, significant air leakages were identified in the LEO building by conducting pressure tests throughout the whole building. Results indicated that the door areas between the air-conditioned space and the (naturally ventilated) atrium space were

![Figure 4.4 Energy consumption for the LEO building in kWh per occupant](image-url)
problematic. This enabled the LEO building management to provide recommendations for improvement of the airtightness of the building.

The report submitted to the ASEAN Energy Awards did not address how facilities management dealt with the occurrence of energy waste. Consideration of this aspect in future reports may perhaps be beneficial to participants as it would increase their knowledge about efficient energy management.

The results of this study indicated that participation rates in energy assessments at the operational stage are still low in the industry. Methods to encourage adoption of such assessments are needed. In this study, the LEO building was a good example of where there is a continuous commitment from the organisation to sustainable energy efficiency performance.

4.5.1.5 Items 15, 16, and 17: Provide sufficient education about energy efficiency to all occupants.

Items 15, 16, and 17 are grouped together since the intention of the measurements is to provide sufficient education about energy efficiency to occupants in the building. Item 15 is to incorporate reminders/circulars of energy efficiency information. The LEO building manager puts up posters on the energy efficiency features of the building. Energy awareness campaigns through pamphlets and emails to staff are also conducted from time to time. Attending training and seminars on energy efficiency is incorporated as one of the key performance indicators for staff. Briefing on the objectives and goals of the organisation’s commitment to energy efficiency are given to new employed staff. Neither the PPJ nor the MoH building management circulate energy efficiency information to the staff. Putting up reminders labels to switch off lights/computers (item 16) is practiced in all three case studies.
The LEO building has reminder stickers to switch off lights and computer monitors. The MoH building and PPJ have reminder stickers to switch lights off but not computers. Additionally, the LEO building and PPJ have reminder stickers to shut doors in spaces that are air-conditioned. In addition to the reminder labels, the PPJ building manager makes an extra effort to remind staff to switch off lights during the office lunch hour by assigning a representative on each floor. Manual switching off of lights has to be done in some areas, since some of the lights do not connect with the EMS. Periodically updating occupants on the energy consumption of the building (item17) is only implemented in the LEO building. The LEO manager also encourages staff to work together with the facility management team to identify opportunities for further improvement. Neither the PPJ nor the MoH building management use these measures. The building managers reported that there is no instruction from the top level management to implement such measures.

Although some of the measures were implemented, it was reported that energy wasting still occurs within the case study buildings. For example, the energy audit of the LEO building discovered that computers and printers were left switched on after office hours, which accumulated to a waste of 3 kWh/m2/ year. It is unknown whether a similar scenario is faced in the other two case studies (the PPJ and the MoH building) due to the inability of the EMSs installed to collect such information. The PPJ building manager indicated that lights were commonly left on during the office lunch hour. The findings from the case studies do not support other findings by intervention studies showing antecedent and consequent tools as being effective strategies to facilitate energy saving behaviour. Therefore there is a need to investigate occupants’ behaviour regarding energy efficiency in more depth.
4.5.1.6 Item 18: Primarily use energy efficient office equipment and networked printers i.e., computers with LCD screens, or laptops.

The LEO building and PPJ facilities management only procured energy efficient office equipment and networked printers. Fifty per cent of the occupants used laptops. Energy efficient LCD computer monitors were also provided and software installed in computers to allow automatic features to be activated in idle mode. The MoH building facilities management provides energy efficient LCD computer monitors together with automatic idle mode software, however does not provide laptops for staff. The building manager in the MoH building reported that procurement and usage of energy efficiency appliances were all up to the occupants in the building. Flexibility in choice of office equipment to be used in buildings is dependent on the level of commitment and budget of the top management. The findings indicate that in practice there is still not a widespread usage of energy efficiency electrical appliances. None of the case studies adopts any form of lease that requires tenants in the building to only use energy efficient office equipment such as is suggested in the Green Lease Guide (Investa Property Group, 2007) and Good Practice Guide (Langley & Stevenson, 2007). In addition, none of the case studies implemented a policy to not allow personal electrical appliance usage in the building (such as personal fans, desk lamps, chargers, printers, and radios) as is suggested in the Energy Management Plan (NZGBC, 2011).

4.5.1.7 Item 19: Provide internal recognition.

None of the three case studies mentioned strategies to increase motivation among the occupants. This finding suggests that there is still room for improvement in how the current facilities management manage energy. As suggested by the EECA (EECA, 2010b) and
Energy Star (Energy Star, 2012), any form of recognition can be used to sustain support and momentum for energy management initiatives.

4.5.2 Evaluation of energy performance and energy management measures against criteria

Figure 4.5 shows that all three case studies consumed energy less than 200kWh/m$^2$/year (ASEAN region Energy Index) and 150 kWh/m$^2$/year (MS1525 Energy Efficiency code). This shows that all three case studies are performing relatively efficiently. The LEO building’s energy consumption was the least with 118 kWh/m$^2$/year, followed by the MoH building in second position (127 kWh/m$^2$/year), and lastly the PPJ with the highest energy consumption (138 kWh/m$^2$/year). Although energy performance appears good when looking at these BEI, the BEI itself is not a sufficiently accurate assessment on which to conclude whether buildings are energy efficient. This is because it does not standardise for weather and other building and operational characteristics, thus equal and fair comparisons of the buildings’ BEIs cannot be conducted (Newsham, et al., 2009; Scofield, 2009). Therefore, in the absence of comparison data from other buildings, it is necessary that each building continuously improves their own energy efficient performance.
Figure 4.6 represents the buildings’ energy use in kWh per occupant. A comparison of the results in Figure 4.5 and Figure 4.6 suggests that measuring energy efficiency performance either in energy use per floor area or energy use per occupant provides different results. Results from Figure 4.5 showed that the green (LEO) building is with the least energy consumption. However, results in Figure 4.6 showed that the green (LEO) building is actually consuming 3,000 kWh more energy per occupant than the conventional (MoH) building. Hence, a combination of both methods may be better to provide a better representation of energy efficiency performance in a building.
Figure 4.6 Energy consumption of building case studies in kWh per occupant

Figure 4.7 shows the scores of the case study buildings on the energy management measures, with the LEO building achieving the highest score of 89%; the PPJ with the second highest (68%) followed by the MoH building (52%). These percentages were calculated based on the checklist of energy management measures as shown in Table 4.4. The total number of items implemented by each facilities management was averaged by the total items in the checklist.
A comparison of Figure 4.5 (Energy Consumption Index) and Figure 4.7 (Energy Management Performance) suggests that the poorest energy performance was by the PPJ (138 kWh/m²/year); although in energy management performance the PPJ scored second at 68%. The MoH building had a good energy consumption index at 127kWh/m²/year; however its energy management performance was the worst at 47%. This suggests that a simple comparison of energy indices does not necessarily indicate the most energy efficient building. It shows energy indices alone do not provide facilities management with a clear representation of energy efficiency in buildings. The energy management framework can be used as a guideline for facilities management to see how they can achieve optimal energy efficient performance.
The proposed energy management framework in this study showed that a building which scored high on energy management does not necessarily score high on energy index performance. Junnila (2007) and Sawyer et al., (2008) identified similar results, where organisations received high scores for energy management, however had the highest energy consumption. This suggests that perhaps there is a need to improve how energy consumption indices are scored and also develop an energy management guideline which represents the appropriate score for energy indices. That way, it can provide better assistance for facilities management to estimate the energy reduction if such measures were taken.

The current investigation found that conventional buildings and (non-certified) green buildings performed better than what would be considered an energy efficient BEI of 150 kWh/m²/year (MS1525, 2007). One could speculate that the BEI target may perhaps be too high. It was expected that that the energy consumption for the conventional building would fall in the range of between 200 kWh/m²/year - 250 kWh/m²/year which is the BEI range for typical office buildings (Chan, 2009). Reducing the target BEI value that indicates energy efficiency may increase the value of gaining certification, as the limited data considered in this study suggests it can be achieved without investment in green design.

4.5.3 Use of green technologies

In all three case studies, green technologies have been installed to reduce the building’s energy consumption. The double glazed glass with a low thermal emissivity layer is used to optimize use of daylight, and reduce heat gain in the building’s thermal envelope. Motion detectors and daylight sensors are installed to avoid the occurrence of energy wastage and to optimize usage of daylight. Variable Air Volume (VAV) is a cooling technology that is more
energy efficient as compared to a conventional air-conditioning system. These are some of the technologies that the case studies have.

4.5.3.1 Double glazed glass fully unitised system with Low E layer.

The MoH building façade glazing was reported to frequently break. More than 10 panes of glass were broken in 2008. The building manager reported ongoing breakage until 2012, but the panes were quickly replaced as they were still under warranty. Based on the report, the breakage appeared due to the extreme external heat from outside which ultimately caused the nickel sulphide breakages in the glass. As a consequence, the possibility of the occurrence of air leakage within the building may impact on the energy performance as the air-conditioning will consume more energy.

4.5.3.2 Motion detectors and daylight sensors.

Building managers in the PPJ and the LEO building reported that motion detector and daylight sensors failed after the warranty period (two years) of the technologies ended. The technologies were not replaced due to budget constraints. A case study by Gabe (2008) in New Zealand reported the same managerial approach, whereby the building manager’s decision caused inefficient energy performance. In the Landcare Research building in Gabe’s study, an electron microscope was not responding well to being powered on and off. The building manager then decided to default the machine to ON, which caused an increase in energy consumption of 5kW. The rationale behind the decision was that getting the machine fixed would cost more when compared to the cost of the waste of energy. An area of improvement is the length of the insurance period of the technologies. The adoption of
technology with a long life cycle is essential as buildings will continue to be used for many years to come.

4.5.3.3 Variable Air Volume System (air-conditioning cooling system).

In all three case studies, there is a need for improvement in the thermal temperature of the building. Often the temperature is unstable and difficult to maintain at 24ºC. The building managers in all three case studies reported that constant manual fine tuning of the system had to be done to regulate the temperature back to 24ºC. This finding is similar to a recent study by Bond (2011) reporting the same problem using a Variable Air Volume (VAV) system which fails to maintain the desired temperature and requires constant fine tuning. Complaints by occupants that the temperature is too hot at 28ºC or too cold at 21ºC were frequently raised several times a month in all three case studies. The findings of this study are consistent with a study by Armitage (2010) in Australia and Gabe (2008) in New Zealand, where occupants complained about the stability of the temperature. There is a need to improve on the Variable Air Volume (VAV) technology for better quality ventilation as well as better energy performance. A study by Bordass (2001) has identified that stable and comfortable thermal conditions will lead to high occupant satisfaction.

4.6 Discussion: the Malaysian and New Zealand case studies

Table 4.5 has been refined from Table 4.1 and Table 4.2 to provide a more comprehensive framework of energy management strategies. This enabled the researcher to provide a comprehensive comparative analysis of the difference between the case studies in the two
countries. The number of items in Table 4.5 has increased from 19 items to 26 items because the findings from the case studies were incorporated into Table 4.5.

Table 4.5 Management Practices in New Zealand and Malaysia to Achieve Energy Efficiency

<table>
<thead>
<tr>
<th>Energy Management Strategies</th>
<th>New Zealand</th>
<th>Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TB</td>
<td>OGG</td>
</tr>
<tr>
<td>1. Energy Policy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A written document stating how the organisation will meet an energy target and continue to improve energy efficiency over time</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>2. Long and short term objectives of the organisations’ commitment to achieve energy efficiency</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>3. A proper energy efficiency target</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. Provide for a designated building maintenance office that is fully equipped with facilities</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>5. An active facility management team whereby there exists a pro-active help desk to deal with complaints</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>6. Energy management system (EMS) installed to measure and track energy consumption in the building</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>7. An effective EMS for the development of control strategies and for detail retrieval of data needed to identify energy waste.</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>8. Testing, commissioning and updating of energy schedule</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

Planning Phase

<table>
<thead>
<tr>
<th>Facility Management</th>
<th>New Zealand</th>
<th>Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TB</td>
<td>OGG</td>
</tr>
<tr>
<td>9. Intervention studies using antecedent tools (e.g., information posters and reminder labels) and consequent tools (e.g., feedback or comparative feedback on energy usage)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Always incorporate reminders for staff/circulate circulars on energy efficiency information:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- emails to remind staff</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>- website checklist ESB</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>- posters on energy efficiency features</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>- energy awareness campaigns through pamphlets</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>- Reminder labels to switch lights/computers off</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>10. Provide training and skills for management staff on a broad range of sustainable building operations topics (knowledge sharing portal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Building manual</td>
<td>/</td>
<td>-</td>
</tr>
<tr>
<td>- Website (knowledge sharing portal)</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>- Attending training and seminars on energy efficiency is incorporated as one of the KPI for staff</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>- New staff given briefing on the organisations commitment to achieve energy efficiency</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Achieving Energy Efficiency

<table>
<thead>
<tr>
<th>New Zealand</th>
<th>Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TB</td>
</tr>
<tr>
<td>18. Mainly use energy efficient office equipment</td>
<td>/</td>
</tr>
<tr>
<td>19. Request tenants to only purchase energy efficient office equipment</td>
<td>/</td>
</tr>
<tr>
<td>20. Applied for an external energy audit assessment/competition</td>
<td>/</td>
</tr>
<tr>
<td>21. Provide internal recognition</td>
<td>-</td>
</tr>
<tr>
<td>22. Monitor sub-metering of building systems to track energy consumption of major building uses and other end use applications</td>
<td>/</td>
</tr>
</tbody>
</table>

Review and Monitoring

<table>
<thead>
<tr>
<th>New Zealand</th>
<th>Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TB</td>
</tr>
<tr>
<td></td>
<td>/</td>
</tr>
</tbody>
</table>
A report to reflect energy efficiency performance to show energy savings over a period of time from existing building historical BEI baseline

Report provide reasons on the energy increase and recommendations plans for further improvement in energy efficiency

Ensure buildings major energy using systems are repaired, operated, and maintained effectively

Provide evidence of documented plan for facility maintenance and preventive maintenance budget

<table>
<thead>
<tr>
<th></th>
<th>23</th>
<th>24</th>
<th>25</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>TOTAL</td>
<td>20/26 (77%)</td>
<td>20/26 (77%)</td>
<td>20/26 (77%)</td>
<td>18/26 (69%)</td>
</tr>
</tbody>
</table>

*Note: [ / ] indicates Yes; [ – ] indicates No ; Green coloured boxes denotes strategies to encourage energy saving behaviour

Figure 4.8 shows the energy management measures scores for each of the case study buildings in New Zealand and in Malaysia. These percentages were calculated based on the checklist of energy management measures listed in Table 4.5. As shown in Figure 4.8, the green LEO building has the highest score (96%), followed by the other green buildings (TB, OGGB, PHC) and the conventional (FoE) building (77%). The percentage scores show which buildings have practiced the most strategies to reduce energy usage.
Lessons learned from the green LEO building can be seen in Table 4.5. The green LEO building has an energy efficient target to meet every year. 100 kWh/m²/year was chosen as the LEO building target since it is significantly lower than the standard building energy efficiency index of 150 kWh/m²/year (MS1525:2007). The green PPJ building and the conventional MoH building in Malaysia are recommended to follow this practice as an initial step in reducing energy usage in buildings. As for the case study buildings in New Zealand, it is difficult for these buildings to have an energy reduction target since there is no standard building energy efficiency index available. The practice in the case study buildings in New Zealand was to reduce current energy usage compared to previous years. Having an appropriate energy efficiency benchmark can aid facility managers to be more consistent in reducing energy usage towards a resilient target.

Another practice in the green LEO building was the effort to encourage the building occupants to save energy, as seen by distributing pamphlets on energy efficiency issues and recommendations of what the building occupants can do to help save energy. These pamphlets were given to new staff in the buildings and were made available to the building occupants and public. The case study buildings in New Zealand and the remaining case study buildings in Malaysia did not use this approach; instead information on energy efficiency issues was uploaded on their website. The advantage of uploading information online is that it is more cost effective and paper wastage can be reduced. However the disadvantage of this approach is that occupants may be unaware of the energy efficiency information online. Distributing pamphlets on energy efficiency is one successful approach to create more awareness amongst the building occupants. An economic analysis of these different strategies of information dissemination in a future study may provide more support for this recommendation.
Another practice by the green LEO building was to put up posters showing the energy efficiency features of the buildings. This approach educates the building occupants about the design of the building. Another practice in the green LEO building that was not used in the other case study buildings was that occupants are briefed on the organization’s commitment to save energy. The facilities management in the other case study buildings could follow this approach to engage the cooperation from the building occupants to help save energy. An additional initiative that was practiced in the green LEO building was including activities such as attending training and seminars on energy efficiency as one of the assessment in the key performance indicator (KPI) for staff.

None of the case study building management provided internal recognition of the building occupants for their energy saving efforts. This strategy had been recommended in the literature; however in practice even the green buildings with a strong commitment to save energy did not adopt this practice as a way of encouraging building occupants to save energy. The common reason given for this was that it incurred additional costs to provide rewards to the building occupants.

4.7 Conclusions

In conclusion, the research findings on energy management measures in green buildings located in two different countries revealed distinct management practices to reduce energy usage in buildings. One of the practices that was different across the case study buildings examined was informing building occupants about the design features of the building. This information was relayed to the occupants by putting up posters showing the energy efficiency
features of the building, as well as providing building manuals informing occupants about the
design of the buildings. In addition, pamphlets were distributed among the building occupants
informing them about what they can do to help save energy. Other practices were to
encourage staff to participate in energy efficiency seminars and to include activities in energy
efficiency programmes as one of the assessments in their key performance indicators of staff.
In addition, the facilities management also briefed the building occupants on their strong
commitment to saving energy.

The comparative study between green and conventional buildings in New Zealand showed
little difference between buildings, mainly because the management of the buildings was
under one organisation. Nevertheless, findings from the study showed that the conventional
OCH building did not have a building manager assigned to energy related matters or an on-
site building maintenance service. The role of a building manager is important to encourage
occupants to save energy, such as reminding the staff to turn off computers.

As for the comparative study between green and conventional buildings in Malaysia, this
showed substantial differences in their energy management practices. A better analysis of
these strategies was seen through the evaluation of their energy indices using the Malaysian
Standard Building Energy Index.
CHAPTER 5  ENERGY SAVING BEHAVIOUR
PRACTICES

This chapter has been extracted from:


5.1  Introduction

In many cases green buildings have not achieved optimal energy efficiency performance. Often the actual energy consumption is different from what was predicted at the design stage, and in the operational stage the green buildings consume more energy in comparison to conventional buildings of the same size and function (Bordass, Cohen et al. 2001, Office 2002, Cohen, Bordass et al. 2007, Sawyer, De Wilde et al. 2008, Wedding 2008, Scofield 2009, Ashuri 2010, Howe and Gerrad 2010). Howe and Gerrad (2010) and Werner and Carmalt (2006) have pointed out that the reality is the majority of green buildings are not energy efficient and these buildings will continue to be used for many years to come. Hes (2005), Armitage (2010) and Bond (2011) have all reported that many four star certified buildings do not perform even at a two star level. A four star certified building is expected to show good performance by the National Australian Built Environment Rating System (NABERS), while a two star certified building was seen to perform below average (Nabers, 2014).
This ‘mismatch’ between expectations of energy savings by green buildings and their actual energy use primarily results from the differences between assumed and actual patterns of occupants, the use of controls, and building operation management (Cole and Steigner 1999, Bordass 2001, Reiss 2005, Kubba 2010). In an ongoing research study by Andrews et al. (2010) it was stated that buildings may fail to perform as planned because operators do not, or cannot, operate the buildings as intended, and because occupants sometimes behave differently than expected. Documented studies showing poor performance such as that indicated above could possibly impede the rate of implementation of green buildings in a country. Therefore, it is important to improve energy performance in green buildings to achieve optimal energy efficiency performance. Successful performance of a green building can be achieved by further reducing energy consumption through changes in human behaviour. Studies by Cole (1999) and Steinberg (2010) have shown that the integration of Energy Saving Behaviours (ESB) has not been given sufficient focus in green buildings. ESB can be divided into two categories: efficiency and curtailment behaviours (Gardner and Stern 2002). Efficiency behaviours include actions such as purchasing energy efficient materials and equipment; for example insulation and energy efficient light bulbs. Curtailment behaviours involve repetitive efforts to reduce energy use, such as lowering thermostat settings. The focus in this chapter is on curtailment behaviours, since green buildings which already have energy efficient technologies have shown that efficiency behaviour alone does not achieve optimum performance in saving energy. In addition, the Energy Efficiency Conservation Authority (EECA), New Zealand (EECA 2011), strongly encourages curtailment behaviour as a way to reduce energy consumption in office buildings. This chapter compares the level of practice of Energy Saving Behaviours (ESB) between green and conventional office buildings. The aim of the chapter is to acquire better understanding
of the occupant’s behaviour in the buildings in order to develop effective intervention strategies to increase ESB adoption rate.

5.2 Energy saving behaviour

Energy saving behaviour is defined as a specific action to reduce energy consumption (Gardner and Stern, 2002). A total of 17 energy saving behaviours was compiled from previous studies in a residential, office, and university context, as shown in Table 5.1. These are common behaviours that building occupants are encouraged to carry out to help save energy. The aim of this chapter is to investigate the current level of practice in ESB between green and conventional office buildings, and identify potential strategies to encourage energy saving behaviour.

<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Item description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dishwasher</td>
<td>ESB1</td>
<td>Use dishwasher only when there is full load</td>
<td>(Barr and Gilg 2006, Wood and Newborough 2007)</td>
</tr>
<tr>
<td>Kettle</td>
<td>ESB2</td>
<td>Boil less water instead of filling up the whole kettle</td>
<td>(Wood and Newborough 2007)</td>
</tr>
<tr>
<td>Computer</td>
<td>ESB5</td>
<td>Reduce multiple computer monitors to one (if you are using multiple computer screen)</td>
<td>(Heerwagen 2010)</td>
</tr>
<tr>
<td></td>
<td>ESB6</td>
<td>Work on a laptop instead of a computer</td>
<td>(EECA 2011)</td>
</tr>
<tr>
<td></td>
<td>ESB7</td>
<td>Turn down computer screen brightness</td>
<td>(Steinberg 2009, Ryu 2010)</td>
</tr>
<tr>
<td></td>
<td>ESB8</td>
<td>Put screen to sleep instead of using screen saver</td>
<td>(Kolata 1986, Ulrich 2008).</td>
</tr>
<tr>
<td></td>
<td>ESB10</td>
<td>Shut down my computer</td>
<td>(Kolata 1986, Stern 1986)</td>
</tr>
<tr>
<td></td>
<td>ESB11</td>
<td>Turn off my computer monitor if seen left turned on</td>
<td>(Kolata 1986, Ulrich 2008, Steinberg 2009).</td>
</tr>
<tr>
<td></td>
<td>ESB12</td>
<td>Use task lighting whenever appropriate, and switch off main lights</td>
<td>(Kolata 1986, Ulrich 2008, Steinberg 2009).</td>
</tr>
<tr>
<td>Printer</td>
<td>ESB9</td>
<td>Print in booklet format or double sided rather than one sided</td>
<td>(Steinberg and Landis 2010)</td>
</tr>
<tr>
<td></td>
<td>ESB3</td>
<td>Read documents on computer screen rather than printing</td>
<td>(Steinberg 2009)</td>
</tr>
<tr>
<td></td>
<td>ESB4</td>
<td>Use double sided printing</td>
<td>(Steinberg 2009)</td>
</tr>
<tr>
<td></td>
<td>ESB14</td>
<td>Switch off lights in unused space</td>
<td>(Heerwagen and Diamond 1992)</td>
</tr>
<tr>
<td></td>
<td>ESB15</td>
<td>Use natural daylight whenever appropriate, and switch off lights</td>
<td>(Heerwagen and Diamond 1992, Heerwagen 2010)</td>
</tr>
<tr>
<td>Heating/cooling</td>
<td>ESB16</td>
<td>Close windows and exterior doors when heating/cooling systems are used</td>
<td>(Heerwagen and Diamond 1992, Barr and Gilg 2006, Andrews, Yi et al. 2011)</td>
</tr>
<tr>
<td>Heating</td>
<td>ESB 17</td>
<td>Close curtain/ window blind at night to prevent heat loss</td>
<td>(EECA 2011)</td>
</tr>
</tbody>
</table>
5.3 Research method

The case study buildings in New Zealand are described in Chapter 2 Research Methodology. A survey was conducted to evaluate the extent of energy saving behaviour practices, and identify potential strategies to encourage energy saving behaviour. The questionnaire was structured into two parts. Part 1 consisted of 17 items on energy saving behaviour asking respondents to rate their actions using a Likert type scale of 5 – Always to 1 - Never. Part 2 required respondents to select which of the electronic appliances they have and consequently select their actions after using those appliances, using a categorical type scale of three option which were “I leave it ON”, “I turn off appliance” and “I turn off main switch”. The method data analysis used in this chapter has been described in Chapter 2 Research Methodology, section 2.4.2 Data Analysis.

5.4 Results and discussion

The response rates of the surveys are discussed in Chapter 2 Research Methodology, section 2.4.1 Sample population.

5.4.1 Results from New Zealand building case studies

Figure 5.1 depicts the respondents’ overall energy saving behaviour scores in the green and the conventional buildings. The proportion of respondents who indicated “I always do” for most of the energy saving behaviours is shown to be higher in the green buildings (26%) than in the conventional buildings (11%). Almost half (47%) of the green building respondents
indicated they “always” or “often” carry out most of the energy saving behaviours compared to just over a quarter (27%) of those from the conventional buildings. This shows that more green building occupants perform behaviours to reduce energy usage than occupants in the conventional buildings. The results depicted in Figure 5.1 further indicate that more conventional building occupants (27%) never reduce their energy usage in buildings compared to occupants in the green buildings (14%). These findings are similar to a study by Tajabadi (2010) which showed that the green building occupants practiced better energy saving behaviour than occupants in the conventional building. Nevertheless, the results in Figure 5.1 illustrate that for both green and conventional buildings, the proportion of occupants who frequently reduce their energy usage in buildings does not differ much from the proportion of occupants who never reduce their energy usage. This shows that there are ample opportunities for overall improvements.
Table 5.2 shows the results for the Mann-Whitney U statistical test. A total of seven behaviours were identified as significantly different where the p values were less than 0.05. These behaviours were more likely to be reported by the green building occupants, as indicated by the highest value in the mean rank column as shown in Table 5.3. The results further reinforce descriptive analysis of data illustrated in Figure 5.1 indicating that green building occupants are more likely to practice better energy saving behaviours than occupants in the conventional buildings. Hence, the findings in this study make clear of the inconclusive findings in the earlier studies where the results showed inconclusive evidence as to whether or not occupants in green buildings are doing better in terms of saving energy than occupants in conventional buildings (Kato & Murugan, 2010; Lynam, 2007; Steinberg, Patchan, Schunn, & Landis, 2009; Tajabadi & Mohamad, 2010).
### Table 5.2 Man-Whitney U test of the energy saving behaviours (New Zealand)

<table>
<thead>
<tr>
<th>Category</th>
<th>CODE</th>
<th>Item Description</th>
<th>Sig. Difference (p)</th>
<th>Existence of Difference</th>
<th>Mean Rank</th>
<th>Higher Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dishwasher</td>
<td>ESB1</td>
<td>Use dishwasher only when there is full load</td>
<td>.000</td>
<td>Significant</td>
<td>79.23</td>
<td>121.78</td>
</tr>
<tr>
<td>Kettle</td>
<td>ESB2</td>
<td>Boil less water instead of filling up the whole kettle</td>
<td>.000</td>
<td>Significant</td>
<td>81.71</td>
<td>119.30</td>
</tr>
<tr>
<td></td>
<td>ESB5</td>
<td>Reduce multiple computer monitors to one if you are using multiple computer screen</td>
<td>.026</td>
<td>Significant</td>
<td>92.81</td>
<td>108.19</td>
</tr>
<tr>
<td></td>
<td>ESB6</td>
<td>Work on a laptop instead of a computer</td>
<td>.009</td>
<td>Significant</td>
<td>90.29</td>
<td>110.71</td>
</tr>
<tr>
<td></td>
<td>ESB7</td>
<td>Turn down computer screen brightness</td>
<td>.033</td>
<td>Significant</td>
<td>94.91</td>
<td>106.09</td>
</tr>
<tr>
<td></td>
<td>ESB8</td>
<td>Put screen to sleep instead of using screen saver</td>
<td>.015</td>
<td>Significant</td>
<td>95.22</td>
<td>105.78</td>
</tr>
<tr>
<td></td>
<td>ESB10</td>
<td>Shut down my computer</td>
<td>.222</td>
<td>Not Significant</td>
<td>95.69</td>
<td>105.31</td>
</tr>
<tr>
<td></td>
<td>ESB11</td>
<td>Shut down colleagues computer if seen left turned on</td>
<td>.159</td>
<td>Not Significant</td>
<td>95.84</td>
<td>105.17</td>
</tr>
<tr>
<td></td>
<td>ESB12</td>
<td>Turn off my computer if seen left turned on</td>
<td>.988</td>
<td>Not Significant</td>
<td>100.56</td>
<td>100.44</td>
</tr>
<tr>
<td>Printer</td>
<td>ESB9</td>
<td>Print in booklet format or double sided rather than one sided</td>
<td>.212</td>
<td>Not Significant</td>
<td>105.45</td>
<td>95.56</td>
</tr>
<tr>
<td></td>
<td>ESB3</td>
<td>Read documents on computer screen rather than printing</td>
<td>.691</td>
<td>Not Significant</td>
<td>98.95</td>
<td>102.05</td>
</tr>
<tr>
<td></td>
<td>ESB4</td>
<td>Use double sided printing</td>
<td>.359</td>
<td>Not Significant</td>
<td>104.09</td>
<td>96.92</td>
</tr>
<tr>
<td>Lights</td>
<td>ESB13</td>
<td>Use task lighting whenever appropriate, and switch off main lights</td>
<td>.011</td>
<td>Significant</td>
<td>87.63</td>
<td>113.38</td>
</tr>
<tr>
<td></td>
<td>ESB14</td>
<td>Switch off lights in unused space</td>
<td>.194</td>
<td>Not Significant</td>
<td>90.53</td>
<td>110.47</td>
</tr>
<tr>
<td></td>
<td>ESB15</td>
<td>Use natural daylight whenever appropriate, and switch off lights</td>
<td>.418</td>
<td>Not Significant</td>
<td>95.32</td>
<td>105.68</td>
</tr>
<tr>
<td>Heating/cooling</td>
<td>ESB16</td>
<td>Close windows and exterior doors when heating/cooling systems are used</td>
<td>.460</td>
<td>Not Significant</td>
<td>97.27</td>
<td>103.74</td>
</tr>
<tr>
<td>Heating</td>
<td>ESB17</td>
<td>Close curtain/ window blind at night to prevent heat loss</td>
<td>.119</td>
<td>Not Significant</td>
<td>103.41</td>
<td>97.60</td>
</tr>
</tbody>
</table>

*Note: Grey shaded rows indicate a statistically significant difference between the means*

For better analysis of the data, Figure 5.2 depicts the overall mean score for each of the behaviours. As shown in Figure 5.2, the red circles indicate that there is a large difference between the occupants’ practices in the green and conventional buildings. The largest gap between the trend line for the green and conventional building is on ESB 1 (“Use dishwasher only when there is full load”). Respondents from the green buildings claimed to often
practice ESB 1 ($\bar{x} = 3.04$), while respondents from the conventional buildings rarely practiced it ($\bar{x} = 1.57$). Green building respondents also claimed to often practice ESB 2 (“Boil less water instead of filling up the whole kettle”) ($\bar{x} = 3.22$), while conventional building respondents claimed to rarely practice this behaviour ($\bar{x} = 1.99$). ESB 5 (“Reduce multiple computer monitors to one”) is sometimes practiced by respondents in the green buildings ($\bar{x} = 2.10$), while in the conventional building it is rarely practiced ($\bar{x} = 1.70$). ESB 6 (“Work on a laptop instead of a computer”) is sometimes practiced by respondents in both the green and conventional buildings, with mean values of 2.72 and 2.19 respectively. ESB 13 (“Use task lighting whenever appropriate, and switch off main lights”) is sometimes practiced by both green and conventional building occupants, with mean values of 2.77 and 2.23 respectively.

A total of six energy saving behaviours had mean scores below 3.00 for both green and conventional building respondents as shown in Table 5.4 (highlighted by the red circles). These results indicate that improvement in the adoption rate of those energy saving behaviours is necessary in both buildings. Nevertheless, improvement of behaviour in the
conventional buildings is required more since there are an additional two energy saving
dbehaviours (ESB 1 and ESB 2) that are identified as having a low score.

Table 5.3 Mean score on each energy saving behaviour

<table>
<thead>
<tr>
<th>CODE</th>
<th>Energy saving behaviour</th>
<th>Mean Score</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Green building</td>
<td>Conventional building</td>
</tr>
<tr>
<td>ESB 10</td>
<td>Shut down my computer</td>
<td>3.69</td>
<td>3.42</td>
</tr>
<tr>
<td>ESB 4</td>
<td>Use double sided printing</td>
<td>3.65</td>
<td>3.81</td>
</tr>
<tr>
<td>ESB 14</td>
<td>Switch off lights in unused space</td>
<td>3.42</td>
<td>3.11</td>
</tr>
<tr>
<td>ESB 12</td>
<td>Turn off my computer if seen left turned on</td>
<td>3.39</td>
<td>3.42</td>
</tr>
<tr>
<td>ESB 8</td>
<td>Put screen to sleep instead of using screen saver</td>
<td>3.38</td>
<td>3.12</td>
</tr>
<tr>
<td>ESB 3</td>
<td>Read documents on computer screen rather than printing</td>
<td>3.34</td>
<td>3.29</td>
</tr>
<tr>
<td>ESB 9</td>
<td>Print in booklet format or double sided rather than one sided</td>
<td>3.24</td>
<td>3.57</td>
</tr>
<tr>
<td>ESB 15</td>
<td>Use natural daylight whenever appropriate, and switch off lights</td>
<td>3.19</td>
<td>3.05</td>
</tr>
<tr>
<td>ESB 16</td>
<td>Close windows and exterior doors when heating/ cooling systems are used</td>
<td>3.09</td>
<td>3.25</td>
</tr>
<tr>
<td>ESB 1</td>
<td>Use dishwasher only when there is full load</td>
<td>3.04</td>
<td>1.57</td>
</tr>
<tr>
<td>ESB 2</td>
<td>Boil less water instead of filling up the whole kettle</td>
<td>3.22</td>
<td>1.99</td>
</tr>
<tr>
<td>ESB 13</td>
<td>Use task lighting whenever appropriate, and switch off main lights</td>
<td>2.77</td>
<td>2.23</td>
</tr>
<tr>
<td>ESB 6</td>
<td>Work on a laptop instead of a computer</td>
<td>2.72</td>
<td>2.19</td>
</tr>
<tr>
<td>ESB 7</td>
<td>Turn down computer screen brightness</td>
<td>2.53</td>
<td>2.24</td>
</tr>
<tr>
<td>ESB 17</td>
<td>Close curtain/ window blind at night to prevent heat loss</td>
<td>2.40</td>
<td>2.05</td>
</tr>
<tr>
<td>ESB 5</td>
<td>Reduce multiple computer monitors to one (if you are using multiple computer screen)</td>
<td>2.10</td>
<td>1.70</td>
</tr>
<tr>
<td>ESB 11</td>
<td>Shut down colleagues computer if seen left turned on</td>
<td>1.77</td>
<td>1.50</td>
</tr>
</tbody>
</table>

*Note: Rows/cells highlighted indicates LOW scores

5.4.2 Ensure electronic appliances are turned off

Table 5.5 shows that there are more occupants in the green buildings (24%) who turn off their personal electronic appliances at the main switch than occupants in the conventional buildings (16%). Very few of the office electronic appliances are turned off at the main switch in both the green and conventional buildings. It is suspected that the reason for the behaviour is because of the sense of ownership of the personal electronic appliances. This creates a higher sense of responsibility for their actions after using the electronic appliances.
Turning off more of the office appliances can potentially save further energy usage in the buildings.

Table 5.4 Turning Off Electronic Appliances

<table>
<thead>
<tr>
<th>Actions</th>
<th>Personal Electronic Appliances</th>
<th>Office Electronic Appliances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional building</td>
<td>Green building</td>
</tr>
<tr>
<td>I leave it ON</td>
<td>29%</td>
<td>26%</td>
</tr>
<tr>
<td>I turn off appliance</td>
<td>56%</td>
<td>51%</td>
</tr>
<tr>
<td>I turn off MAIN switch</td>
<td>16%</td>
<td>24%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

5.4.2 Results from the Malaysia building case studies

Table 5.5 shows that there are a total of eleven behaviours that are significantly different with p values less than 0.05. Occupants in the green buildings practiced eight energy saving behaviours more than those in the conventional building. Occupants in the conventional building practiced three energy saving behaviours more than the conventional building occupant. This shows that there is a difference of five type of behaviour practiced higher than the other. Hence, it can be concluded that occupants in the green building are doing better than occupants in the conventional building in terms of saving energy. The findings in the Malaysia building case studies are similar to the New Zealand building case studies. The results in this chapter make clear make clear of the inconclusive findings in the earlier studies as to whether or not occupants in green buildings reduces energy use more than the occupants in the conventional building (Kato & Murugan, 2010; Lynam, 2007; Steinberg et al., 2009; Tajabadi & Mohamad, 2010). The following chapter examines the relationship between the behaviours with the management strategies implemented in the building case studies. This is to gain a deeper insight on how to encourage occupants to save energy. The results from
Table 5.2 and Table 5.5 indicates that energy saving practices is observed most in computer use. The findings from the New Zealand building case studies (Table 5.2) showed that four out of the seven behaviours are related to computer use. The findings from the Malaysia building case studies showed that six out of the eleven behaviours are related to computer use (Table 5.5). This indicates that computer related behaviour is essential and must be looked into. Therefore, the next chapter of this thesis examines the behaviours in computer use and the strategies implemented in the building case studies.

<table>
<thead>
<tr>
<th>Category</th>
<th>CODE</th>
<th>Item Description</th>
<th>Sig. Difference ($\rho$)</th>
<th>Existence of Difference</th>
<th>Mean Rank</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dishwasher</td>
<td>ESB1</td>
<td>Use dishwasher only when there is full load</td>
<td>.000</td>
<td>significant</td>
<td>107.00</td>
<td>138.94 Green</td>
</tr>
<tr>
<td>Kettle</td>
<td>ESB2</td>
<td>Boil less water instead of filling up the whole kettle</td>
<td>.159</td>
<td></td>
<td>110.63</td>
<td>125.01</td>
</tr>
<tr>
<td>Computer</td>
<td>ESB5</td>
<td>Reduce multiple computer monitors to one (if you are using multiple computer screen)</td>
<td>.005</td>
<td>significant</td>
<td>108.54</td>
<td>139.08 Green</td>
</tr>
<tr>
<td></td>
<td>ESB6</td>
<td>Work on a laptop instead of a computer</td>
<td>.001</td>
<td>significant</td>
<td>104.87</td>
<td>140.19 Green</td>
</tr>
<tr>
<td></td>
<td>ESB7</td>
<td>Turn down computer screen brightness</td>
<td>.272</td>
<td></td>
<td>122.84</td>
<td>134.76</td>
</tr>
<tr>
<td></td>
<td>ESB8</td>
<td>Put screen to sleep instead of using screen saver</td>
<td>.003</td>
<td>significant</td>
<td>107.66</td>
<td>139.35 Green</td>
</tr>
<tr>
<td></td>
<td>ESB10</td>
<td>Shut down my computer</td>
<td>.000</td>
<td>significant</td>
<td>164.57</td>
<td>122.16 Conventional</td>
</tr>
<tr>
<td></td>
<td>ESB11</td>
<td>Shut down colleagues computer if seen left turned on</td>
<td>.000</td>
<td>significant</td>
<td>173.63</td>
<td>119.43 Conventional</td>
</tr>
<tr>
<td></td>
<td>ESB12</td>
<td>Turn off my computer if seen left turned on</td>
<td>.002</td>
<td>significant</td>
<td>144.03</td>
<td>112.66 Conventional</td>
</tr>
<tr>
<td>Printer</td>
<td>ESB9</td>
<td>Print in booklet format or double sided rather than one sided</td>
<td>.000</td>
<td>significant</td>
<td>161.38</td>
<td>105.07 Conventional</td>
</tr>
<tr>
<td></td>
<td>ESB3</td>
<td>Read documents on computer screen rather than printing</td>
<td>.000</td>
<td></td>
<td>0.00</td>
<td>60.50 Conventional</td>
</tr>
<tr>
<td></td>
<td>ESB4</td>
<td>Use double sided printing</td>
<td>.000</td>
<td></td>
<td>73.50</td>
<td>149.67 Green</td>
</tr>
<tr>
<td>Lights</td>
<td>ESB13</td>
<td>Use task lighting whenever appropriate, and switch off main lights</td>
<td>.002</td>
<td>significant</td>
<td>145.66</td>
<td>114.07 Conventional</td>
</tr>
<tr>
<td></td>
<td>ESB14</td>
<td>Switch off lights in unused space</td>
<td>.001</td>
<td>significant</td>
<td>160.51</td>
<td>123.39 Conventional</td>
</tr>
<tr>
<td></td>
<td>ESB15</td>
<td>Use natural daylight whenever appropriate, and switch off lights</td>
<td>.574</td>
<td></td>
<td>136.65</td>
<td>130.60</td>
</tr>
<tr>
<td>Heating/cooling</td>
<td>ESB16</td>
<td>Close windows and exterior doors when heating/cooling systems are used</td>
<td>.471</td>
<td></td>
<td>116.57</td>
<td>123.82</td>
</tr>
<tr>
<td>Heating</td>
<td>ESB17</td>
<td>Close curtain/ window blind at night to prevent heat loss</td>
<td>.992</td>
<td></td>
<td>120.58</td>
<td>120.48</td>
</tr>
</tbody>
</table>
5.5 Conclusion

In conclusion, the findings presented in this chapter suggest that occupants in the green buildings practice better energy saving behaviours than occupants in the conventional buildings. Multiple analyses on the data were conducted to depict the overall view of the occupants’ practices for reducing energy usage in buildings. These results provide useful insights for designers to aid in the development of better intervention strategies to encourage energy saving behaviour in office buildings. The findings also indicate that there is a relationship between occupants’ behaviour and being an occupant in a green building. Further investigation into the management of energy usage in green and conventional buildings should provide a better understanding of the occupants’ behaviour.
CHAPTER 6: COMPUTER ENERGY SAVING BEHAVIOUR PRACTICE

This chapter has been extracted from:


6.1 Introduction

Green buildings often fail to achieve optimal energy efficiency performance. When measured, the actual energy consumption of the building is different from that predicted at the design stage. In some cases, more energy is consumed in green buildings in comparison to conventional buildings of the same size and function (Ashuri, 2010; Cohen et al., 2007; Howe and Gerrad, 2010; Sawyer et al., 2008; Scofield, 2009).

Kato et al., (2010) and Bond (2011) have reported that many four star certified buildings do not perform at a two star level. According to The National Australian Built Environment Rating System (NABERS), with the two star rating the building is considered as performing below average, while a four star rating demonstrates good performance (Nabers, 2014).

Previous studies have shown that poor performance is primarily due to the differences between assumed and actual behavioural patterns of occupants, the use of controls, and building operations management (Bordass et al., 2001; Kubba, 2010; Reiss, 2005). Another study showed that buildings may fail to perform as planned, because operators do not manage
the buildings as intended and the occupants sometimes behave differently than expected (Andrews et al., 2010). Research showing the poor performance of green buildings impedes their rate of implementation (British Columbia Construction Association, 2011; D’Arelli, 2008; Gabe, 2011; Scofield, 2009; Turner and Frankel, 2008).

Both the Malaysian and New Zealand governments have expressed interest in a more widespread implementation of green buildings (Esa et al., 2011; MoE, 2006; Razak, 2011). Successful performance of green buildings can be achieved by further reducing energy consumption through changes in human behaviour. Studies by Cole and Steigner (1999) and Steinberg et al., (2009) have shown that integration of energy saving behaviours has not been given sufficient focus in green buildings. The Energy Efficiency Conservation Authority (EECA, 2012) in New Zealand, as well as other organisations in developed countries, such as the Carbon Trust in the United Kingdom (2010), Energy Star in the United States (2011), and international guidelines such as International Standard Organisation (ISO, 2011) encourage energy saving behaviour as a way of reducing energy consumption in office buildings. The Ministry of Energy, Green Technology and Water in Malaysia developed a guideline to encourage energy saving behaviour practices (MGGTW, 2010). The guideline reports examples of energy saving behaviours that can be practiced by occupants in office buildings in many countries including Malaysia. There is limited research into understanding the current level of practice of energy saving behaviours in green versus conventional buildings.

A wide range of behaviours to save energy have been investigated such as reducing waste, recycling, taking shorter showers, turning off lights, and keeping heating low to save energy (Black et al., 2009; Clevenger et al., 2013; Goldblatt, 2005). However, there are limited research studies that investigate the level of practice in computer energy saving behaviours in office buildings (Kato et al., 2010; Steinberg et al., 2010; Tajabadi, 2010). Computer usage
was chosen as the focus in this study since it is one of the most common daily activities by occupants in office buildings and provides a good opportunity to save energy. A range of six computer energy saving behaviours were identified including shutting down computer desktops, turning off computer monitors, putting the screen to sleep instead of using a screen saver, reducing screen brightness on the computer monitor, working on a laptop instead of a desktop, and using one computer monitor instead of two (DoE, 2013; Porter et al., 2006; Webber et al., 2006).

Earlier studies showed that there is inconclusive evidence to show that green building occupants practice better energy saving behaviour in computer use than occupants in conventional buildings (Kato et al., 2010; Steinberg et al., 2010; Tajabadi, 2010). The current study covered all six identified computer energy saving behaviours and compared the practice between green and conventional building occupants in New Zealand and in Malaysia. This study attempted to answer the question of whether the occupants in green buildings practice more energy saving behaviours as compared to occupants in conventional buildings in regards to computer usage. Given the findings of this study, which pointed to better energy saving behaviour in green buildings, the thesis then discusses the strategies used by the different buildings to encourage energy saving behaviour. This information will contribute towards developing more effective intervention strategies to increase energy saving behaviour.

### 6.2 Energy saving behaviours on computer usage

An energy saving behaviour is defined as a specific action to reduce energy consumption (Browne & Frame, 1999; Cole & Steigner, 1999; Monroe, 2003). The following are typical energy saving behaviours in computer usage: shutting down computer desktops, turning off
computer monitors, putting the screen to sleep instead of using a screen saver, reducing 
screen brightness on the computer monitor, working on a laptop instead of a desktop, and 
using one computer monitor instead of two. These energy saving behaviours are common as 
they encourage occupants in buildings to help save energy via the management of their 
computer power consumption. Computers and monitors account for approximately 90% of 
of office equipment energy costs (Sustainable Solutions Pty Ltd, 2001) and for approximately 
15% of an office building’s energy consumption (EECA, 2011).

The EECA (2010) recommends that building occupants should shut down computers if they 
not used for an hour. However other studies (DoE, 2013; Porter et al., 2006; Webber et al., 
2006) advise occupants to switch computers off if they are not used over a longer period, 
such as overnight, to avoid spending too much time restarting computers during working 
hours. Switching computers on and off may be difficult if computers are being used 
throughout the day (Ulrich, 2008), although more energy is saved if computers are turned off. 
In terms of costs, computer desktops use up to 250 W per hour (DoE, 2013; Hinders; 2014; 
Ulrich, 2008), and so energy cost savings in New Zealand can be worked out as being 
potentially over $2,000 USD per year if computer desktops were turned off for an hour when 
not in use (calculated as USD$0.23/kWh for 100 computers). In Malaysia, an approximate 
$3212.76 USD a year could be saved if computers were turned off for an hour (calculated as 
USD0.12/ kWh). These estimated figures for Malaysia come from realistic estimates of 
consumption from Tenaga Nasional Berhad, which is the largest electric utility company in 
Southeast Asia (Tenaga Nasional Berhad, 2014), and the data for New Zealand are from the 

Laptops consume less energy compared to a typical computer desktop and are approximately 
50-80% more efficient (EECA, 2011). Adopting large-scale laptop use could save a
significant amount of energy. However, the practicalities depend on how convenient it is for occupants, as large scale laptop adoption has been shown to impact on work productivity due to the smaller size of the screen and slower speed (Webber et al., 2006).

Other energy saving advice for computer management is to turn down the brightness setting on the computer monitor and reduce the use of multiple computer monitors (Morris et al., 2013; Ryu, 2010; Steinberg et al., 2010). Both these activities reduce energy consumption.

Although recommended computer energy saving advice is available, the level of practice of those measures by building occupants is not known, including whether there is a difference between people working in a green or a conventional building. With the increasing demand for green buildings, energy saving behaviour represents a significant untapped potential for the increase of end-use energy efficiency in buildings (Lopes et al., 2012).

6.3 Comparison studies on energy saving behaviour between green and conventional building

A study by Tajabadi (2010) surveyed occupants’ energy saving behaviour between a green and conventional building, and showed that turning computer desktops off was found to be practiced significantly more in a green building compared to a conventional building. However, turning off the computer monitor and putting a screen to sleep, instead of using a screen saver, was not significantly different between the two building types, and only 10% of the respondents performed monitor and screen sleep actions. The rest of the energy saving behaviours, such as reducing computer screen brightness, the preference of working on a laptop instead of a computer desktop and willingness to reduce multiple computer monitors
to one was not assessed in the study. Furthermore, the study was a small case study where only two buildings were involved and it did not investigate the underlying reasons for behaviours, such as whether working in a green building influenced occupants’ behaviour. Tajabadi (2010) did not investigate the occupants’ level of awareness about energy efficiency.

Steinberg et al. (2009) surveyed occupants who were planning to work in a green building and discovered that none of the respondents shut down computers or turned off computer monitors when they were not in use for more than an hour. Also, none of the respondents claimed to turn down the computer screen brightness or use a laptop instead of a computer. However, the majority of the respondents (80%) claimed to put the screen to sleep instead of using a screen saver. Steinberg et al. (2010) also compared occupants’ willingness to change behaviour between occupants who were planning to work in a green building and occupants who were working in a conventional building. Occupants planning to work in a green building claimed that they were more willing to change behaviour to support their new workplace, were encouraged by the green building certification and wanted to ensure the success of the building’s energy performance. Although occupants appear to be willing to change their behaviour, this is not necessarily the case in practice. For example, several studies in certified green buildings reported that occupants left computer desktops turned on when not in use (Andrews et al., 2010; Bordass et al., 2001; Browne & Frame, 1999; Heerwagen, 2010; Tajabadi, 2010); however these studies gave no underlying reasons for the behaviour.

There are also conflicting views in the research. For instance, Deuble and de Dear (2012) predicted that occupants in green buildings would practice more energy saving behaviour; however Lynam (2007) showed occupants practice more energy saving behaviour in
conventional buildings. The difference in the relative dates between the studies might account for some of the contradictions. More awareness of green buildings in the later study may account for the change.

Focussing on green buildings, Kato et al. (2010) studied occupants’ behaviour in 10 certified green buildings and showed that more than half of the respondents turned off computer desktops and monitors at the end of the day. The study found that the image of working in a green building had a positive impact on employees where almost half of the respondents agreed that they felt loyal to their organisation because of its sustainability practices and policies. Kato et al. (2010) did not investigate the influence of green certification on other energy saving behaviours (e.g., putting computer monitor screens to sleep, turning down computer screen brightness, working on a laptop instead of a computer desktop and reducing multiple computer monitors to one), or assess the difference in occupants’ practices between green and conventional buildings.

In summary, the earlier studies showed that occupants felt encouraged to reduce computer energy usage when they worked in green certified buildings (Kato et al., 2010; Steinberg et al., 2010). However, these studies did not cover all of the six identified energy saving behaviours that can potentially reduce energy use in computers. The study by Tajabadi (2010) showed that occupants in green buildings practiced better energy saving behaviour in computer usage than occupants in conventional buildings. However, that study also did not cover the range of all the computer usage behaviour nor did it provide reasons for it. As a result, it is difficult to draw the conclusion that green building occupants practice better energy saving behaviour in regards to computer usage. Furthermore, Kato et al. (2010) did not compare the green building occupants’ practices with those of the conventional building.
occupants. A comparison study is required to investigate whether or not working in green buildings affects how occupants behave.

This chapter enhances past studies and adds to the green versus conventional building debate around energy saving behaviour. This chapter presents a comparison study on the level of practice in energy saving behaviour between green and conventional buildings, including on the strategies adopted to encourage energy saving behaviour.

6.4 Research method

The details of the case studies in New Zealand and Malaysia can be referred to in Chapter 2 Research Methodology. The research method used in this chapter is a quantitative method, whereby a survey was conducted to understand how occupants in the building behave to in regards to energy conservation and making their building environment comfortable. The research methods are explained in more depth in Chapter 2.

Questionnaires were used as the method to gain the relevant data for the purpose of this study. The purpose of the questionnaire was to evaluate the extent of energy saving behaviour practices, and identify potential strategies to encourage energy saving behaviour. A total of six energy saving behaviours related to computer management were identified as having the potential to reduce energy use by building occupants. These energy saving behaviours are:

- reducing the use of multiple computer monitors to one
- working on a laptop instead of a computer
- turning down the computer screen brightness
- putting screen to sleep instead of using a screen saver
- shutting down the computer
- turning off the computer monitor
The questionnaire required respondents to rate their actions using a Likert scale (Likert, 1932) with responses ranging from 5 – Always, to 1– Never. When energy saving behaviour actions were not relevant to the respondents they were given the option of selecting “N/A” (not applicable). Analysis using SPSS Statistic 22 software was used to run the statistical tests of the data. The Mann-Whitney U test was used to identify which of the energy saving behaviours were significantly different between the two building types. Energy saving behaviours identified as significantly different via the Mann-Whitney U test were further analysed using frequency distribution description and crosstab analysis to ascertain which building types have the most energy saving behaviour practices.

The questionnaire also asked respondents to report when they usually implement the energy saving behaviour using a categorical scale of three options which were “At the end of the day”, “If away for an hour or more” and “If away for 10 minutes or more”. Frequency and crosstab analysis was used to examine the difference in occupants’ behaviour between the building types.

6.5 Results

6.5.1 Comparison between green and conventional buildings in Malaysia

Figure 6.1 shows the difference in computer usage between occupants in the green (LEO and PPJ) buildings and the conventional (MoH) building. Statistical analysis using the Mann-Whitney U test indicated that there were five energy saving behaviours which was significantly different between the green (LEO and PPJ) buildings and the conventional (MoH) building. The response rate difference was checked using Zimmerman’s (2011) guidelines on the difference in sample sizes between groups and potential bias was not found.
Energy saving behaviours identified as significantly different were: reducing multiple computer screens to one; working on a laptop instead of a computer; putting the screen to sleep instead of using a screensaver; shutting down computers and turning off computer monitors. Figure 6.1 shows that three out of the five energy saving behaviours are practiced significantly more in the green buildings (the LEO building and PPJ). These energy saving behaviours are reducing multiple computer screens to one; working on a laptop instead of a desktop; and putting the screen to sleep instead of using a screen saver. Figure 6.1 shows that when asked about whether they reduced the use of multiple computer screens to one, 34% of
green building (LEO and PPJ) and 11% of conventional building (MoH) occupants answered “I often/always do” ($p = 0.005$). When asked about putting screens to sleep, 51% of green building (LEO and PPJ) and 25% of conventional building (MoH) respondents answered “I often/always do” ($p = 0.003$); while 22% of both the green buildings and 2% of the conventional building respondents answered “I often/always do” ($p = 0.001$) regarding working on laptops.

These findings demonstrated the good energy saving practices of the green building occupants who responded to the questionnaire. The results for putting screens to sleep and working on laptops are consistent with Steinberg and colleagues’ (2010) findings, where more occupants in green buildings than in the conventional building put screens to sleep, and worked on laptops. The findings in this study go beyond Steinberg et al.’s work in assessing occupants’ willingness to reduce multiple computer monitors to one, indicating that more occupants in the two green buildings practice this than in the conventional building.

The findings reported in this study shows there are more occupants in the green case study buildings practicing energy saving behaviours than in the conventional building and it is believed that this is because the occupants in the green buildings have higher awareness of energy efficiency. Raising occupants’ awareness about energy efficiency is the main strategy implemented in the green case study buildings to increase energy saving behaviour practices. The occupants in the LEO building were given guidelines on how to reduce energy usage. The guideline provided a whole range of energy saving behaviours including the conservation of energy and water, recycling of waste, purchase of eco-friendly products, and using energy conserving forms of transportation. The advice given in the guideline on computer management was to “put computer screen on sleep mode instead of using screen savers, shut down computers and turn off computer monitors”.

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There were other strategies to raise occupants’ awareness of energy efficiency implemented in the green LEO building. The LEO building management put up posters about the energy efficiency features of the building. Energy awareness campaigns through the distribution of pamphlets and emails to staff are also conducted from time to time. Attending training and seminars on energy efficiency is incorporated as one of the key performance indicators for staff. For example, the international Greentech and Eco Products exhibition and conference in Malaysia is organized annually by the LEO building management. Briefings on the objectives and goals of the organisation’s commitment to energy efficiency are given to newly employed staff. Occupants of the LEO building are also periodically updated about the energy consumption of the building. The LEO building facilities management team also encourages staff to work together with them to identify opportunities for further improvement. The other green building (PPJ building) did not have these strategies in place, but had a building manager assigned on each floor to remind staff to save energy.

The effectiveness of the implemented strategies is demonstrated through the overall performance of the occupants’ energy saving behaviour in the green (LEO and PPJ) buildings, where more of the occupants claimed to practice energy saving behaviour than in the conventional (MoH) building (Figure 6.1).

The effectiveness of the strategies implemented in the LEO and PPJ buildings can be compared by examining some of the data received from the building occupants. The Mann-Whitney U test results showed that the only significant difference in the energy saving behaviours between the green building occupants’ behaviours was in “reducing multiple computer screens to one”. Figure 6.2 shows that there were significantly more occupants in the LEO building than in the PPJ building that reduced their use of multiple computer screens to one. 40% of the occupants in the LEO building and 28% of occupants in the PPJ building
answered “I always/often” \((p = 0.001)\). There was no significant difference between the LEO and PPJ building occupants for the rest of the energy saving behaviours, where the \(p\) values were all more than 0.05.

Note* Energy saving behaviours that are significantly different according to the Mann-Whitney U test \((p\) values < 0.05)

![Graph showing energy saving behaviour practices in the certified green building Vs. the non-certified green building](image)

**Figure 6.2** Energy saving behaviour practices in the certified green building Vs. the non-certified green building

There were significantly more occupants in the LEO building than in the PPJ building that reduced multiple computer screens to one because the policy in the LEO building restricted additional appliances into the building. No such policy was implemented in the PPJ building.

The occupants in both the green buildings were provided with laptops. Approximately 50% of the staff in managerial positions were provided with laptops. Occupants in the conventional building were not provided with laptops. This explains why there are more
occupants in the green buildings who work on laptops than occupants in the conventional building.

In addition to the strategies for increasing energy efficiency awareness among the occupants, the LEO green building displays reminder stickers to switch off computer monitors. The other green building (the PPJ) and the conventional building (MoH) did not have reminder stickers to switch off computer monitors. The conventional building did not implement any of the strategies mentioned above to encourage energy saving behaviour towards computer usage. Interestingly, there were more occupants in the MoH building that shut down computer desktops and turned off computer monitors than in the green (LEO and PPJ) buildings. As shown in Figure 6.1, 62% of occupants in the green buildings and 84% of occupants in the conventional building always or often shut down computers ($p = 0.000$). 41% of occupants in the two green case study buildings and 55% of occupants in the conventional building always or often turn off computer monitors ($p = 0.002$). Given the encouragement to adopt energy saving behaviours in both the LEO and PPJ buildings, it is difficult to understand these differences as one would expect many more people in the green buildings to be adopting energy saving behaviours than in the MoH building where no strategies were being promoted. However, when looking at the strategies being used (Table 6.3), there appears to be few strategies specifically targeted at computer use in the green buildings over other strategies. Also, it is possible that there is occupant complacency where there are expectations that the building management will be responsible for energy savings; and where management are focussed on bigger energy saving strategies (such as lighting or air conditioning), not specifically on computer usage.
Table 6.1 Strategies to Encourage Energy Saving Behaviour

<table>
<thead>
<tr>
<th>No</th>
<th>Energy Management Strategies to encourage energy saving behaviour</th>
<th>LEO</th>
<th>PPJ</th>
<th>MoH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Guidelines on how to reduce energy usage</td>
<td>/</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Posters on energy efficiency features of the building</td>
<td>/</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Pamphlets on energy efficiency</td>
<td>/</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Email to staff from time to time</td>
<td>/</td>
<td>/</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>Attending training and seminars on energy efficiency</td>
<td>/</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>Briefing on the objectives and goals of the organisations commitment to energy efficiency are given to new employed staff</td>
<td>/</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>Updating occupants on energy consumption of the building</td>
<td>/</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>Encourages staff to work together with the facility management team to identify opportunities for further improvement</td>
<td>/</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>Reminder sticker labels on computers</td>
<td>/</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10</td>
<td>Participate in third party energy schemes</td>
<td>/</td>
<td>/</td>
<td>X</td>
</tr>
<tr>
<td>11</td>
<td>Building manager assigned on each floor to remind staff to save energy</td>
<td>X</td>
<td>/</td>
<td>X</td>
</tr>
<tr>
<td>12</td>
<td>Provide laptops</td>
<td>/</td>
<td>/</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11/12</td>
<td>4/12</td>
<td>0/12</td>
</tr>
</tbody>
</table>

Note: [ / ] denotes as YES, [ - ] denotes as NO

The results in this study contradict those of Tajabadi (2010), where the findings indicated that more occupants in the green buildings shut down computer desktops than occupants in the conventional building. The results of this study for turning off computer monitors are also different to Tajabadi (2010), who found no significant difference between the building types.

Fewer occupants in the green buildings in Malaysia turn off computer desktops and computer monitors, although there are more strategies to encourage energy saving practices implemented in the green buildings than in the conventional building. The occupants in the green buildings may feel less responsible for these actions than the occupants in the conventional building. The facilities management in green buildings have a stronger commitment to maintaining the energy efficiency performance of the building than the facilities management in the conventional building. The green building facilities management showed commitment by participating in multiple third party energy schemes. The energy
schemes include the best practice competition ASEAN Energy Award, Green Building Index certification, and energy audits by an external agency (Green Tech). The conventional building (MoH) did not participate in any of the energy schemes.

Comparatively fewer occupants in the green buildings than in the conventional building shut down computer desktops and turn off computer monitors. Nevertheless, these behaviours are the most common energy saving practice in both building types with almost half of the building occupants claiming to shut down computers. Although results for occupants behaviour between building type differs in this study differs from Tajabadi (2010) but the percentage size of occupants practicing these behaviours showed similar results to this study indicating that it is highly practiced. The findings in this study add to current knowledge by showing that even in the conventional building (MoH), half of the occupants shut down computer desktops.

As for computer monitors, the results in this study also differ from Tajabadi (2010) who found that only a small percentage of occupants (7%) in both of the building types turn off computer monitors. However, the results complements those of Kato et al. (2010) where approximately 50% of the occupants in green buildings turn off computer monitors. These inconsistent findings show that further research on green and conventional building occupants’ behaviour regarding computer monitors is necessary. Nevertheless, these results demonstrate that there is potential for improvements to further reduce energy usage.

Only one energy saving behaviour in this study was not significantly different between the green and conventional building occupants; that of “turning down computer screen brightness” \( (p = 0.272) \). The results in Figure 6.1 show that 35% of occupants in the green, and 20% of the occupants in the conventional building often or always turn down computer screen brightness. The finding contradicts that of Steinberg et al. (2010) who found that 80%
of the occupants in green buildings were willing to turn down computer screen brightness, although Steinburg et al. asked about willingness, and this research asked about actual practice. None of the strategies implemented in the green and conventional buildings encouraged occupants to turn down computer screen brightness. The facilities management in the buildings (LEO, PPJ and MoH) could potentially reduce energy usage by incorporating advice about screen brightness into their policies.

In order to gain a better understanding of energy saving behaviour, occupants were asked to select when they perform the energy saving behaviours, and were given three response options: “at the end of the day," “if away for an hour or more” and “if away for 10 minutes of more.” The percentage of occupants turning off computer desktops and monitors increases with the length of time (Figure 6.3).

![Figure 6.3 Computer desktop and computer monitor turned off at different time events](image)

The results in Figure 6.3 further show that energy saving behaviours are practiced more frequently in the two green (LEO and PPJ) buildings than in the conventional (MoH) building. Figure 6.3 shows that when occupants are away from their desk for between 10
minutes or an hour or more, 39% of the occupants in the green buildings and 13% of occupants in the conventional building turn off their computer monitors. 26% of occupants in the green buildings and 2% of occupants in the conventional (MoH) building shut down computer desktops when they are away from their desk for between 10 minutes or an hour or more. These findings are again consistent with Steinberg et al. (2010), where the study showed that people are willing to practice these behaviours more frequently when they work in a green building. The findings of the current study suggest that, although collectively there are more occupants in the conventional building that shut down computer desktops and turn off computer monitors, these practices are mostly conducted at the end of the day whereas occupants in the green buildings practice them more frequent by performing the actions when away for 10 minutes or an hour or more.

6.5.1.1 An explanation on the significant differences

In summary, there are more occupants in the green buildings than in the conventional building that put the computer screen to sleep, use laptops, and reduce the use of multiple screens to one. There are also more occupants in green buildings that shut down computer desktops and turn off computer monitors at a frequent rate, whereby they turn the devices off when away from their desk for a period of time of between 10 minutes to over an hour, instead of waiting till the end of the day. Occupants in green buildings practice better energy saving behaviour than occupants in the conventional building because the occupants’ have more awareness of energy efficiency due to the intensive strategies that have been implemented in the green buildings. Table 6.3 shows that the green (LEO and PPJ) buildings’ operations team approach for managing occupants’ energy usage is more active than that used in the conventional (MoH) building. The LEO building practices almost all of the
strategies (12 strategies), while the PPJ building practices four of them. None of the strategies were implemented in the MoH building.

Between the LEO building and PPJ buildings, the strategies did not appear to make much difference in the levels of energy saving behaviour practices of the occupants. The level of energy saving behaviour practices was similar in both buildings, except for the reduction of multiple computer screens to one. There were significantly more occupants in the LEO building than the PPJ building that reduced multiple computer screens to one. If the MoH building were to adopt even just one of the PPJ building strategies, they would be likely to see an increase in energy saving behaviour.

6.5.1.2 Strategies and recommendation

The strategies implemented in the green certified and non-certified buildings have been shown to be successful in increasing energy saving behaviours that are relatively easy to perform, such as putting computer screens to sleep, working on laptops instead of computers, and reducing multiple computer screens to one. Behaviours that require more effort from the occupants to perform such as shutting down computer desktops and turning off computer monitors were performed less when the facilities' management level of commitment was higher. Additional information is required to develop strategies aimed at making occupants more responsible for their actions rather than relying on the facilities management alone to carry out energy saving behaviours. A key limitation of this study is that it did not investigate the sociological influences on the building occupants. An in depth investigation needs to be conducted to examine the sociological dimensions that impact on building occupants’ energy saving behaviour in order to formulate more comprehensive intervention strategies, which is scope for further research in this area.
6.5.2 Comparison between green and conventional buildings in New Zealand

Figure 6.4 shows the difference in computer usage between occupants in the green (TB and OGGB) and conventional (OCH and FoE) case study buildings in New Zealand. Statistical analysis using the Mann-Whitney U test indicated that there are four energy saving behaviours that were significantly different between the green and conventional buildings. Energy saving behaviours identified as significantly different were reducing multiple computer screens to one, working on a laptop instead of a computer, turning down computer screen brightness, and putting the screen to sleep instead of using a screen saver.
Note* Energy saving behaviours that are significant different through Man-Whitney U test (p values< 0.05)

There were significantly more occupants in the conventional buildings that do not reduce multiple screens to one, work on a laptop instead of a desktop and turn down computer screen brightness than the green building occupants. This is seen from the results in Figure 6.4 where 83% of the occupants in the conventional (OCH and FoE) buildings and 55% of the green (TB and OGGB) buildings do not reduce the use of multiple screens (p = 0.001). In the conventional buildings, 70% of the conventional building occupants and 53% of the green building occupants do not work on a laptop instead of a desktop (p = 0.005) and 66% of the conventional and 53% of the green building occupants do not reduce the computer screen brightness (p =0.000).

Although neither the green nor conventional building occupants practiced these energy saving behaviours regularly, there were comparatively fewer occupants doing them in the conventional buildings than in the green buildings. Therefore, occupants in the green buildings practiced better energy saving behaviours compared to those in the conventional buildings. Nonetheless, overall there is room for improvement in the behaviour of occupants in both building types. These results contradict findings by Steinberg et al. (2009), where none of the green building occupants turned down the computer screen brightness or used laptops instead of a computer desktop. The findings from the New Zealand case studies indicated that these practices are used. An explanation for the difference could be due to the variation in how the buildings were managed.

Reducing multiple screens to one, working on a laptop instead of a desktop and turning down computer screen brightness were the least practiced energy saving behaviours, in contrast to putting the computer screen to sleep which was the most practiced behaviour. There were
significantly more occupants in the green buildings who put their screen to sleep than occupants in the conventional buildings (p value = 0.016). This is seen from Figure 6.4 where 52% of the occupants in the green buildings and 39% of the conventional buildings put their screen to sleep. The results reinforce findings by Steinberg et al. (2010), where putting screens to sleep was practiced more in the green building in that study than in the conventional building, but contradicts the findings of a study by Tajabadi (2010), which found no significant differences in the energy saving practices of occupants in the two building types.

In summary, there are more occupants in the green buildings than in the conventional buildings that reduce multiple computer screens to one, work on laptops, and turn down computer screen brightness. Nevertheless, these behaviours are not regularly practiced in either the green or the conventional buildings. Putting the screen to sleep is the only energy saving behaviour that is regularly practiced by the green building occupants. The findings revealed that putting screens to sleep is already practiced regularly and that there is a lack of other behaviours such as decreasing the number of screens used to one, working on laptops rather than PCs, and turning down the computer screen brightness. Therefore, this shows that there is room for improvement in energy saving behaviours to further reduce energy usage in buildings.

Earlier studies by Tajabadi (2010) and Steinberg et al. (2010) showed that the green building occupants practiced only one computer energy saving behaviour more than those occupants in the conventional building, while the current study showed four computer energy saving behaviours are more likely to be practiced by green building occupants. Given that there is a greater variety in the energy saving behaviours practiced in the green buildings, the results in
this study reinforce the findings from the earlier studies to conclude that green building occupants do practice energy saving behaviours more than conventional building occupants.

Shutting down desktop computers and turning off computer monitors are the only energy saving behaviours that were not significantly different between the two building types, with p values of 0.294 and 0.479, respectively. This result differs from Tajabadi’s (2010) findings, where turning off computer desktops was found to be practiced significantly more in green buildings. However, for the action of turning off computer monitors, the results in this study were similar to those of Tajabadi, where no significant difference was found. The findings in the current study are consistent with those of Kato et al. (2010) which indicated that shutting down computer desktops and turning off computer monitors is regularly practiced by building occupants. Given that these are the most frequently practiced behaviours by the building occupants from both building types, this suggests that the current energy management strategies applied in both the green and conventional buildings in this study appear to be effective (see Table 6.4). Kato et al. also commented on an energy management strategy applied in green buildings which included incentives for staff to engage in various energy saving behaviours. Both the results in this study and results by Kato et al. (2010) show that energy management strategies are effective in encouraging occupants to shut down computer desktops and turn off computer monitors.

In order to gain a better understanding of the energy saving behaviours, occupants were required to select an option for when they perform the energy saving behaviours. There were three options to choose from: “at the end of the day”, “if away for an hour or more” or “if away for 10 minutes or more”. The results portrayed in Figure 6.5 showed that occupants from both of the building types mostly turn off computer desktops at the end of the day (78% and 80% of conventional and green building occupants respectively). Computer monitors are
also turned off at the end of the day (53% and 59% conventional and green building occupants respectively). The results are similar to those of a study by Kato et al. (2010) of 10 certified green buildings, where it too showed that half of the occupants turned off computer desktops and monitors at the end of the day.

![Graph showing computer desktop and monitor turnoff percentages]

Figure 6. Computer desktop and computer monitor turn off at different time events

The percentage of occupants turning off computer desktops and monitors increases with the length of time. Figure 6.5 shows that less than 30% of occupants turn off computer desktops and monitors if away for an hour or more. Figure 6.5 also shows fewer than 20% turn off computer desktops and monitors if away for 10 minutes or more. These results confirm those of the study by Steinberg et al. (2009) where none of the building occupants turned off computers if they were away for 10 minutes or for an hour. Steinberg and colleagues’ study and these results demonstrate that there is an opportunity to improve on the level of
frequency in practicing these energy saving behaviours in both green and conventional buildings.

In summary, there are more occupants in the green buildings than in the conventional buildings who reduce their multiple computer screen use to one, work on laptops, and turn down their computer screen brightness. Nevertheless, these behaviours are not regularly practiced in either the green or conventional buildings. Putting screens to sleep was the only action found to be practiced more regularly in the green buildings.

6.5.2.1 Building management strategies used

Table 6.4 tabulates the strategies implemented in the green (TB and OGGB) and conventional (OCH and FOE) case study buildings in NZ. The green buildings have slightly more strategies applied than the conventional buildings. The additional strategy implemented in the green buildings is that emails are sent out occasionally by the buildings’ managers to remind staff to save energy. The strategies implemented in the green buildings may cause the occupants to be more aware of energy efficiency issues and explain why more occupants in the green buildings turn down the computer screen brightness and put computer screens to sleep when not in use than in conventional buildings. Earlier studies have indicated that occupants report that when they work in a green building, they feel encouraged to save energy (Kato et al., 2010; Steinberg et al., 2010). The findings of the current study extend those studies by providing a more in-depth explanation. Occupants in the green buildings are encouraged to save energy more than occupants in the conventional buildings because of the difference in the way the buildings are managed.

Additional strategies used in the buildings include providing guidelines to all occupants through an accessible website and a clear statement on the organisation's commitment to
saving energy. A list of energy saving behaviours related to computer management is uploaded on the website. The energy saving behaviours listed include turning off the computer screen when not in use and at the end of the day. However, desktop computers are sometimes required to be left on at the end of the day so the Information Technology managers can arrange back up data and updates. Also, other energy saving behaviours related to computer management are not mentioned on the website, including reducing the use of multiple screens to one, working on a laptop instead of a desktop, turning down the computer screen brightness, and putting the screen to sleep.

Another energy management strategy is to assign a building manager to encourage reduced energy consumption. Both the green case study buildings have building managers assigned. However in the conventional buildings only the FoE building has a building manager, while the OCH has no building manager for energy usage matters. An active building manager can keep occupants informed about energy issues, encourage them to work together with the facilities management team and participate in third party energy schemes such as the Energy Efficiency Conservation Authority Energy Award.

<table>
<thead>
<tr>
<th>No</th>
<th>Implemented strategies to encourage energy saving behaviour</th>
<th>Conventional Buildings</th>
<th>Green Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OCH</td>
<td>FOE</td>
</tr>
<tr>
<td>1</td>
<td>Guidelines on how to reduce energy usage</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>2</td>
<td>Posters on energy efficiency features of the building</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Pamphlets on energy efficiency</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Email to staff from time to time</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Attending training and seminars on energy efficiency</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Briefing on the objectives and goals of the organisations commitment to energy efficiency are given to new employed staff</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>7</td>
<td>Updating occupants on energy consumption of the</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
In discussing strategies with the case study building managers, the green building managers mentioned that they discourage occupants having additional appliances in the buildings, such as multiple computer screens. More green building occupants reported using laptops than occupants in the conventional buildings. It is difficult to know why this is the case, as neither the green nor the conventional buildings have a policy in their buildings to encourage the use of laptops instead of desktop computers. Since laptops are portable, it is suspected that the reason could be due to the nature of the green building occupants’ work, where occupants in the green buildings may be more flexible in their working conditions than occupants in the conventional buildings.

The strategies implemented in both the green and conventional buildings appear to have been successful in promoting the energy saving behaviours of shutting down computers and computer monitors. These behaviours are the most commonly practiced ones in both building types and no significant difference in the level of practice was found between the building types. The only additional strategy implemented in the green buildings that was not implemented in the conventional buildings was that the building manager sends out emails occasionally to remind occupants to save energy. However, this strategy provided no
difference for energy saving behaviours that required more effort (i.e., shut down computer desktops and computer monitors). This strategy was shown to be successful for energy saving behaviours that are relatively easy to practice (i.e., turn down computer screen brightness, putting screens to sleep). Occupants probably became more aware on energy efficiency due to the active role played by the building manager.

6.6 Discussion New Zealand and Malaysia

The findings from the New Zealand case studies showed similar results to the findings from the Malaysia case study buildings where occupants in the green buildings practice better energy saving behaviour than occupants in the conventional buildings. Reducing multiple computer screens to one, working on laptops instead of desktops, and putting screens to sleep are practiced significantly more by the occupants in the green buildings in Malaysia and in New Zealand than the conventional building occupants in Malaysia and in New Zealand.

Findings that were different between the case study buildings in New Zealand and Malaysia are seen in the practice of shutting down computer desktops and turning off computer monitors. In the Malaysia case study buildings, the occupants in the conventional building practiced more shutting computer desktops and computer monitors than occupants in the green building. While case study buildings in New Zealand showed that these practices were the same between the green and conventional buildings. An explanation for this is that there were few strategies used as shown in Table 6.3 and Table 6.4 that were specifically targeted at computer use. Most of the strategies used were general which included strategies to reduce on energy usage lighting, air-conditioning and other office appliances. Another explanation is that green building occupants in Malaysia have higher expectations that the facility management will be responsible for energy savings.
Nevertheless, the strategies implemented in the green buildings as shown in Table 6.3 and Table 6.4 successfully encouraged the green building occupants to practice energy reducing actions such as reducing multiple computer screens to one, working on laptops instead of desktops, and putting screens to sleep. The findings from the case studies showed there were more strategies implemented in the green buildings than in the conventional buildings in both New Zealand and Malaysia. Raising awareness of energy efficiency encouraged occupants to save energy. This shows the importance of raising awareness of energy efficiency issues amongst building occupants. The strategies used to encourage occupants to save energy included uploading guidelines on how to save energy in computer usage on the organisation website (as practiced in the case study buildings in New Zealand and in the green (LEO) building). Other strategies included discouraging occupants from having additional office appliances in the buildings, and to providing laptops for occupants.

Nevertheless, there are opportunities for improvement identified from the case study buildings. The conventional buildings were exposed to the same level of awareness on energy efficiency with the green buildings in New Zealand, and yet there were more of the green building occupants that practiced saving energy usage than those occupants in the conventional building. The findings from the study showed that the difference occurred due to how active the building managers were in managing energy usage in their buildings. Case studies from the green buildings in New Zealand and Malaysia showed that an active building manager in engaging occupants’ cooperation to save energy showed a significant impact in encouraging the occupants to save energy. Amongst the strategies used by the building managers were to email staff from time to time to save energy. An additional effort by the building manager in one of the green building (LEO) in Malaysia was to update the occupants on the energy consumption of the building. The case study buildings, both green and conventional in New Zealand, already have energy reports for the building managers in
each case study buildings for them to assess, but this information were not made available to the building occupants in each case study buildings. Only the total energy consumption saved were published in the website, but not the detailed breakdown of energy saved in each case study buildings. Therefore by following the practice of the green (LEO) building in Malaysia future energy saving could be made.

The sample size population of the building case studies between New Zealand and Malaysia differs in their occupation (office workers vs academicians). Despite their different occupation, the respondents have almost similar disciplinary background (i.e major business, engineers, and environmentalists). Therefore, it is unlikely that the results in this study are affected by this variable. Psychology researcher by Gifford and Nilsson (2014) reviewed literature and found that there is an unclear relationship between whether different disciplinary background influences energy saving practice. There are several evidences showing that higher level of awareness on energy efficiency regardless of their disciplinary background is more likely to conserve energy (Gifford, Hay, & Boros, 1982; Mobley, Vagias, & DeWard, 2010). The building occupants in New Zealand have higher academic qualification (i.e PhD degree) as results from the sample population shows that almost 50% of the respondents are lecturers. Earlier studies showed that those of higher academic qualification are more concerned about the environment than those with lower qualifications (Ostman & Parker, 1987). While this suggests that the building occupants in New Zealand should be more concerned about the environment compared to the building occupants in Malaysia, findings show no difference in their practice to reduce energy consumption. Although earlier studies showed that behaviour may vary due to different context and cultures (Ajzen, 1991; Kollmuss & Agyeman, 2002), findings show that this is not necessarily the case.
6.7 Conclusion

In conclusion, findings from the case study buildings in New Zealand and Malaysia showed that there were more occupants in the green building that practices energy saving in computer usage than occupants in the conventional buildings. The energy saving practices that were significantly more in the green buildings were the same in both countries, even though the green buildings in Malaysia showed more energy management measures as compared to the green buildings in New Zealand. The findings in this chapter provided a better understanding of what strategies to use to encourage occupants to save energy. Amongst the key strategies in encouraging building occupants to save energy are to have active building managers to engage with the occupants. Another key strategy is to raise awareness on energy efficiency issues amongst the building occupants. The originality of this research is that it examines the relationship between the behaviours in computer use with the building management strategies implemented. There is a gap in the body of knowledge with regards to understanding the differences in the management between the building types and its impact on the occupants’ behaviour. Despite the socio-cultural differences between New Zealand and Malaysia, the implications of the research finding showed that there are common strategies that can be applied in both contexts. The common strategies applied in both New Zealand and Malaysia can be adopted in any country and building regardless of their socio-cultural and building type differences.
CHAPTER 7  OCCUPANTS RESPONSE TO DISCOMFORT

This chapter has been extracted from:


7.1 Introduction

Thermal comfort is defined by the International Standard American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) as “that state of mind which expresses satisfaction with the thermal environment”. Green buildings, which are mostly mechanically and naturally ventilated buildings, adopt the ASHRAE 55 (2010) and ISO 7730 guidelines which suggest a thermal comfort temperature of between 20ºC to 24ºC. Studies have shown that the thermal comfort at these temperatures is generally acceptable to building occupants (Grimme, 2003; Law, 2013, p. 20; Rohles, 2007). Post occupancy studies on comfort have shown that, in general, green buildings are more comfortable when compared to conventional buildings (Isa et al., 2010; Leaman & Bordass, 2007).

Although a temperature of between 20ºC to 24ºC is an accepted comfort range for most occupants, Nicol and Humphreys (2012) argue that the temperature range suggested by the ASHRAE 55 2010 standard and ISO 7730 (2005) guideline is too narrow. This is supported by other studies that have found high levels of discomfort issues in green buildings, where
occupants find it too cold during the winter and too hot during the summer (Abbaszadeh, 2006; Baird, 2010; Leaman & Bordass, 2007, Paul & Taylor, 2008). Occupants will make environmental adjustments to buildings when they are experiencing discomfort with the thermal, daylight and natural ventilation conditions in the buildings (Bordass et al., 2010; Heerwagen, 2010; Heerwagen & Diamond, 1992; Reiss, 2005; Sawyer et al., 2008).

The adaptive thermal comfort model (i.e., the International standard ASHRAE RP884 (de Dear & Brager, 1997) and the European Standard (EN 15251)) proposes a wider temperature range of up to 30°C and claims that buildings should be designed in a way that provides a wider opportunity for occupants to adopt behavioural adaptations (Brager & de Dear, 1998; Nicol et al., 2012). The adaptive thermal comfort model is not widely adopted in a controlled thermal environment such as an air-conditioned building (Law, 2013). This is because there is a huge challenge in behavioural change as it requires a lifestyle change that is too onerous (Law, 2013).

Scholars have categorized behaviour adaptations as responses to the discomfort of being too cold or too hot (Nicol et al., 2012; Heerwagen & Diamond, 1992). There are three types of behaviour adaptations which are (i) personal adjustment; such as “adjusting activity, adjusting posture”, (ii) technological or environmental adjustment; such as turning on fans or heaters and (iii) psychological adjustments; that is “just put up with it, or try to ignore the problem”. However, limited studies have been conducted on the level of practice of these behaviours. By investigating the level of practice of behaviour adaptations to thermal comfort, it is possible to gain a better understanding on how buildings can encourage better behaviour adaptations.

Environmental adjustments have energy implications for the building. Among the post-occupancy issues in green buildings are lack of knowledge and skills about how to operate
the environmental control systems efficiently (Bordass et al., 2001; Gabe, 2008; Mosly & Zhang, 2010), and limitation of accessibility to the control systems, which causes occupants to make their own personal modifications (e.g., use a personal fan or heater.) to achieve optimum comfort (Bordass et al., 2001; Brown, 2009; Reiss, 2005). Studies have also found that occupants’ desire to achieve optimum comfort causes controls to be overridden, such as mechanical cooling and heating systems (Gabe, 2008; Reiss, 2005; Sawyer et al., 2008). Against the need to change controls, Heewargen and Diamond (1992) suggest that an adverse impact of providing good automated building control systems is creation of the “desk couch potato” where there may be a lack of muscle movement, and an increase of social isolation.

Heerwaagen and Diamond (1992) examined the three types of behaviour adjustments (personal adjustment, environmental adjustment, and psychological adjustment) in green buildings. The findings showed that the green buildings encouraged more personal adjustments than environmental adjustments. Personal adjustments were made more than environmental adjustments in spaces where occupants have limited access to the control systems, such as an open plan space. While in private offices within the building, the occupants made more environmental adjustments than personal adjustments.

Advocates for personal adjustments believe they not only help reduce the energy consumption in buildings, but also create healthier personal actions for the occupants since there is more muscle movement (Heewargen & Diamond, 1992). In order to further the debate about thermal comfort in buildings, the study in this chapter examines what people do when they are too hot or too cold, and whether there are significant differences in the behaviour of occupants between green and conventional buildings.

Comparison studies between the different climates showed that occupants’ responses to thermal discomfort varies (van Hoof & Hensen, 2007; Yu, Cao, Cui, Ouyang, & Zhu, 2013;
These studies did not account for any coping mechanisms in response to thermal discomfort. The study limited the occupants’ level of clothing insulation as well as their coping mechanism in response to thermal discomfort by only allowing sedentary activities such as reading, writing, and surfing the internet. A recent study by Zhu, Ouyang, Cao, Zhou, & Yu (2015) raised concern that there are limited studies that examine the differences in occupants’ behaviour in different climate regions. There is a need to understand better on the varied behaviour of occupants in buildings to produce buildings that are healthier and with lesser energy consumption (Baird, 2015; Humphreys, 1995). Therefore, an analysis of occupants’ responses in thermal discomfort in different climates (Malaysia vs New Zealand) adds to the debate in the field of thermal comfort.

### 7.2 Coping mechanisms in response to discomfort

Reviews of the international literature indicate that there are three basic types of coping mechanism (as mentioned in the previous section: personal adjustments, technological or environmental adjustments, and psychological adjustments) in response to discomfort that occupants normally use in buildings (Brager & de Dear, 1998; Heerwagen & Diamond, 1992). Table 7.1 provides a detailed list of adjustments considered to be personal adjustments in response to thermal discomfort.

<table>
<thead>
<tr>
<th>Personal Adjustment</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clothing adjustment when felt cold and hot</td>
<td>(Baker &amp; Standeven, 1996; Barlow &amp; Fiala, 2007; Brager &amp; de Dear, 1998; Heerwagen &amp; Diamond, 1992; Humphreys, 1997; Humphreys, 1994; Indraganti, 2010; Oseland &amp; Humphreys, 1994)</td>
</tr>
<tr>
<td>After timing of their work pattern to avoid uncomfortable working conditions</td>
<td>(Baker &amp; Standeven, 1996; Brager &amp; de Dear, 1998; Humphreys, 1994; Indraganti, 2010; Oseland &amp; Humphreys, 1994)</td>
</tr>
<tr>
<td>Adjusting posture</td>
<td>(Brager &amp; de Dear, 1998)</td>
</tr>
<tr>
<td>Consuming hot or cold food and drinks</td>
<td>(Baker &amp; Standeven, 1996; Brager &amp; de Dear, 1998; Heerwagen &amp; Diamond, 1992; Humphreys, 1997; Humphreys, 1994; Oseland &amp; Humphreys, 1994)</td>
</tr>
</tbody>
</table>
As shown in Table 7.1, clothing adjustment is a common personal adjustment made in response to discomfort. This behaviour has been promoted in office buildings. For example, there was a campaign on no neck ties in Japan in 2005 (Healy, 2005), and employees have been encouraged to adopt a casual dress code in the United Nation Headquarters, New York (Tan, 2008). The rationalization for this campaign was that flexibility in dress code in office buildings provides occupants more adaptive strategies to cope with thermal discomfort. O’Connor et al. (2002) categorised these behaviour changes as “suffer discomfort”. Although discomfort is not relieved entirely by personal adjustment, these behaviours have important functions such as making people move around more and engage in social interactions (Heerwagen & Diamond, 1992). The mental and social benefits generated from personal adjustments are worthwhile and create a healthier environment for the occupants (Heerwagen & Diamond, 1992). Furthermore, these actions conserve energy and as a result, energy performance of green buildings can be improved (Heerwagen & Diamond, 1992; 2010).

There are limited understanding on whether the design of a green building encourages occupants to engage in personal adaptation (Healey & Webster-Mannison, 2012; Keyvanfer, Shafaghat, Majid, Lamit, & Ali, 2014; Zhang & Barret, 2012). For example, Healey and Webster-Mannison (2012) reported that occupants engaged in more personal adjustments (i.e. dress in layers, consumed hot/cold beverages, disposition) due to the influences of the socio-cultural aspects within the building, but did not relate the adaptive behaviour responses to the
physical environment in the building. Moezzi and Goins (2011) reported that occupants in commercial buildings engaged in less personal adjustments (i.e. drink hot/cold beverages; dress in layers, walk around more) than environmental adjustments and speculated that it is due to the lack of physical environment such as a place to buy coffee, and a place to retreat. However, findings by Gautheir and Shipworth (2015) showed a different result to Moezzi and Goins (2011) where physical environment does not necessarily encourage occupants to engage in personal adjustments. Several earlier studies indicated that building design features such as spacious common room and access view to the natural environment reduces occupants stress level and increases work productivity (Haynes, 2007; Joye, 2007; McCunn & Gifford, 2012; Miller, Pogue, Gough, & Davis, 2009).

Environmental adjustments are how occupants interact with the building control systems (such as windows, blinds, switches, and other controls). Occupants who engage in this thermal discomfort coping mechanism can impact on energy usage if the building control systems are not operated efficiently (Bordass et al., 2001; Cole & Steigner, 1999; Leaman & Bordass, 2007).

Inefficient operation of the building control systems are described in the following studies. For example, Gabe (2008) and Sawyer et al., (2008) discovered that occupants increased the load of the cooling and heating systems to accommodate comfort. Reiss (2005) discovered that occupants routinely override switches for natural ventilation or mechanical cooling because they don’t know what conditions each option is intended for. Reiss also discovered that occupants did not open the window when they were supposed to, which caused the heating system to consume five times more energy than predicted. Heerwagen and Wise (1998) showed that occupants kept doors open for fresh air causing mechanical systems to
consume more energy. Bordass et al. (2001) and Brown (2009) have also reported that occupants used personal heaters or fans to relieve discomfort. These studies led to the assumption that when occupants are provided with high access to the environmental control systems, they will be more likely to make adjustments that will impact energy usage in buildings (Cole & Brown, 2009; Heerwagen & Diamond, 1992). This prediction was further supported by findings from Riccardi and Burrati (Ricciardi, Buratti, & Burrati, 2012) and Moezzi and Goins (Moezzi & Goins, 2011) where the occupants engaged in less environmental adjustments when they had limited access to the building environmental control systems. O’Brien and Gunay (O’Brien & Gunay, 2014) raised concern that contextual factors such as occupants’ awareness and perception of working in a green building can influence their choice of adaptive behaviour. For instance, occupants may adopt poor energy saving behaviours in energy efficient design buildings due to the ‘rebound effect’ (Bourrelle, 2014; Sorrell, Dimitropoulos, & Sommerville, 2009).

Heerwagen and Diamond (1992) defined a psychological coping mechanism as an attempt to adjust to a situation by managing the emotions or thoughts about the situation. Occupants responded to either feeling hot or cold by just putting up with the discomfort, believing there was nothing they could do, or try to ignore the discomfort. Heerwagen and Diamond (1992) found that almost one fifth of the occupants who experienced thermal discomfort, either feeling too hot or cold, chose to not do anything. Occupants engaged more in this coping mechanism when environmental adjustments were limited, and when other coping mechanisms are not effective in relieving discomfort (Heerwagen & Diamond, 1992).

Previous studies (Bordass et al., 2001; Heerwagen, 2010; Heerwagen & Diamond, 1992; Sawyer & Turpin-Brooks, 2008) describe adjustments made by occupants to relieve
discomfort. These studies did not quantify the frequency of the behaviours. Quantification of the frequency of behaviours can aid building designers to make better predictions of energy usage. Current energy modelling software assumes occupants schedules are similar to building operation schedules (8am to 5pm) with no absence from their offices during workdays, such as lunch breaks and meetings (Azar & Menassa, 2012). Building occupants’ frequent act use of additional heaters or fans, and corresponding adjustments of temperature are not accounted for in the energy simulation tools (Hoes et al., 2009; Li & Lim, 2013, p286; Turner and Frankel, 2008). Often designers make inaccurate assumptions, such as that occupants would open windows to optimize the usage of natural ventilation (Li & Lim, 2013, p. 286). It is important to better understand occupants’ interaction with the building control systems when faced with discomfort. Even when building control systems are operated efficiently, they may not relieve the occupants’ discomfort entirely. Building occupants have a high tolerance to discomfort. Moujalled et al (2008) discovered that occupants preferred more naturally ventilated buildings as compared to air-conditioned buildings, even if these buildings were colder.

To design buildings that encourage occupants to practice energy saving behaviour, designers must understand occupants’ level of interaction with the building control system. A study by Santin (2011) found that energy-conscious households conserve more energy with systems that require active involvement, while less energy-conscious households conserve more energy with systems that do not require active involvement. Similar behaviours by occupants in commercial buildings are seen in a study by (Andrews, Yi, Krogmann, Senick, & Wener, 2011) where occupants who were more energy-conscious are more likely to be actively involved in the building control systems. The findings of these studies are suggesting that the building control systems should be designed with active involvement in building control systems assuming that majority of the occupants are energy-conscious, but the scope of the
study had only focused on occupants’ adaptive behaviour in lighting discomfort. Although energy conscious occupants are showing energy saving practices for lighting, but they may not show the same level of energy saving practices in thermal discomfort.

This chapter provides a better understanding of occupants’ behaviour through comparative analysis between green and conventional buildings. The findings in this chapter will help designers to design better buildings that encourage green practice. This chapter extends the research by Heerwagen and Diamond (1992) and Azar and Menassa (2012) by comparing behaviours in conventional buildings with those in green buildings to see whether green buildings have any different influences on how occupants behave in response to thermal discomfort.

7.3 Research method

The details of the case studies in New Zealand and in Malaysia can be referred to in Chapter 2 Research Methodology. The research method used in this chapter is a quantitative method, whereby a survey was conducted to understand how occupants in the building behave to achieve comfort.

Invitations to participate in this study were sent through an email, and a follow up call to the building managers was made. The building managers in each of three case study buildings then distributed an online survey to the occupants in the buildings by uploading it onto the building website. The researcher then sent a follow up email requesting that the building manager circulate the website link to the occupants in the building after two weeks. Hard copies were also provided to the building manager for occupants who wished to fill in the questionnaire manually. In order to increase the response rate, the researcher was given
access to the case study buildings to invite participants to take part in the research face-to-face. Hard copies as well as the website link were given to interested participants.

The aim of the questionnaire was to understand how occupants use the building to adjust their thermal comfort. Questions about coping mechanisms for each environmental condition were asked. Occupants were asked to rate their actions to achieve comfort using a Lickert scale of (5): I always do to (1): I never do. Option N/A was also provided for actions that are not relevant to the participant. Occupants were also asked to tick whether they had access to the building control systems, such as being able to adjust temperatures or open and close windows and doors.

Analysis was undertaken using SPSS Statistic 22. The Mann U Whitney test was used to identify which of the coping mechanisms were significantly different between the building types. The coping mechanisms identified as significantly different via the Mann U Whitney test were further analysed using frequency description and crosstab analysis to ascertain occupants which building types practiced the most coping mechanisms.

Occupants were also asked whether working in a green building meant they would sacrifice their comfort level to save energy by responding to the statement “I am willing to sacrifice my comfort level and change my lifestyle to save energy” using a Lickert scale from (5) Strongly Agree to (1) Strongly Disagree. Frequency analysis was used to identify the highest percentage of response for each factor.
7.4 Results

7.4.1 The significant differences in how occupants’ in green and conventional buildings respond when they feel cold (New Zealand Case Studies)

The results in Figure 7.1 show the NZ case study building occupants’ responses when they were feeling cold. Statistical analysis using the Mann-Whitney U test showed that there are five actions that were significantly different between the green (TB and OGGB) and conventional (FoE and OCH) buildings in terms of occupants responses when they were feeling cold. These actions included two actions of environmental adjustment, two actions of behavioural adjustment and one of psychological adjustment. Under environmental adjustment, Figure 7.1 shows that occupants in the green buildings were significantly less likely (p = 0.026) to adjust the temperature on the heating system in their working space. In addition, occupants in the green buildings were significantly less likely to use a personal heater (p = 0.000).

As for personal adjustment, Figure 7.1 shows that occupants in the green buildings complained significantly less (p = 0.000) to the building manager when they were feeling too cold. Occupants in the green buildings were significantly more likely (p = 0.000) to walk around to heat up their body. In terms of psychological adjustment, there were significantly more (p = 0.000) occupants in the green buildings who choose not to do anything about their discomfort. Occupants in the green buildings were less likely than those in the conventional buildings to change the environmental conditions in the building (that is, they were less likely to adjust the heating system and less likely to use a personal heater) and chose more personal adjustment (that is, they complained less to the building manager, walked more around in the building to heat up their body). Furthermore, the green buildings had significantly more occupants who do not do anything when they are feeling too cold.
Note* energy saving behaviours that are significant different through Man-U Whitney test (p values < 0.05)

Figure 7.1 Occupants response when feeling cold in their working space (New Zealand)
7.4.2 The significant differences in how occupants’ in green and conventional buildings respond when they feel cold (Malaysia Case Studies)

Figure 7.2 presents an overview of the Malaysian case study buildings occupants’ responses when feeling cold. Statistical analysis using the Mann-Whitney U test showed that there are three actions that were significantly different between the green (LEO and PPJ) and conventional (MoH) buildings in terms of occupants responses when they were feeling cold. These actions concerned environmental adjustment (that is, “adjust temperature on the air-conditioning system”) and two actions on personal adjustment (“put on warmer clothes” and “alter timing of their work pattern”).

Under environmental adjustment, Figure 7.2 shows that the occupants in the green buildings are less likely to adjust the temperature on the cooling system when they feel cold (p = 0.001). As for personal adjustment, Figure 7.2 shows that the occupants in the green (LEO and PPJ) buildings are significantly less likely to put on warmer clothes (p = 0.000) and alter the timing of their work pattern to avoid uncomfortable working conditions (p = 0.021).
Note* energy saving behaviours that are significant different through Man-Whitney U test (p values <0.05)

Figure 7. Occupants response when feeling cold in their working space (Malaysia)
7.4.3 The significant differences in how occupants’ in green and conventional buildings respond when they feel hot (New Zealand Case Studies)

As for the thermal condition of the building being too hot, Figure 7.3 shows that there are four actions which are statistically significantly different between the two building types in New Zealand. These actions are two actions on environmental adjustment, one action on behavioural adjustment, and one action on psychological adjustment. Under environmental adjustment, Figure 7.3 shows that occupants in the green (TB and OGGB) buildings are significantly less likely \((p = 0.004)\) to adjust the temperature on the cooling system. In addition, they are also less likely to use a personal fan \((p = 0.031)\). Under personal adjustment, Figure 7.3 shows that occupants in the green buildings complain significantly more \((p = 0.002)\) to the building manager when feeling too hot.

As for psychological adjustment, there are significantly fewer \((p = 0.018)\) occupants in the green buildings who did not do anything when feeling hot. Occupants in the green buildings appear to cope more with discomfort when they are hot than occupants in the conventional buildings. Hence, generally occupants in the green buildings chose less environmental adjustment (that is, temperatures on the cooling systems are less likely to be adjusted, and less usage of personal fans) and less personal adjustment (that is they are less likely to complain to the building manager) when they feel too hot. As for psychological adjustment, more green building occupants than conventional building occupants do not do anything in response to discomfort.
Note* energy saving behaviour that are significant different through Man-U Whitney test (p values< 0.05)

Figure 7. 3 Occupants response when feeling hot in their working space (New Zealand)
7.4.4 The significant differences in how occupants’ in green and conventional buildings respond when they feel hot (Malaysia Case Studies)

Figure 7.4 shows three actions that were statistically significantly different between the two building types in Malaysia. These actions are on environmental adjustment (that is, green building occupants are less likely to adjust the temperature; \( p = 0.021 \) and less likely to use personal fans; \( p = 0.000 \)), and on personal adjustment (green building occupants are less likely to consume cold drinks or food; \( p = 0.007 \)). Thus both of these adjustments are seen less in the green buildings than the conventional buildings.
Note* energy saving behaviours that are significant different through Man-U Whitney test (p values <0.05)

Figure 7.4 Occupants response when feeling hot in their working space (Malaysia)
7.4.5 What access do occupants have to adjust building control systems? (New Zealand Case Studies)

Figure 7.5 shows the ability of occupants to access the building control systems in the New Zealand case studies. The results show that the occupants in the green (TB and OGGB) buildings have more access to the systems to adjust the temperature compared to occupants in conventional (FoE and OCH) buildings. As for access to the windows, occupants in the conventional buildings have more access than occupants in the green buildings. Occupants in the green and conventional buildings have the same level of access to the doors.

Figure 7. 5 Accessibility to the building control system (New Zealand Case Studies)
7.4.6 What access do occupants have to adjust building control systems? (Malaysia Case Studies)

Figure 7.6 shows the occupants’ ability to access the building control systems in the Malaysian case studies. The results show that the occupants in the green (LEO and PPJ) buildings have more access to adjust temperature system (15%) as compared to the conventional (MoH) building occupants (5%). Similarly, accessibility to windows is also greater in the green buildings (56%) than in the conventional buildings (17%). The occupants in the green buildings (69%) also have greater access to the doors than in the conventional buildings (54%).

The comparison results between Figure 7.5 and 7.6 shows that the green building occupants in New Zealand have greater accessibility than the conventional building occupants for only adjusting the temperature system. While the remaining environmental control systems are almost equally accessible by occupants in both green and conventional buildings. This is different from the building case studies in Malaysia, whereby the green building occupants have greater accessibility for all the building...
environmental control systems than the conventional building occupants. The impact of the differences in the level of accessibility is further discussed in section 7.5.

7.4.7 The effects of working in a green building on building changes (New Zealand Case Studies)

Twenty per cent of the green building occupants in this study perceived their building as green. Out of those 20%, 80% disagreed that working in a green building meant that they had to sacrifice comfort (as shown in Figure 7.7).

![Figure 7.7 Percentage of occupants who sacrifice comfort to save energy (New Zealand)](image)

7.4.8 The effects of working in a green building on building changes (Malaysia)

Occupants in the green (LEO and PPJ) buildings were asked whether they perceived the building they work in as being a green building. Only 38% of the green (PPJ) building occupants perceived their building as green, while 75% of the green (LEO) building occupants perceived their building as green. Occupants who were aware of the green
building status were asked whether working in a green building meant that they sacrificed comfort to save energy. The largest proportion of occupants in both the green buildings agreed to this behavioural adaptation. As shown in Figure 7A, 53% of the green (LEO) building occupants and (as per Figure 7B) 43% of the green (PPJ) building occupants had selected “agree” and “strongly agree” in response to the idea that they sacrificed comfort to save energy. These results demonstrate that those respondents have a high level of awareness about energy efficiency.

Figure 7. 8Percentage of occupants who sacrifice comfort to save energy (Malaysia)

7.5 Discussion Malaysia and New Zealand

The study found that responses to thermal discomfort are different between green and conventional building occupants
7.5.1 Environmental Control Systems

7.5.1.1 Adjust temperature system

Earlier studies have reported that occupants in green buildings adjust the temperature systems in response to discomfort (Bordass et al., 2001; Brown, 2009; Heerwagen & Diamond, 1992; Sawyer et al., 2008). The current study in New Zealand and in Malaysia found that these practices are carried out significantly less by occupants in green buildings than by occupants in the conventional buildings.

The findings in the present study indicated that although occupants in the green buildings in New Zealand and in Malaysia have greater access to the controls to adjust the temperature than occupants in the conventional buildings, they were significantly less likely to adjust the temperature when feeling too cold and hot. As reported above, these findings are in contrast with earlier studies which showed that occupants with higher accessibility to adjust the temperature systems were more likely to adjust the temperature systems (Heerwagen & Diamond, 1992; Gabe, 2008; Sawyer et al., 2008).

The findings also suggest that there is no evidence to support the hypothesis put forward by earlier studies that higher accessibility to the building control systems creates the “desk couch potato” social phenomena (Heerwagen & Diamond, 1992) nor does it support the idea put forward by earlier studies whereby occupants adopt poor energy saving behaviours in energy efficient design buildings (Bourrelle, 2014; Howden-Chapman et al., 2009; Sorrell et al., 2009).

Due to the climate differences, building occupants in Malaysia and New Zealand perceive as feeling too cold or hot at a different level of temperature degree. On average, the indoor thermal environment temperature below 23°C is considered as too cold in
Malaysia (Daghigh, 2015), while in New Zealand below 18°C (Leardini, Manfredini, & Callau, 2015). Despite the differences in the perceived thermal discomfort range of temperature, results in this study shows that their behaviour responses are the same in which they make less environmental adjustment in comparative to their counter conventional buildings. However, there is a difference in the level of personal adjustments engaged by the building occupants between these two countries. Building case studies in Malaysia showed that there were significantly less personal adjustments made by the building occupants. Almost 30% of the green building occupants were less likely to put warmer clothes and only 20% of the green building occupants alter their work patterns than the conventional building occupants. While in New Zealand, the building case studies showed that these personal adjustments were higher with almost 70% of the green building occupants put warmer clothes and 30% more of the green building occupants take walks around in the building when feeling cold. The results indicate that the warmer climate condition in Malaysia are more suitable to design buildings using the adaptive thermal comfort standard since there will be less likely for the occupants to make changes to maintain their comfort. An analysis on the measurement of the building environment such as the air velocity, air temperature, mean radiant temperature and relative humidity level in the future research can provide better understanding in the relationship between buildings and the occupants. The adaptive thermal comfort standard will more likely be challenging for buildings in colder climate conditions such as illustrated in the building case studies in New Zealand that required occupants to engage in more personal adjustments to maintain comfort. Occupants may be frustrated that they would need to engage in more behaviour adaptation in order to maintain comfort. Despite this frustration, the personal adjustments provide healthier benefits for the occupants as they prevent occupants from being sedentary.
The green building occupants in Malaysia mostly agreed that working in a green building meant that they have to sacrifice their comfort to save energy, while the majority of the green building occupants in New Zealand disagreed with this. In the Malaysian case studies, given that those occupants agreed to sacrifice comfort, the green building occupants could be more aware of the impact of changing the temperatures on energy use in the building and therefore do not adjust the temperature. The findings from the Malaysian case study reinforces earlier studies that green building occupants are more tolerant of discomfort than those in conventional buildings (Deuble & de Dear, 2012; Leaman & Bordass, 2007).

Green building occupants in New Zealand did not feel they sacrificed comfort to save energy and they were also less likely to adjust the temperature. One explanation for the different results from the Malaysian case studies is that the green building occupants in New Zealand engaged in more personal adjustments whereby they chose to walk around in the building more than those occupants in the conventional buildings. This behaviour adaptation reduces discomfort and means adjusting temperature is unnecessary. The findings from the New Zealand case studies do not support findings of other studies where green building occupants are reported to be more tolerant of discomfort (Deuble & de Dear, 2012; Leaman and Bordass, 2007). The findings in this study support the explanation offered by Heerwagen and Diamond (1992) and Wener (2006) that personal adjustments can relieve discomfort to some extent and that buildings should allow more opportunity for occupants to make personal adjustments, which leads to healthier building occupants as well as saves energy.
7.5.1.2 Windows

Other studies have reported that designers make inaccurate assumptions that building occupants will open windows to optimize natural ventilation (Li & Lim, 2013). The findings in the current study showed that approximately 50% of the building occupants out from those who had access to the windows (figure 7.5 and 7.6) from the New Zealand and Malaysian case studies in both the green and conventional buildings do not open or close the windows in response to feeling hot or cold. The findings extend those of the study by NREL (2005) since the percentage of occupants who did not open the windows in that study was unknown. The findings from this study are potentially useful for predicting energy use in buildings since other studies (Azar & Menassa, 2012; Li & Lim, 2013) have not accounted for occupants’ levels of interaction with the windows. For example, when modelling energy, often the designers assume that occupants would open windows to optimize usage of natural ventilation (Li & Lim, 2013), however the results in this study showed only 50% of occupants with access would open the windows. The results showed no difference between Malaysia and New Zealand building case studies. The result in this chapter extends the study by Heerwagen & Diamond (1992) by showing a clearer demonstration on the variation of the behaviour in different building types. Heerwagen & Diamond (1992) reported that 17% occupants are more likely to open windows/doors when they are hot, 5% close window when they are cold. While results in this chapter showed a higher percentage of approximately 50% of the occupants in both building types in two different countries are more likely to open the windows/doors when they are hot, and close the windows/doors when they are cold.

The results demonstrated that reliance on building occupants to operate the building control systems efficiently is a continuous challenge. These findings are consistent with
other studies which have reported that building occupants do not open or close the windows (NREL, 2005; Reis, 2005). Hence, it is recommended to install a hybrid control system where the controls are interfaced with the Building Management System and have the ability to manually override the controls for ensuring energy efficient performance in a building. The findings in the current study thus support the suggestion by Reiss (2005) and NREL (2005) that a hybrid control system is recommended for ensuring energy efficient performance in a building.

7.5.1.3 Fans/heaters

Other studies in green buildings have found that occupants used personal heaters and fans to relieve discomfort (e.g., Heerwargen & Diamond, 1992; Bordass et al., 2001; Brown, 2009). However, the case studies in New Zealand found that these practices were carried out significantly less in the green buildings than in the conventional buildings. Similarly, the case studies in Malaysia also showed that occupants in the green buildings used personal fans less than occupants in the conventional buildings. The current practice of predicting energy usage did not account for behaviours that use additional fans/heaters (Azar & Menassa, 2012; Li & Lim, 2013). The results in this chapter showed almost 10% of occupants would use additional fans/heaters in response to discomfort. Therefore an adjustment of a more realistic percentage can be made for the designers when predicting energy usage.

One theory might be that as green (New Zealand and Malaysia) building occupants are more aware of the impact changing temperature and personal heaters/fans have on the energy use and therefore do not change their building controls. The green buildings (New Zealand and Malaysia) have active on-site building managers where they frequently
remind the building occupants to save energy which cause the occupants to be more aware on energy efficiency. As for the conventional buildings (New Zealand and Malaysia), the on-site building manager were not as active as those in the green buildings whereby sending reminders on energy savings were not as frequent as the building managers in the green (New Zealand and Malaysia) buildings. Based on the discussion with the building managers, the reason for this is because the building managers in the green (New Zealand and Malaysia) buildings have the perception that since the green (New Zealand and Malaysia) buildings are designed to be energy efficient, the operation of the building should also support energy efficiency. The building case studies in New Zealand showed that despite the universities commitment to reduce energy usage, the perception of working in green buildings had encouraged the building managers more to persistently reduce energy use. The results in this study supports Moezzi and Goins (2011) where building managers in green buildings had also discouraged the occupants in the buildings to use personal fans or heaters. The building case studies in Malaysia showed different findings from the New Zealand building case studies as the buildings are office buildings. In Malaysia, it was found that building managers were outsourced to a facility management service company. Their role was to ensure energy efficient performance of the buildings. Any additional effort to reduce energy usage would not be done if there were no encouragement by the client. This was seen in the conventional building in Malaysia as described in Chapter 4 where the building manager showed reactive response instead of proactive response. Contrary to findings in New Zealand where building managers were more proactive in exercising their role to ensure energy efficiency, the Malaysian building managers were only driven to reduce energy levels if it was demanded by the building client.
7.5.2 Personal Adjustments

7.5.2.1 Walk around in the building

Heerwagen and Diamond (1992) reported that occupants in green buildings walk around when they feel cold. The findings from the New Zealand case studies showed that this was practiced significantly more in the green buildings than in the conventional buildings; while the findings from the case studies in Malaysia showed that the practice was the same in both the green and conventional buildings. One possible reason is that it could be due to the similar design attributes that the Malaysian green and conventional buildings have.

Other studies have also found that views of the natural environment can help occupants feel less stressed (Joyce, 2007; McCunn & Gifford, 2012). The green buildings in New Zealand and Malaysia, and the conventional building in Malaysia are highly glazed buildings which provide wide access to views of the natural environment outside the buildings. The conventional buildings in New Zealand did not have these design attributes. In addition, studies have reported that green buildings are more spacious which makes occupants feel more productive at work (Hayness, 2007; Miller et al., 2009), the current case studies of the green buildings in New Zealand and Malaysia and the conventional building in Malaysia demonstrated that the common spaces provide an opportunity for occupants to exercise healthy adjustments in response to discomfort. The findings in this study also support the speculation by Moezzi and Goins (2011) where physical environment can encourage occupants to make healthy adjustments such as by walking around more. However, findings in this study do not support Gauthier and Shipworth (2015) indicating that occupants’ adaptive behaviour varies according to the different demand level of comfort. The findings extends earlier studies by Joye (2007),
Hayness (2007), Miller et al., (2009) and McCunn and Gifford, (2012) by showing that not only do these design features (i.e. spacious common room and access to view the natural environment) can make occupants feel less stressed, but it can potentially encourage occupants to engage in more personal adjustments.

7.5.2.2 Put warmer clothes, alter work pattern, consume cold drinks/food, and contact building manager, walk around in the building

The findings from the Malaysian case studies indicated that when they feel cold, the occupants in the green buildings were less likely to put on warmer clothes or alter their work patterns than occupants in the conventional building. The case studies in Malaysia also found that the occupants in the green buildings were less likely to consume cold drinks or food and they were more likely to contact the building manager when they feel too hot. These practices were the same in both the green and conventional buildings in New Zealand.

The results from the Malaysian case studies demonstrated that the occupants in the green buildings are more tolerant of discomfort since they are significantly less likely to engage in personal coping mechanisms than the occupants in the conventional buildings. These findings reinforce the results of other studies, whereby occupants in green buildings are more tolerant of discomfort than occupants in conventional buildings (Deuble and de Dear, 2012; Leaman and Bordass, 2007). Nevertheless, given that the case studies in New Zealand did not show any differences in the level of these practices between the two building types, the results of the New Zealand case studies do not support the earlier studies. The findings from the New Zealand case studies did not provide any evidence that occupants in green buildings are more tolerant of discomfort.
The green building occupants in Malaysia are more tolerant of discomfort than those in New Zealand because of the differences in climate. Occupants are more accepting in feeling too cold or too hot in warm and humid climate weather such as Malaysia as opposed to colder climates such as New Zealand. This is contrary to earlier studies which shows that building occupants from colder climates are more tolerant of discomfort than building occupants in the warmer climate (Yu et al., 2013, 2014). The findings in this chapter extends these prior studies by showing the behaviour of occupants in a more realistic circumstance where occupants are allowed to make necessary adjustments to reduce thermal discomfort, in which this was not accounted in the study by Yu et al.,(2013, 2014). Furthermore, the results from the comparison in different climates add more evidence to the literature to indicate that occupants from the colder climate are less tolerant to discomfort and will make more personal adjustment in response to thermal discomfort than those from the warmer climate. Nevertheless, further research can be conducted to affirm this finding since many of the contextual factors such as the measurement of the indoor environment temperature were not taken during the conduct of the survey. In addition, the differences in the cultural and social contextual dimension of the building case studies is also a significant part that must be looked into for better understanding on the reasons for the occupants choice of responses in thermal discomfort.

7.6 Conclusion

In conclusion, the study found that the occupants’ response to thermal discomfort is different between green and conventional buildings in both countries. Although occupants in the green buildings have higher access to the building control systems, occupants in the green buildings in New Zealand and in Malaysia engaged in fewer environmental
adjustments (they were less likely to adjust temperature, less likely to use personal fans/heaters) than those occupants in the conventional buildings. The findings from the Malaysian and New Zealand case studies suggest that the green building occupants cope with discomfort better than occupants in the conventional buildings. In addition, results from the green buildings in Malaysia showed that the majority of the occupants agreed that working in a green building meant that they have to sacrifice their comfort to save energy. However, the green building occupants in New Zealand did not agree. Despite the different perceptions of working in a green building, both types of building occupants in the two countries demonstrated energy saving behaviours by engaging in fewer environmental adjustments. The design attributes such as buildings with highly glazed windows and wide common areas encourage building occupants to engage in personal adjustments such as walking around when feeling cold. These results may assist designers of green and conventional buildings to understand how to moderate designs for the benefit and comfort of the occupants.
This chapter has been extracted from:


8.1 Introduction

Scholars have tried to understand what makes occupants engage in pro-environmental behaviour at work (Jackson & Seo, 2010; Russell & Griffiths, 2008, Scherbaum et al., 2008; Tudor et al., 2008). A study by Bissing-Olson et al., (2013) found that occupants who are more calm, relaxed, and content are more likely to practice pro-environmental behaviour. Design features in green buildings such as the wide accessibility to outdoor views from inside the building, indoor vegetation, and architectural natural forms are believed to facilitate employee satisfaction and increased productivity, and to reduce stress (Joye, 2007; Leaman & Bordass, 2007; McCunn & Gifford, 2012); therefore it is likely that the occupants in green buildings practice more pro-environmental behaviour.
Given that energy saving behaviour is a subset of pro-environmental behaviour, these studies therefore demonstrate that green buildings have the potential to encourage occupants to practice energy saving behaviour.

There is evidence in the literature that occupants’ working in green buildings practice more energy saving behaviour than occupants in conventional buildings (Tajabadi, 2010; Steinberg et al., 2010). The studies by Tajabadi (2010) and Steinberg et al., (2010) reported findings about energy saving behaviour but did not examine the motivations for such behaviour. Only the research conducted by Deuble and De Dear (2012) indicates that occupants in green buildings are more concerned about the environment. Other studies, such as work by McCunn and Gifford (2012), have raised a similar issue whereby there is limited research reported on how green buildings affect pro-environmental behaviour. The research in this study extended the work of Deuble and De Dear (2012) by asking about motivations to practice energy saving behaviour and examined whether there are differences in motivations and behaviour between building types.

8.2 Motivation and energy saving behaviour

Stern (2000) suggests that information and knowledge have the potential to lead to behaviour change. Studies on occupants in residential buildings have produced inconsistent findings regarding the relationship between level of concern for the environment and the level of practice in pro-environmental behaviour. For example, Poortinga et al. (2004), Schultz and Zelenzy (1998), and Vining and Ebreo (2002) have found that there is a weak relationship between level of concern for the environment and the level of practice of pro-environmental behaviour. According to Andersson et al. (2005) and Steg and Vleg (2009), energy saving behaviour in residential buildings is
more likely to be encouraged by knowing about the exact reductions in energy costs that result from this behaviour than just having concern for the environment issues, since the energy costs are paid for by the occupants (Andersson et al., 2005; Steg & Vleg, 2009).

However, other studies in residential and university buildings have confirmed a relationship between level of concern for the environment and level of practice of pro-environmental behaviour (Collins et al., 2007; Groot & Steg, 2008; Nordlund & Garvill, 2002; Schultz & Zelezny, 1999; Stern et al., 1995; Thogersen & Ölander, 2002).

Studies in conventional office buildings have found that occupants who are concerned about the environment are more likely to practice energy saving behaviour (e.g., Andersson et al., 2005; Scherbaum et al., 2008). Ucci et al. (2014) suggest that energy saving behaviours in office buildings are more likely to be encouraged by concern for the environment rather than knowing the amount of energy costs reduced since the energy costs are not paid for by the occupants. Concern for the environment is seen as a motivator to practice energy saving behaviour.

There are limited studies that examine whether working in green building increases occupants’ awareness of environmental issues. Lynam (2007) suggests that green buildings have the potential to communicate pro-environmental message to occupants. Studies (Deuble & De Dear, 2012; Lynam, 2007; Kato et al., 2010; Wu et al., 2013) have produced different findings on whether working in green buildings increases occupants’ level of awareness of environmental issues. Kato et al. (2010) analysed occupants’ motivations to practice energy saving behaviour in 10 certified green buildings. The results of the study reported that 35% of the respondents claimed that their awareness of environmental issues had increased through working in a green building.
It is current practice for the facilities management in green buildings to issue an energy report providing information about the amount of energy costs saved by green initiatives in the building (Azizi et al., 2013). These energy reports are disseminated to the building occupants informing the occupants about the energy cost savings in the organisation. Providing regular information about energy costs is acknowledged as an important motivator to continuously encourage occupants to save energy in office buildings (DoE, 2011). The energy efficient guideline for commercial buildings developed by the Energy Efficiency Conservation Authority (EECA), New Zealand (EECA, 2010), suggests informing building occupants about the savings in energy costs. However, several studies have found that occupants working in office buildings are not motivated by energy cost information to save energy, since the individuals do not pay the energy bills (Andersson et al., 2005; Carrico and Reimer, 2005). A study by Steinberg et al. (2010) reported that it is essential to provide the adequate amount of information necessary to encourage energy saving behaviour practices. This shows that there are conflicting perceptions on whether energy costs motivate building occupants to save energy.

Given that the practice of facilities management in green buildings is to inform the building occupants about the amount of energy costs saved, and that occupants are motivated to save energy when they know about the energy costs saved (DoE, 2011), it is therefore necessary to investigate whether there are there any differences in the motivation between green and conventional building occupants with respect to energy costs.

Ucci (2010) suggests that the social environment and social norms play a significant role in promoting energy saving behaviours in office buildings. In order to create this social environment, energy efficient guidelines, such as those produced by the EECA (2010), have suggested that it is important to have energy champions in an organisation that show leadership in setting an example to others to save energy. This leadership can take the
form of a proactive facilities manager. The facilities management in green buildings often communicate their concern for the environment to the building occupants (McCunn & Gifford, 2012), and provide environmental leadership to the other buildings (Azizi et al., 2012; Li et al., 2013). This leads to the question of whether these facility management practices create a new attitude among the green building occupants so that they want to be an example to others. Thus the impact of this collective attitude potentially creates a new social norm among the green building occupants.

Design attributes are also thought to influence behaviour. For instance, McCunn and Gifford (2012) suggest that the design attributes in a green building may influence occupants’ behaviour so that building occupants are less stressed and more productive. Bissing-Olson et al. (2013) have found that individuals who are less stressed are more likely to exhibit pro-environmental behaviour.

Further motivating factors can be found in the work of Steinberg et al. (2010) who showed that the occupants’ energy saving behaviour was encouraged by the green building certification process and the occupants wanting to ensure building performance success. Steinberg et al. (2010) compared the impact of different types of information on occupants’ willingness to practice energy saving behaviour in a green building. Information on the (1) green building standards, (2) impact of energy saving behaviours, and (3) environmental issues was given to the occupants. The results showed that occupants were more likely to practice energy saving behaviour if given more information on the green building standards (such as the Leadership Energy Efficient Design, LEED) as compared to environmental issues information.

Kato et al.,(2010) found that green building certification does not necessarily encourage staff to be environmentally conscious. Kato et al. (2010) believed that there was a gap
between managers and staff in terms of perceptions of how green certification affects environmentally friendly behaviours within an office. The managers of the green buildings believed that working in a certified green building helped motivate their staff to be more environmentally friendly. However, the staff did not believe green certified office status encouraged them to be environmentally conscious. Nevertheless, the green building occupants studied by Kato et al. (2010) claimed that they are more likely to save energy if they are given more understanding of the green features of the building. However, the outcome of a study by McCunn and Gifford (2012) showed no positive association between the green features of a building and energy saving behaviour.

The research in this study examined whether working in a certified and non-certified green building motivates occupants to save energy. There are studies in non-certified green buildings which have shown that the occupants’ concern for the environment was higher than the occupants’ concern in a conventional building (Deuble & De Dear, 2012). However there are also studies, for example by Lynam (2007), suggesting that occupants working in a conventional building have higher concern for the environment than occupants in a green building. The research in this study adds to the debate about the energy saving motivations of occupants in green and conventional buildings.

8.3 Research method

The purpose of the questionnaire was to examine whether occupants’ motivations to practice energy saving behaviours in green buildings are different to motivations of occupants in conventional buildings. The following statements were examined to ascertain the motivation of occupants to save energy. These were:
• “knowing that energy scarcity is a global issue is an important motivator for me to save energy”
• “knowing that I can help to save energy costs is an important motivator for me to save energy”
• “I want to set an example to others is an important motivator for me to save energy”.

Occupants in the certified green building were asked whether working in a green building that is certified by the Green Building Council (GBC) motivates them to save energy; while occupants in the non-certified green buildings were asked whether knowing that their building has green features, even without formal recognition from the Green Building Council (GBC), motivates them to save energy. Prior to answering the question, the building occupants were asked whether they perceived their buildings as ‘green’ using a categorical scale (yes/ no/ I don’t know). Only the occupants who perceived their buildings as green were included in the recorded responses.

The questionnaire required respondents to rank the importance of the factors in motivating them to save energy using a Lickert scale (responses ranging from 5 - Very Important to 1- Not Important). Analysis using SPSS Statistic 22 software was used to conduct the statistical tests. The Mann-Whitney U test was used to identify which of the motivational factors were significantly different between the building types. Frequency descriptions and crosstab analysis were used to examine the differences in the responses between the building types.
8.4 Results

8.4.1 Comparison between green and conventional buildings in Malaysia

The results in Figure 8.1 demonstrate that occupants in both the green and conventional buildings believed that knowing that energy scarcity is a global issue is important for them in being motivated to save energy. As shown in Figure 8.1, an approximate total of 80% of the building occupants selected “important” and “very important” as a response. These results reinforce the findings of earlier studies whereby occupants were found to be motivated to save energy when they have a higher level of awareness about environmental issues (see, for example Andersson et al., 2005; Scherbaum et al., 2008; Ucci et al., 2014).

![Figure 8.1 Motivator of knowing that energy scarcity is a global issue](image)

Given the earlier studies by Kato et al. (2010) and Wu et al. (2013), who found that green building occupants believed their awareness of environmental issues increased when they worked in a green building, the findings in this study did not support the notion as results
in this study showed no difference in their motivation between occupants in the green and conventional buildings. The conventional building occupants are as motivated as the green building occupants to save energy when they know that energy is scarce. Earlier studies (e.g., Lynam, 2007; Deuble & De Dear, 2012) found that there is a difference in level of concern for environmental issues between green and conventional building occupants, however the findings of this study indicated that there is no difference between what motivates occupants in green building to save energy compared to occupants in conventional buildings when occupants are asked about specific motivations such as energy scarce \( (p = 0.292) \).

The results from the Mann-Whitney U test also showed that there is no difference between the green and conventional buildings in what motivates occupants to save energy with respect to the question about saving energy costs \( (p = 0.357) \). The occupants in the green and conventional buildings both believed that saving energy costs motivates them to save energy. As shown in Figure 8.2, approximately 80% of the occupants from both of the building types felt that this was an important factor for them to be motivated to save energy. This finding demonstrates that the current practice of the facilities management in green buildings of informing the building occupants about the amount of energy costs saved (Azizi et al., 2012) does not induce the green building occupants to be more motivated to save energy out of concern for saving energy costs than those occupants in the conventional buildings.
The findings in this study contrast with those of earlier studies which have found that occupants in commercial buildings are unlikely to be motivated to save energy costs for the organisation (Anderson et al., 2005; Carrico & Reimer, 2005). Christina et al., (2014) suggest that building occupants in commercial buildings are motivated to save energy if they profit from the energy cost savings; however the current study suggests that occupants can be motivated to save energy costs even without profiting directly from their behaviour.

Occupants in both green and the conventional buildings felt motivated to save energy if it meant setting an example for others. As shown in Figure 8.3, approximately 60% of the occupants from both building types selected either “very important”, “important” or “slightly important” as a response to this factor as a motivator. There were no differences found in the responses between the building types (p = 0.185).
Although the facilities management in green buildings often provides environmental leadership to other buildings (Azizi et al., 2012; Li et al., 2013) and communicates concerns for the environment to the building occupants (McCunn & Gifford, 2012), the findings in Figure 8.3 show that it does not induce the green building occupants to provide the example of environmental leadership to others more than the conventional building occupants.

Other studies have found that working in green buildings influences occupants’ behaviour (McCunn & Gifford, 2012; Steinberg et al., 2010; Tajabadi, 2010). However, the findings in this study did not provide evidence to show that green buildings influenced occupants to be motivated to save energy any more than those in conventional buildings.

While earlier studies (Kato et al., 2010; Steinberg et al., 2010) have indicated there are conflicting views on whether certified green buildings encourage occupants to save energy, the findings of the present study showed that working in a certified green building motivates occupants to save energy. As shown in Figure 8.4, 63% of the occupants
believed that working in a green building that is certified is an important motivator for them to save energy. As for the occupants working in a green building that is not certified, they were asked whether knowing about the green features of the building motivated them to save energy. The results presented in Figure 8.5 show that 55% of the occupants believed that knowing about the green features of their building is an important motivator for them to save energy. However, the building occupants who responded to this question were occupants who perceived their buildings as ‘green’, which represented only 38% of the building occupants who responded to the survey. The results in Figure 8.5 resolve the conflicting findings of the earlier studies (Kato et al., 2010; McCunn & Gifford, 2012) on whether green features in a building induce energy saving behaviour.

![Figure 8.4](image1.png)  
**Figure 8.4** Green building occupants motivated to save energy when working in a certified green building, number of respondents n=206

![Figure 8.5](image2.png)  
**Figure 8.5** Green building occupants motivated to save energy when they know more on the green features of the building, number of respondents n=206
8.4.2 Comparison between green and conventional buildings in New Zealand

The results in Figure 8.6 show that occupants in both green and conventional buildings are motivated to save energy when they know that energy is scarce. Examining Figure 8.6, approximately 70% of the occupants in both building types responded that this issue is either “important” or “very important” as a motivating factor. The findings confirm those of previous studies in conventional office buildings (e.g., Andersson et al., 2005; Scherbaum et al., 2008; Ucci et al., 2014) which showed that occupants are motivated to save energy when they have high level of awareness about environmental issues.

No significant differences were shown in the responses between the building types through statistical analysis using the Mann-Whitney U test (p = 0.407). The findings contrast with earlier studies (Lynam, 2007; Deuble & De Dear, 2012) which showed a difference in the occupants’ level of concern about environmental issues. The findings also do not support the notion that green building occupants are more likely to be motivated to save energy out of concern for environmental issues (Kato et al., 2010; Wu et al., 2013) than occupants in conventional buildings.

![Figure 8.6 Motivator of knowing that energy is a global issue](image)
Figure 8.7 shows that the occupants in both the green and conventional buildings reported that they felt motivated to save energy when they know that they could help reduce energy costs. The results from the Mann-Whitney U test indicated that there is no significant difference in the responses between green and conventional buildings (p = 0.941).

Examine Figure 8.7, the results showed that approximately 70% of the occupants in both the green and conventional buildings believed it is important for them to know the amount of energy costs saved for them to be motivated to save energy. The green building occupants responded that this issue is either “important” (42%) or “very important (27%)” as a motivator for them to save energy; while the conventional building occupants responded that it is either “important” (45%) or “very important” (26%). The findings contradict those of other studies which have claimed that energy cost is not a motivator for staff in commercial buildings to practice energy saving, since the individuals do not pay the energy bills (Anderson et al., 2005; Carrico & Reimer, 2005). The findings go
beyond the work of Christina et al. (2014) by showing that occupants are still motivated to save energy costs for the organisation even without directly profiting from their behaviour as individuals.

As shown in Figure 8.8, over 40% of occupants from both the green and conventional buildings felt neutral in wanting to be an example to others by saving energy (44% and 45% respectively). The statistical analysis using the Mann-Whitney U test also showed no significant difference in the two groups of occupants’ responses to this potential motivator (p = 0.052). Although the green building facilities management demonstrate environmental leadership to others (Azizi et al., 2012; Li et al., 2013), this practice does not appear to motivate the green building occupants to want to show environmental leadership to others any more than the occupants in the conventional buildings.

![Figure 8.8 Motivation of “I want to set an example to others”](image-url)
The study by Kato et al. (2010) found that occupants are motivated to save energy if they are given more information to help them understand the green features of the building. However, the results of the current study do not support Kato et al.’s findings. Only 20% of the green building occupants in this study perceived their building as ‘green’. Out of the 20% of those occupants, as illustrated in Figure 8.9 only 30% of those green building occupants felt motivated to save energy if they understand the green features of the building. The majority of the green building occupants (63%) responded with “neutral” or “not important” when asked about the importance knowing about the green features of the building as a motivational factor. This result reinforces the work by McCunn and Gifford (2012) who found that no evidence of a significant association between appreciating the green features of a building and the practice of saving energy usage.

![Figure 8.9 Green building occupants in New Zealand motivated to save energy when they know more about the green features of the building, number of respondents n= 157](image)
8.5 Discussion: Evidence from Malaysia and New Zealand and motivations for energy saving behaviour

Previous studies have found that occupants in green buildings practice more energy saving behaviour than occupants in conventional buildings (Azizi et al., 2014; Steinberg et al., 2010; Tajabadi, 2010). However, these studies had only examined behaviour and not the motivation for the behaviour. Hence, this study examined whether green building occupants are more motivated to save energy than occupants in the conventional buildings.

The present findings from the New Zealand and Malaysian case studies showed that there was no difference between the motivating factors behind the green and conventional building occupants’ energy saving behaviour. Occupants in both the green and conventional buildings were equally motivated to save energy by knowing that energy is at scarcity, and by knowing that they can help to reduce energy costs. However the building occupants were least motivated to save energy because they wanted to be an example to others.

This study also added to the debate on whether non-certified green buildings motivate occupants to save energy (Kato et al., 2010; McCunn & Gifford, 2012). The results from the New Zealand case studies showed that occupants in the non-certified green buildings are not motivated to save energy by knowing about the green features in the building. However, the findings from the Malaysian case studies showed a different result, where occupants in the non-certified green buildings believed that knowing about the green features of the building motivates them to save energy. In addition, the findings from the Malaysian case study also indicated that occupants feel motivated to save energy when they work in green buildings that are certified. Hence, this suggests buildings that are
designed green and that obtain green certification further encourage occupants to save energy. The results also suggest that providing knowledge about the green features of a building has the potential to motivate occupants to practice energy saving behaviour.

The building occupants in both the New Zealand and Malaysia building case studies perceived their buildings as green which demonstrates that these occupants have awareness on the need to reduce energy use. Although the building occupants are aware on energy scarce, the research findings show that the impact of the different types of information varies between the two countries. While the Malaysia building occupants felt encouraged to save energy when working in a green-certified building and by knowing more about the green features of the building, this does not imply the same for the New Zealand building occupants. An explanation for this are speculated due to the difference in the level of awareness on energy efficiency. As mentioned earlier in Chapter 2, the population of the New Zealand have a higher awareness on green issues than the population in Malaysia.

8.6 Conclusion

In conclusion, this chapter examined whether there are any differences in the motivational factors behind energy saving behaviour between green and conventional buildings. The findings showed that none of the motivation factors tested is different for either occupant group and that occupants are motivated by the same factors. The results presented in this chapter of the thesis provide a better understanding about what encourages occupants to conserve energy usage in office buildings. This information is useful in designing better intervention strategies to encourage energy saving behaviour. The results indicated that
factors such as perceptions of energy scarce and contributing to reductions in energy costs are important motivators driving building occupants’ energy saving behaviour. The findings in this study also showed that occupants working in green buildings that are certified have a better chance of increasing awareness about this aspect since the results showed that occupants already felt motivated to save energy when they work in a green building that is certified. As for green buildings that do not have green certification, these also have the potential to encourage energy saving behaviour by increasing occupants’ knowledge about the green features of the building.
CHAPTER 9  CONCLUSION

9.1 Introduction

This chapter provides a conclusion to this thesis. There were six main research objectives addressed in this study. These objectives were researched under the four stages outlined in Chapter 1. The following section describes the findings for each of the research objectives according to the stages of the study. This chapter also addresses the study limitations and implications for future research in the area.

9.2 Review of research Objectives

9.2.1 Stage 1 Development of the energy management framework

There were two research objectives addressed in stage 1 of this study. The first research objective explored the risks associated in implementing green buildings in order to determine the focus of the study. The findings of the first research objective led to the second research objective, which was to identify energy management strategies to reduce energy usage in office buildings.
9.2.1.1 Objective 1: To investigate the risks associated in implementing green buildings in three stages of a project (1) design stage (2) construction stage and (3) operational stage.

The first research objective has been addressed in Chapter 3 of this thesis. The risks associated in implementing green buildings were identified by reviewing academic studies, project reports and discussion with the practitioners in the industry.

9.2.1.1.1 Major findings

The findings in Chapter 3 led to the understanding that risks in the operational phase of a building are significant issue and that these risks required further investigation. The findings showed that approximately 50% of the literature constituting as the highest percentage reports on the importance of maintaining and operating the green buildings to ensure energy efficiency performance. Input from the practitioners further supports this as a recognised issue, and have recommended that it is crucial to examine the existing green buildings that are in operation to be able to provide feedback on areas in the design and construction stages for improvement.

9.2.1.2 Objective 2: To identify the energy management strategies used in green and conventional buildings in Malaysia and New Zealand

The second research objective was addressed in Chapter 4 of this thesis. The energy management strategies used to achieve energy efficient performance in an office building were identified from a variety of international guidelines, academic studies, and reports. The outcome from the review of these documents was a total list of 19 items (Table.4.1).

The energy management strategies listed were then tested using case studies of green and conventional buildings in Malaysia and New Zealand. Relevant documents about each case study building as well as discussions with the building managers and architects were used to examine the extent of the current practice of these energy management measures.
The findings from the case study buildings led to the refinement of the energy management framework which increased the 19 items to a list of 26 energy management strategy items (Table 4.5). This provided a more comprehensive energy management framework and allowed for a better comparison of the case study buildings.

9.2.1.2.1 Major findings

The findings from the case studies showed that there were more energy management strategies practiced in the green buildings than the conventional buildings (Figure 4.4). Energy management practices that were evident in the green buildings tended to be more focused on encouraging energy saving behaviour. Despite the comparative analysis between building types, the findings showed that the Malaysia building case studies have more energy management strategies than the New Zealand building case studies. The effectiveness of these strategies was then evaluated based on occupants’ reported levels of practicing energy reducing behaviour which was used as a basis for the continuing study as reported in Chapters 5, 6 and 7. The findings in Chapter 4 also showed that different evaluation methods in assessing the buildings energy performance provide different results. When the energy use of the buildings were compared with the Building Energy Index values in kWh/m²/year, the results showed that the building was consuming the least energy. However, when the energy use was compared in kWh/occupant, the building is actually consuming more energy than the rest of the buildings. Hence, using both methods of assessment can provide better analysis of the energy performance of a building. Another significant finding is that the evaluation of the energy performance against the energy management strategies implemented indicated that energy indices alone do not provide facilities management with a clear representation of energy efficiency in buildings. The energy management framework can be used as a guideline.
for facilities management to see how they can achieve optimal energy efficient performance.

9.2.2 Stage 2 Energy saving behaviour practice

Stage 2 of this thesis comprised of two research objectives. The first research objective was to examine the occupants’ overall level of practice in reducing energy usage in office appliances and lighting; and heating, ventilation, and air conditioning (HVAC). The second research objective was to examine occupants’ practices in reducing the amount of energy used in computer usage and the strategies used to encourage the energy reducing behaviour.

9.2.2.1 Objective 3: To investigate the overall practice in energy saving behaviour in green and conventional buildings

This research objective is addressed in Chapter 5 of this thesis. A survey of energy saving behaviour was conducted among the occupants from the green and conventional case study buildings in New Zealand and in Malaysia. Questionnaires were used to capture the occupants’ level of practice in reducing energy usage in regards to 17 items of energy saving behaviours. Data analysis, such as calculating the total average score of the occupants’ overall performance in reducing energy usage, mean values, and the Mann-Whitney U test, was used to depict the overall practice of occupants in reducing energy usage in office buildings. The findings discussed in Chapter 5 showed that occupants in the green buildings practiced better energy saving than occupants in the conventional buildings.
9.2.2.1.1 Major findings

The findings from the building case studies in New Zealand and in Malaysia showed that in overall, occupants in the green buildings saves more energy than occupants in the conventional buildings. The findings also showed that energy saving practice in computer use were seen as the most by the building occupants. This chapter contributes to the body of knowledge by providing empirical evidence that green building occupants do practice energy saving more than the conventional building occupants.

9.2.2.2 Objective 4: To investigate whether occupants in green buildings perform better energy saving behaviour in computer usage than occupants in conventional buildings and the strategies used encourage the behaviour.

This research objective is addressed in Chapter 6 of this thesis. An in-depth analysis of the occupants’ behaviour gave a better understanding of the strategies used in the different buildings. Occupants in the case study buildings were surveyed using a questionnaire to capture the level of practice of the occupants in reducing energy in computer use.

9.2.2.2.1 Major findings

The findings in this chapter showed that green building occupants practices better energy saving in computer use because there are more energy management strategies in the green buildings than in the conventional buildings. Given that the findings were the same in New Zealand and Malaysia; this provided more evidence to elucidate the debate in the earlier studies as to whether or not green building occupants saves energy more than those occupants in conventional buildings (Kato et al., 2010; Lynam, 2007; Steinberg et al., 200910; Tajabadi, 2010). The findings in this chapter extended the prior studies by providing a better understanding on the occupants’ behaviour in energy conservation through the examination of the energy management strategies emplaced in the buildings.
Another significant finding was that there were more energy management measures in the green buildings in Malaysia than in the green buildings in New Zealand. Given that New Zealand is known for its green image and the high awareness of energy efficiency issues amongst the general population (Brown & Stone, 2007; Smith, 2008), the findings in this study showed that the New Zealand buildings require fewer energy management measures to encourage occupants to conserve energy.

The findings from this chapter recommended strategies that are suitable to be applied in both an office and a university building. Although there is a distinction in the socio-culture within a population and the building category, similar strategies were identified as successful in encouraging occupants to conserve energy. These strategies can be implemented in other non-residential building categories to encourage building occupants to reduce energy use.

Among the strategies were to have an active building manager committed to save energy use. Additional efforts to engage with the building occupants are required such as e-mailing occupants from time to time on energy use matter to encourage the occupants to help save energy. The findings had shown that a passive building manager led to less of the occupants in conserving energy use. Earlier studies (Bordass, Cohen, Standeven, & Leaman, 2001; Hinks, 2004) and current energy efficient building operation guidelines (CarbonTrust, 2011; EECA, 2012; EnergyStar, 2012; ISO, 2011) have already emphasised the importance of having an active building manager, while this study extended the literature by showing that there is a currently a difference between the theory and in practice. Although the energy efficient operation management guidelines are available, it has not been implemented fully in practice. In practice, how active the
building manager differed from building to building, and inconsequently influenced occupants’ behaviour. The existing gap between the theory and practice of the building managers indicates that there is a need to explore ways on how to bridge the gap.

Another energy management strategy that was successful in encouraging occupants to save energy is the participation of a third party energy scheme such as the green certification assessment (Green Building Index, and GreenStar NZ), ASEAN energy award, and the Energy Management Award by the Energy Efficiency and Conservation Authority (EECA). The findings supports the recommendation by the current existing guidelines (CarbonTrust, 2011; EECA, 2012; EnergyStar, 2012; ISO, 2011) as well as prior studies that creating a competition environment within the organisation to save energy can motivate occupants to save energy. Although occupants are more likely to reduce energy use due to the participation of an energy scheme, the practicality of engaging this strategy needs to be reviewed since there will be cost implications in adopting this strategy. Calculation of the amount of energy cost saved from the building occupants’ effort is a potential area for future research that dictates the feasibility of adopting this strategy.

Strategies that were not likely effective were the distribution of pamphlets on energy efficiency issues and sticker reminders. These strategies have been suggested in the literature in Chapter 4 to encourage occupants to save energy, while the findings in this chapter had shown that even with buildings without these strategies were doing well as those who did not have these strategies implemented in the building. This was seen in the building case studies in Malaysia and in New Zealand. Intensive information on energy efficiency awareness through seminars were found to have no impact on saving energy.
use on computers. However, it may have an impact on other conservation behaviours aside from behaviours in computer use.

The findings in this chapter extends the literature in cross-cultural studies by showing that although antecedents of predicting energy saving practice through values, beliefs, and norm differs (Milfont, Duckitt, & Cameron, 2006), the behaviour for saving energy in computer use showed no significant differences. However, the results may differ for other energy saving behaviours.

9.2.3 Stage 3 Occupants response to thermal discomfort

9.2.3.1 Objective 5: To examine what people do when they are too hot or too cold, and whether there are significant differences in the behaviour of occupants between green and conventional buildings.

This research objective is addressed in Chapter 7 of this thesis. Three types of coping mechanism were identified and tested: (i) environmental adjustment, (ii) personal adjustment and (iii) psychological adjustment. A survey was conducted of the occupants of both the green and conventional case study buildings to compare their coping mechanisms in response to thermal discomfort.

9.2.3.1.1 Major findings

The findings discussed in Chapter 7 showed that occupants in the green buildings engaged in fewer environmental adjustments, although they had greater access to the building control systems than the conventional building occupants. This result demonstrates that there is no evidence to support the argument proposed by Sorrel et al. (2001) that building occupants use more energy in energy efficient buildings, nor does it
support Heerwagen and Diamond’s (1992) suggestion of the possibility of creating a “desk couch potato” social phenomena where occupants become passive and engage in fewer personal adjustments.

The New Zealand green building occupants were, more likely to make personal adjustments such as walking around in the building to stay warm. Findings from the Malaysia building case studies showed that there was no difference between occupants in the green and conventional building in engaging personal adjustment when feeling cold and hot. The comparison analysis between building types (green and conventional buildings) in both countries (New Zealand and Malaysia) showed similar findings, in which occupants in the green buildings reduces energy use when experiencing thermal discomfort than those occupants in the conventional buildings. The findings extended the results from Chapter 6 by showing that not only are the green building occupant’s saving energy in computer use, but also in the heating and cooling energy use of the buildings. More evidence provided in this thesis made clear of the debate found in the literature (Kato et al., 2010; Lynam, 2007; Steinberg et al., 2009; Tajabadi, 2010). with regards to whether or not occupants in green building saves more energy use than occupants in the conventional buildings. The findings extended the literature by showing that despite the climate and cultural differences, the green building occupants are still practicing more energy saving behaviour than the conventional building occupants.

The findings in this chapter are also an indication that the energy management strategies implemented in the green buildings are successful in encouraging occupants to save energy. Therefore, it is recommended that the strategies to be taken as a universal strategy for non-residential buildings. Apart from the energy management strategies in the
building, this chapter identified the possible design features of the buildings that can encourage occupants to engage in healthy adjustments in response to thermal discomfort. The highly glazed building with access to view the natural environment, and the spacious common room area provided the opportunity for the occupants to walk around in the building to warm their bodies when they are feeling cold. Therefore, these design features can be adopted in the design for future buildings to encourage occupants to make healthier adjustments when in crisis of discomfort.

The climate differences between New Zealand and Malaysia showed that there are different challenges in designing a building to encourage occupants to make healthy adjustments when they are feeling too cold or too hot. The colder climate such as in New Zealand required the building occupants to make more personal adjustment to maintain their comfort than the building occupants in Malaysia with a warmer climate. The building occupants in New Zealand claimed that they put on warmer clothes in addition to walking around in the building when they felt cold. While the building occupants in Malaysia walked around in the building without the need to put on warmer clothes. The various personal adjustments adopted by the building occupants in New Zealand to reduce thermal discomfort can lead to occupants to be frustrated. Therefore, the challenge in designing the buildings in New Zealand is to encourage occupants engage in healthy adjustments without causing the occupants to feel annoyed. The findings indicate that the warmer climate such as in Malaysia have a higher opportunity to adopt the adaptive thermal comfort model in designing buildings since the building occupants engaged in fewer personal adjustments than the occupants in the building case studies in New Zealand.
The findings also showed that occupants in green buildings cope with discomfort better than occupants in conventional buildings. This was particularly seen in the Malaysian case study buildings where occupants in the green buildings agreed that working in a green building meant that they have to sacrifice their level of comfort. However, the results from the New Zealand case studies did not reflect the same belief. The green building occupants disagreed with the perception that working in a green building meant that they needed accept that their level of comfort would be reduced. Nevertheless, they were still less likely to engage in environmental adjustments even though they had the ability to make them.

The results from the case study buildings on occupants’ level of interaction with the environmental control system in the building provides useful information for modelling and better predicting energy usage in buildings. The findings also showed that the design features in buildings (i.e. access to view natural environment and spacious common room areas) encourages occupants to engage in personal adjustments such as walking around in the building when feeling cold.

9.2.4 Stage 4 Motivational factors to encourage energy saving behaviour

9.2.4.1 Objective 6: To examine whether the building occupants’ motivation to save energy differs across the different building types.

This research objective was addressed by identifying the motivating factors that encourage energy saving behaviour. A survey on the importance of various motivating factors that may encourage the building occupants to save energy was conducted across the case study buildings.
9.2.4.1.1 Major findings

As discussed in Chapter 8, the findings of this thesis showed that occupants from both the green and conventional buildings were motivated to save energy by knowing that energy scarcity is a global issue, and by knowing that they can help to reduce energy costs. The findings have extended the literature by showing that despite the cultural differences in the building occupants population between New Zealand and Malaysia, occupants motivation to save energy does not necessarily differ such as predicted by (Milfont et al., 2006).

The building occupants were least motivated to save energy by wanting to show an example to others. The findings in Chapter 8 did not provide evidence to show that green building occupants are more motivated to save energy than occupants in the conventional buildings. The results demonstrate that the current energy management measures implemented in the green and conventional buildings do not impact the building occupants differently in terms of what motivates them to save energy. Other findings from the study included evidence from the Malaysian case study buildings that occupants are motivated to save energy when they understand the green features of the building. However, this was not the case in New Zealand.

9.2.5 Main aim of thesis: To improve energy management strategies in buildings

The main aim of this study was achieved by addressing all six research objectives described in this thesis. Energy management strategies in buildings can be improved by adopting the energy measures which have shown to be successful in encouraging occupants to save energy. The comparison study between the green and conventional
buildings showed that the energy management measures implemented in the green buildings are more successful in encouraging occupants to save energy than those implemented in the conventional buildings. There were more energy management measures implemented in the green buildings than in the conventional buildings. Strategies used in the green buildings included having a building manager assigned to energy use matters and a building maintenance office equipped with the appropriate tools to manage energy use, such as the application of an effective energy management system. Occupants in buildings that lacked this strategy practiced fewer energy reduction actions than occupants in buildings which had these strategies implemented.

The findings in this thesis demonstrated that the energy management framework described here can be used as a guideline for facility managers in formulating strategies to reduce energy usage in buildings. The findings in this thesis have indicated that within a context where occupants have a greater levels of awareness of energy efficiency issues, fewer energy management measures are required to encourage the occupants to reduce energy usage in buildings. Despite the differences in the level of awareness in the sample population of the building occupants between New Zealand and Malaysia, common strategies that were shown as successful in encouraging energy saving practice among the building occupants were able to be retrieved.
9.3 **Contribution to the body of knowledge**

The findings in this thesis contribute to the existing body of knowledge in understanding the relationship between occupants’ behaviour and buildings. The debate raised in the previous studies on whether green or conventional building occupants are different in their levels of practice in reducing energy usage has been addressed in this thesis. The findings described here provide a better understanding of how green buildings encourage occupants to reduce energy usage and how the management of buildings encourages occupants to adopt energy saving behaviours.

The study also provided useful information about the building occupants’ level of interaction with the building control system. This information is useful for modelling energy use in buildings since the data represents actual occupants’ behaviour. As a result, better prediction of energy use in buildings can be achieved by considering the variability of the occupants’ level of interaction with the building control system.

The practical contribution of this research is in the strategies that have been identified. These can be applied in other buildings to increase the rate of practice of energy saving behaviours amongst the occupants to reduce energy usage in buildings. Another significant finding from this study was that green buildings are not only designed to reduce energy consumption, but also encourage the occupants to practice green behaviour by engaging in personal adjustments. The design attributes of the green buildings, such as accessibility to view the natural environment outside the building, natural design features, and provision of common spaces facilitate this behaviour.

*9.3.1 Implications/recommendation to the industry from the findings of this research.*
The industries that are operating their own commercial buildings can benefit the outcome of this study to further reduce energy use. The current existing energy management guidelines for building operation that were identified as not holistic and too general can be improved by incorporating the specific strategies illustrated in this thesis. The findings in this thesis also showed that not all the strategies recommended in the available energy management guidelines that were implemented in practice were effective. Ineffective strategies such as sticker label reminders to turn off computer desktop may be removed from the energy management guidelines. Hence, the findings are useful to aid the building managers understanding on how to effectively engage cooperation from the building occupants to help save energy use together. Another implication of the research findings is that the designers can gain feedback on their design features that were successful in encourage building occupants to reduce energy use.

9.4 Research limitations

This study has provided a conceptual energy management framework which is intended to facilitate the energy efficient performance of a building. The level of practice of these energy management measures was tested using case studies of green and conventional buildings in Malaysia and New Zealand. During the course of the study, there was no appropriate energy benchmark identified to determine the energy efficiency performance of a building that is unique in its function, such as occurred with the case study buildings in New Zealand (which area combination of offices and research laboratories). The researcher encountered the limitation when attempting to compare the current energy use with the historical data on energy use of the buildings, and trying to calculate the percentage difference. Given that the New Zealand case study buildings had no energy
efficiency benchmark compared to the Malaysian case study buildings, the parameters for the comparison could not be identical. The limitation of using historical energy data is that the researcher could not compare the energy performance of the New Zealand buildings with the other buildings. This also limited the researcher’s ability to test the effectiveness of the energy management measures that have been implemented in the case study buildings in New Zealand. In addition, the climate differences between New Zealand and Malaysia limited the researcher to do a comprehensive comparison analysis on the energy performance between the two countries.

The sample population between the building case studies in New Zealand and in Malaysia are different in terms gender. The disproportionate percentage of males and females may have an impact on the results since earlier studies showed that generally females tend to feel more colder than males (Rupp, Vásquez, & Lamberts, 2015) and that females are likely more concerned about the environment than males (Gifford & Nilsson, 2014). Hence, the findings may have better represented for the female occupants.

Another research limitation in this thesis is the researcher was unable to analyse the remaining data received from the occupants’ survey due to insufficient time. The questionnaire can be referred in Appendix D for the English version. Data that were not analysed were such as occupants’ responses on their preference of strategies to encourage reduce energy use, occupants’ behaviour in electrical appliances use, and occupants’ responses in lighting discomfort. Analysis of these data can further supplement the findings from this thesis.
9.5 Recommendations for future research

This thesis study examined the energy management measures used in green and conventional buildings in two different countries. The effectiveness of these measures was evaluated based on the occupants’ level of practicing energy reducing behaviours in the buildings and the resultant reduction of energy use in the building. The findings presented in this thesis may lead to future research studies that can be explored to expand on the results of this thesis.

A future research study could evaluate the effectiveness of the energy management framework using more case study buildings that have a standard building energy efficiency index. The use of the two methods (i.e., an energy management framework and a building energy index) to evaluate the energy efficiency performance of a building can aid facility managers to better formulate and monitor strategies to reduce energy usage in buildings.

Another area for future research is to test the recommended strategies to encourage energy saving behaviour. It is recommended that strategies are tested using case study buildings over a certain period of time to measure whether there is a reduction in energy use in the building, as well as surveying the occupants on the effectiveness of the strategies in encouraging their behaviour to reduce energy use in buildings. Another research avenue that could be explored is to undertake a cost-benefit analysis of the recommended energy management measures to encourage energy saving behaviour practices.

It needs to be investigated whether the green building rating assessment tool can be improved by incorporating the proposed energy management framework. This could provide a more comprehensive assessment tool to measure energy efficiency performance of buildings which could become a practical and useful tool for the industry.
Another research project could focus on developing and testing a comprehensive tool to measure the energy efficiency behaviour of building occupants. The tool may provide useful information as it would generate an indication of how green the building occupants currently are. This could aid facilities management in designing a range of intervention strategies to encourage energy saving practices according to the building occupants’ level of energy efficiency practice.

Socio-cultural variables such as the individual values, beliefs and norm can influence the building occupants practice in saving energy use (Cordano, Welcomer, Scherer, Pradenas, & Parada, 2010; Kaiser & Biel, 2000). The findings in this thesis showed that despite the differences in the socio-cultural values of the building occupants between New Zealand and Malaysia, several common strategies from the building case studies in the two countries were identified to be successful in encouraging occupants to reduce energy use. Other various strategies to encourage energy saving practices amongst the building occupants can be identified from a thorough examination of the socio-cultural variables. Future research can assess these variables by using the Value Belief Norm (VBN) theory model of environmentalism developed by Stern, Dietz, & Abel (1999) which offer a more holistic analysis of the differences in the variables. A better understanding on the occupants’ socio-cultural variables can assist in developing an effective intervention strategy.

The findings in this thesis suggests that the building occupants in Malaysia felt encouraged to save energy when they know more about the green features in a building, while the building occupants in New Zealand found that it does not motivate them to save energy use. Future research can examine the influences of knowledge about the green features in a building by using advanced statistical method to determine the strength of the relationship with energy saving practice. This study can be extended by incorporating
more international building case studies to understand the different expectations amongst the occupants when working in a green building.
APPENDIX

Appendix A: Ethics Approval Letter
Appendix B: Sample of Participation Information Sheet
Appendix C: Consent Form
Appendix D: Questionnaire for building occupants (English Version)
Appendix E: Questionnaire for building occupants (Malay Version)
Appendix F: Questions for discussion with Building managers
Appendix G: Questions for discussion on building design
Appendix H: Poster
Appendix I: Website Logo design
Appendix J: Questions for discussion on Risks Associated in Implementation of Green Buildings
Appendix A: Ethics Approval Letter
UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE

11-Apr-2012

MEMORANDUM TO:

Dr Elizabeth Fassman
Civil & Environmental Engineer

Re: Application for Ethics Approval (Our Ref. 7830)

The Committee considered your application for ethics approval for your project titled Influences of human behaviour on energy efficiency in green buildings on 11-Apr-2012.

Ethics approval was given for a period of three years.

The expiry date for this approval is 11-Apr-2015.

If the project changes significantly you are required to resubmit a new application to the Committee for further consideration.

In order that an up-to-date record can be maintained, you are requested to notify the Committee once your project is completed.

The Chair and the members of the Committee would be happy to discuss general matters relating to ethics approvals if you wish to do so. Contact should be made through the UAHPEC secretary at humanethics@auckland.ac.nz in the first instance.

All communication with the UAHPEC regarding this application should include this reference number: 7830.

(This is a computer generated letter. No signature required.)

Secretary
University of Auckland Human Participants Ethics Committee

c.c. Head of Department / School, Civil & Environmental Engineer
   Assoc Prof Suzanne Wilkinson
   Prof Pierre Quenneville

Additional information:
1. Should you need to make any changes to the project, write to the Committee giving full details including revised documentation.
2. Should you require an extension, write to the Committee before the expiry date giving full details along with revised documentation. An extension can be granted for up to three years, after which time you must make a new application.

3. At the end of three years, or if the project is completed before the expiry, you are requested to advise the Committee of its completion.

4. Do not forget to fill in the ‘approval wording’ on the Participant Information Sheets and Consent Forms, giving the dates of approval and the reference number, before you send them out to your participants.

5. Send a copy of this approval letter to the Manager - Funding Processes, Research Office if you have obtained funding other than from UniServices. For UniServices contract, send a copy of the approval letter to: Contract Manager, UniServices.

6. Please note that the Committee may from time to time conduct audits of approved projects to ensure that the research has been carried out according to the approval that was given.
Appendix B: Sample of Participation Information Sheet
You are invited to participate in a PhD study funded by the University of Auckland. The specific aim of the doctoral investigation is to develop a guideline on how human behaviour can play its role to achieve energy efficient performance in office buildings.

Research Background
The rising demand to reduce energy consumption has majorly focused on technology, such as implementation of green buildings, and adoptions of energy efficient appliances. While this is a good strategy to reduce energy consumption, less focus has been given in adopting energy saving behaviour. An improvement in this area will contribute to better overall energy efficiency. This study uses a comparison case study between green buildings and conventional buildings to contribute to a better understanding. The following questions are raised: What energy saving behaviours are occupants doing and not doing? To what extent does human behaviour influences building energy efficiency? What strategy encourages energy saving behaviour? What are the different expectations between building users and building managers regarding occupants’ use of a building (in terms of behaviour contributing to energy efficiency)?

Participation
A major part of this investigation is to gather information about how people use energy in their place of work. For this purpose, your participation is a vital contribution to the successful outcome of this research. The questionnaire will take approximately 10 minutes to answer and will be sent via email, fax, or printed hardcopy depending on your preferences. Your participation is entirely voluntarily. Interested participants shall make direct contact with the researcher. It is confirmed by the authorized manager that your participation or non-participation will not affect your employment status. Upon consent from the participants, the questionnaire survey will be sent via email, fax, or printed hardcopy depending on your preferences.

Ethics, data storage, and anonymity
This questionnaire has been given permission from the University of Auckland Human Participants Ethics Committee (UAHPEC). You have the right to withdraw from participation at any time you wish. Withdrawal of data provided can be done up to one month after undertaking the survey.
All raw data (soft copy and hard copy) will be kept confidential stored in a secured authorized access only by the researcher and supervisors via hard disk drives, data store websites, and locked cabinet. These data will be stored with the researcher for 6 years, after which will be destroyed permanently by deleting the saved files from all storage, and hard copies will be shredded and sent for recycling. All data will be used only for the purpose of this doctoral research and subsequent publications in academic journals. For both purposes, all data from participants will be analysed and presented in a way that does not identify the source either by name and inference. In addition to this, the organisation/name will be kept confidential. A draft of summary findings will be made available upon request.

**Contact details**

Should you have any queries regarding the same detailed below are the persons to be contacted:

**Researcher:** Nurul Sakina Mokhtar Azizi  
Mobile: 64 226809427 (New Zealand) +60176807941 (Malaysia)  
Email: s.mokhtar@auckland.ac.nz

**Supervisors:** Dr. Elizabeth Fassman  
Assoc. Prof. Suzanne Wilksinson  
Phone: 64 09 3737599 ext 84540 +64 9 3737599 ext. 88184  
Email: e.fassman@auckland.ac.nz  
  s.wilkinson@auckland.ac.nz

**Head of the Department:** Prof. Pierre Quenneville  
Phone: 64 09 3737599 ext 87920  
Email: p.quenneville@auckland.ac.nz

For any queries regarding ethical concerns you may contact:  
The Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Office of the Vice Chancellor, Private Bag 92019, Auckland 1142. Telephone: 09 373 7599 ext. 83711.

"APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 11-APRIL 2012 for 3 Year(s) from 11-APRIL-2012 to 11-Apr-2015 , Reference Number 7830"
Participant Information Sheet (PIS) (Manager)

Title of project: Influences of Human Behaviour on Energy Efficiency in Green Buildings
Name of researcher: NURUL SAKINA MOKHTAR AZIZI
Degree: PhD in Civil Engineering
Department: Civil and Environmental Engineering
Research Supervisors: Dr. Elizabeth Fassman and Assoc. Prof Suzanne Wilkinson

Your organisation is invited to participate in a PhD study funded by the University of Auckland. The specific aim of the doctoral investigation is to develop a guideline on how human behaviour can play its role to achieve energy efficient performance in green buildings.

Research Background

The rising demand to reduce energy consumption has majorly focused on technology, such as implementation of green buildings, and adoption of energy efficient appliances. While this is a good strategy to reduce energy consumption, less focus has been given in adopting energy saving behaviour. An improvement in this area will contribute to better overall energy efficiency. This study uses a comparison case study between green buildings and conventional buildings to contribute to a better understanding. The following questions are raised: What energy saving behaviours are occupants doing and not doing? To what extent does human behaviour influence building energy efficiency? What strategy encourages energy saving behaviour? What are the different expectations between building users and building managers regarding occupants’ use of a building (in terms of behaviour contributing to energy efficiency)?

Participation

The purpose of this Participant Information Sheet (PIS) is to seek your consent to invite your staff to participate in this research. Also, it is to seek confirmation that participation or non-participation will not in any way affect employment status of your staff. In addition, it is also to inform you on the ethics, data storage and anonymity upon your participation.

A major part of this investigation is to gather information about how people use energy in their place of work. For this purpose, your participation including your staff will be a vital contribution to the successful outcome of this research.

A questionnaire survey will be used to gain relevant data. This will take approximately 20 minutes of you and your staff’s time to answer.

We seek your cooperation to help circulate the Participation Information Sheet (PIS) and Consent Form (CF) to your staff. Participation is entirely voluntarily. Participants will have their right whether to participate or not. Interested participants shall make direct contact with the researcher. Upon
consent from the participants, the questionnaire survey will be sent via email, fax, or printed hardcopy depending on participants preferences.

**Ethics, data storage, and anonymity**

This questionnaire has been given permission from the University of Auckland Human Participants Ethics Committee (UAHPEC). Participants have the right to withdraw from participation at any time they wish. Withdrawal of data provided can be done up to one month after undertaking the survey.

All raw data (soft copy and hard copy) will be kept confidential stored in a secured authorized access only by the researcher and supervisors via hard disk drives, data store websites, and locked cabinet. These data will be stored with the researcher for 6 years, after which will be destroyed permanently by deleting the saved files from all storage, and hard copies will be shredded and sent for recycling.

All data will be used only for the purpose of this doctoral research and subsequent publications in academic journals. For both purposes, all data from participants will be analysed and presented in a way that does not identify the source either by name and inference. In addition to this, the organisation/name will be kept confidential. A draft of summary findings will be made available upon request.

**Contact details**

Should you have any queries regarding the same detailed below are the persons to be contacted:

**Researcher:** Nurul Sakina Mokhtar Azizi  
**Mobile:** +64 21 0260 1805 (New Zealand) +60176807941 (Malaysia)  
**Email:** s.mokhtar@auckland.ac.nz

**Supervisors:** Dr. Elizabeth Fassman  
**Phone:** +64 09 3737599 ext 84540  
**Email:** e.fassman@auckland.ac.nz  
**Assoc. Prof. Suzanne Wilksinson**  
**Phone:** +64 9 3737599 ext. 88184  
**Email:** s.wilkinson@auckland.ac.nz

**Head of the Department:** Prof. Pierre Quenneville  
**Phone:** +64 09 3737599 ext 87920  
**Email:** p.quenneville@auckland.ac.nz

For any queries regarding ethical concerns you may contact:  
The Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Office of the Vice Chancellor, Private Bag 92019, Auckland 1142. Telephone: 09 373 7599 ext. 83711.

“APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 11-April-2012 for 3 Year(s) from 11-April-2012 to 11-Apr-2015, Reference Number 7830”
CONSENT FORM (CF) (Participant)

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS

Title of project: Influences of Human Behaviour on Energy Efficiency in Green Buildings

Name of researcher: NURUL SAKINA MOKHTAR AZIZI

I have read the Participant Information Sheet (PIS), and have understood the nature of the research and why I have been selected. I have also had the opportunity to ask questions and have them answered to my satisfaction.

- I understand that permission to participate in this research has been obtained by the authorized manager
- I understand that my participation or non-participation will not affect my employment status
- I understand that I have rights to withdraw from participation at any time I wish
- I understand that withdrawal of data provided can be done up to one month after undertaking the survey
- I understand all data will be kept confidential stored in a secured authorized access only by the researcher and supervisors via hard disk drives, data store websites, and locked cabinet
- I understand that data will be kept for 6 years, after which they will be destroyed
- I understand that analysis and findings from the obtained data will be used only for the purpose of his doctoral research and subsequent publications in academic journals
- I wish questionnaire to be sent via email / fax / printed hardcopy
- I wish / do not wish to receive the summary of findings.

Name: ........................................................................................................

Signature: ........................................... Date:.................................

Company/Organisational name: ......................................................
Correspondence address: ...........................................................................

Telephone: .......................................Mobile Telephone:..................
Fax:...................................................... Email:............................................

"APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 11-April 2012 for 3 Year(s) from 11-April-2012 to 11-Apr-2015 , Reference Number 7830"
CONSENT FORM (CF) (Manager)

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS

Title of project: Influences of Human Behaviour on Energy Efficiency in Green Buildings

Name of researcher: NURUL SAKINA MOKHTAR AZIZI

I have read the Participant Information Sheet (PIS), and have understood the nature of the research and why I have been selected. I have also had the opportunity to ask questions and have them answered to my satisfaction.

I confirm that I hold the appropriate authority to provide consent for the following statements:

- I authorize the permission for staff in my organization to take part in the research
- I confirm that participation and non-participation will not in any way affect employment status of the staff
- I understand that participants have rights to withdraw participation at any time they wish
- I understand that withdrawal of data provided can be done up to one month after undertaking the survey
- I understand all data will be kept confidential stored in a secured authorized access only by the researcher and supervisors via hard disk drives, data store websites, and locked cabinet
- I understand that data will be kept for 6 years, after which they will be destroyed
- I understand that analysis and findings from the obtained data will be used only for the purpose of this doctoral research and subsequent publications in academic journals
• I wish questionnaire to be sent via email / fax / printed hardcopy

• I wish / do not wish to receive the summary of findings.

• I agree to help circulate the Participation Information Sheet (PIS) and Consent Form (CF) to staff in my organization

• I understand that interested participants will contact the researcher directly

Name: ...........................................................................................................

Signature: ........................................... Date:..............................................

Company/Organisational name: .................................................................
Correspondence address: ...........................................................................
Telephone: .....................................Mobile Telephone:............................
Fax:............................................................... Email:....................................

“APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 11-April-2012 for 3 Year(s) from 11-April-2012 to 11-Apr-2015, Reference Number 7830/”
Appendix D: Questionnaire for building occupants (English Version)
Title of project: Influences of Human Behaviour on Energy Efficiency in Green Buildings
Name of researcher: Nurul Sakina Mokhtar Azizi
Degree: PhD in Civil Engineering
Department: Civil and Environmental Engineering
Research Supervisors: Dr. Elizabeth Fassman and Assoc. Prof Suzanne Wilkinson

Participation
A major part of this investigation is to gather information about how people use energy in their place of work. For this purpose, your participation is a vital contribution to the successful outcome of this research. The questionnaire will take approximately 10 minutes to answer and will be sent via email, fax, or printed hardcopy depending on your preferences. Your participation is entirely voluntary. Interested participants shall make direct contact with the researcher. It is confirmed by the authorized manager that your participation or non-participation will not affect your employment status. Upon consent from the participants, the questionnaire survey will be sent via email, fax, or printed hardcopy depending on your preferences.

Ethics, data storage, and anonymity
This questionnaire has been given permission from the University of Auckland Human Participants Ethics Committee (UAHPEC). You have the right to withdraw from participation at any time you wish. Withdrawal of data provided can be done up to one month after undertaking the survey. All raw data (soft copy and hard copy) will be kept confidential stored in a secured authorized access only by the researcher and supervisors via hard disk drives, data store websites, and locked cabinet. These data will be stored with the researcher for 6 years, after which will be destroyed permanently by deleting the saved files from all storage, and hard copies will be shredded and sent for recycling. All data will be used only for the purpose of this doctoral research and subsequent publications in academic journals. For both purposes, all data from participants will be analysed and presented in a way that does not identify the source either by name and inference. In addition to this, the organisation/name will be kept confidential. A draft of summary findings will be made available upon request.

Contact details
Should you have any queries regarding the same detailed below are the persons to be contacted:
Researcher: Nurul Sakina Mokhtar Azizi
Mobile: +64 226809427 (New Zealand) +60176807941 (Malaysia)
Email: s.mokhtar@auckland.ac.nz

Supervisors: Dr. Elizabeth Fassman Assoc. Prof. Suzanne Wilkinson
Phone: 64 09 3737599 ext 84540 +64 9 3737599 ext. 88184
Email: e.fassman@auckland.ac.nz s.wilkinson@auckland.ac.nz

Head of the Department: Prof. Pierre Quenneville
Phone: 64 09 3737599 ext 87920
Email: p.quenneville@auckland
I have read the Participant Information Sheet (PIS), and have understood the nature of the research and why I have been selected. I have also had the opportunity to ask questions and have them answered to my satisfaction.

- I understand that permission to participate in this research has been obtained by the authorized manager

- I understand that my participation or non-participation will not affect my employment status

- I understand that I have rights to withdraw from participation at any time I wish

- I understand that withdrawal of data provided can be done up to one month after undertaking the survey

- I understand all data will be kept confidential stored in a secured authorized access only by the researcher and supervisors via hard disk drives, data store websites, and locked cabinet

- I understand that data will be kept for 6 years, after which they will be destroyed

- I understand that analysis and findings from the obtained data will be used only for the purpose of his doctoral research and subsequent publications in academic journals

**1. With the statements above...**

- I Agree
- I Disagree

**2. Do you wish to receive the summary findings?**

- Yes
- No
Section A: Background Information

3. Your e-mail

4. Please state your occupation

5. What is your age?
   - <20
   - 20-30
   - 31-40
   - 41-50
   - >50

6. What is your sex?
   - Female
   - Male

7. Which one best describes your working space?
   - private office room
   - room shared by 5 staff or less
   - open plan office with work stations separated via partitions/room shared by more than 5 staff
   - common public space (i.e. office lobby, reception, etc)
   - Others

Other (please specify)
8. Please state your office room location in this building

9. Approximately how many hours daily do you spend in this building?
**11. Do you do any of the following actions?**

<table>
<thead>
<tr>
<th>Action</th>
<th>I never do this</th>
<th>I rarely do this</th>
<th>I sometimes do this</th>
<th>I often do this</th>
<th>I always do this</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use dishwasher only when there is full load</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Boil less water instead of filling up the whole kettle</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Read documents on computer screen rather than printing</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Use double sided printing</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Reduce multiple computer monitors to one (if you are using multiple computer screen)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Work on a laptop instead of a computer</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Turn down computer screen brightness</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Put screen to sleep instead of using screen saver</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Print in booklet format or double sided rather than one sided</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Shut down my computer</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Shut down colleagues computer if seen left turned on</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Turn off my computer monitor</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Turn off colleagues computer monitor if seen left turned on</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Use task lighting whenever appropriate, and switch off main lights</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Switch off lights in unused space</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Use natural daylight whenever appropriate, and switch off lights</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Close windows and exterior doors when heating/cooling systems are used</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Close curtain/window blind at night to prevent heat loss</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

What other actions do you do to help save energy?
Please tick which appliances you use in your office AND actions you take after usage?

<table>
<thead>
<tr>
<th></th>
<th>Availability?</th>
<th>ACTIONS AFTER USAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NO I don’t</td>
<td>YES I have</td>
</tr>
<tr>
<td></td>
<td>have</td>
<td>I leave it on</td>
</tr>
<tr>
<td></td>
<td></td>
<td>standby mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(turn off appliance)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I leave it ON</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I turn off MAIN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>switch</td>
</tr>
<tr>
<td><strong>Personal Appliances you own</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell phone charger</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Personal fan</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Two computer monitor</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Personal printer</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Personal heater</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Radio</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Personal laptop</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td><strong>Office Appliances</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office printer</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Office fax machine</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Office copier</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Office dishwasher</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Office coffeemaker</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Office kettle</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Office microwave</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Office toaster</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Others__________________</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>
### 12. When do you do the following? (Ignore this question, if you don't)

<table>
<thead>
<tr>
<th>Action</th>
<th>At the end of the day</th>
<th>If away for an hour or more</th>
<th>If away for 10 minutes or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shut down computer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn off computer monitor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch off lights in unused space</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 13. How often have you witnessed the following scenarios in your office?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff leaving air conditioning system ON in empty rooms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioning system operated at an overcooling temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioning system in the setting where door and window remained open</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff leaving computers on when there is no one using it</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lights left on in unused spaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plug point left ON when appliances are not used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### SECTION C: MAINTAINING COMFORT AT OFFICE

14. Do you have access to do the following actions in your working space?

<table>
<thead>
<tr>
<th>Action</th>
<th>I have access to do this</th>
<th>I don't have access to do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust temperature on the cooling system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open/close the window</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open/close the door</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjust curtain blind</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch on/off lights</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15. When you are feeling cold in your working space, what do you do to maintain your comfort? Please tick which applies to you best

<table>
<thead>
<tr>
<th>Action</th>
<th>I never do this</th>
<th>I rarely do this</th>
<th>I sometimes do this</th>
<th>I often do this</th>
<th>I always do this</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>I adjust the temperature on the heating system in my working space</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I use my personal heater</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I complain to the building manager</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I close the window blinds/doors to prevent heat loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I consume hot drinks/food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I walk around to heat up my body</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I put on warmer clothes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I move to a different location where it is warmer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I alter timing of my work pattern to avoid uncomfortable working conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don't do anything</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other (please specify)
16. When you are feeling warm in your working space, what do you do to maintain your comfort? Please tick which applies to you best

<table>
<thead>
<tr>
<th>Action</th>
<th>I never do this</th>
<th>I rarely do this</th>
<th>I sometimes do this</th>
<th>I often do this</th>
<th>I always do this</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust the temperature on the cooling system in my working space</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Use my personal fan</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Complain to the building manager</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Open windows and exterior doors for natural ventilation</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Consume cold drinks/food instead</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Go outside for walks where it is cooler</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Wear lesser clothes</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Move to a different location where it is cooler</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Alter timing of my work pattern to avoid uncomfortable working conditions</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Don't do anything</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
17. When you experience sun glare in your working space, what do you do to maintain comfort? Please tick which applies to you best

<table>
<thead>
<tr>
<th>Action</th>
<th>I never do this</th>
<th>I rarely do this</th>
<th>I sometimes do this</th>
<th>I often do this</th>
<th>I always do this</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch on the lights</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complain to the building manager</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjust posture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Move to a different location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjust the curtain blinds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don’t do anything</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. Which condition are you willing to sacrifice your comfort at work to help reduce energy? You may tick more than one

- [ ] Feeling too hot in your working space
- [ ] Feeling too cold in your working space
- [ ] Feeling too bright with the sunlight in your working space
- [ ] None
19. Please estimate how you think your productivity at work is decreased or increased by the environmental conditions in the building? (Please try to evaluate this building with respect to your experience of using this building in general)

Productivity
DECREASED by -40%
-30%
-20%
-10%
0
+10%
+20%
+30%
Productivity
INCREASED by +40%

| Feeling HOT in your working space | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 |
| Feeling COLD in your working space | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 |
| Experiencing sun glare in your working space | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 | 😐 |

What is your perception of a "green" lifestyle to reduce energy consumption?

A: Low comfort, low temperature setting, average technologies
B: High comfort, high temperature setting, better technologies
C: Moderate comfort, moderate temperature setting, better technologies
### SECTION D: AWARENESS ON ENERGY USE IN BUILDING

21. How would you rate yourself in terms of practicing energy saving behavior at work?

<table>
<thead>
<tr>
<th>self perception on energy saving behaviour measurement scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very poor</td>
</tr>
</tbody>
</table>

22. Would you consider this building to be a "green" building?

- Yes
- No
- I don't know

Please explain

23. How well do you think this building is performing in terms of energy efficiency?

<table>
<thead>
<tr>
<th>energy efficiency performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very poor</td>
</tr>
</tbody>
</table>

24. Please indicate your opinion on the following statements

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Don't Know</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching lights on and off does not save energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL appliances are on stand-by mode when plug point is 'on' but appliance is 'off'.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computers consume more energy on start up and it is better to leave it on.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Putting screen to sleep instead of using screen saver would not save much energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working in a green building means I have to sacrifice my comfort level and change my life style to save energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don't need to reduce my energy consumption since this building is already designed to be energy efficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I tend to forget to switch off appliances after use and lights in unused spaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

25. Please rank the importance of the following statements in motivating you to reduce energy usage? You may add your opinion in the space below

<table>
<thead>
<tr>
<th>Statement</th>
<th>not important</th>
<th>slightly important</th>
<th>neutral</th>
<th>important</th>
<th>very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowing that energy scarcity is a global issue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowing that I can help to save energy costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I want to set an example to others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working in a green building that is certified by the Green Building Council (GBC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowing that this building has green features without formal recognition from Green Building Council (GBC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
26. The following are strategies to encourage energy saving behaviours. Please tick which applies to you the best. You may add your own opinion in the space below.

<table>
<thead>
<tr>
<th>Not at all interested</th>
<th>Not interested</th>
<th>Neutral</th>
<th>Somewhat interested</th>
<th>Very Interested</th>
<th>Already Implemented in my building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reminders through energy saving messages in internal communications: presentations, newsletters, in memos, emails, staff meetings, and energy saving posters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Updates on how much energy saved in brochures, websites, reports and other external communications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Updates on buildings energy usage compared to other buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have display systems on energy usage on electrical appliances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opportunity in the organisation for you to suggest and contribute ideas regularly and feedback.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Give rewards to the best energy saving ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have a hosted morning tea session when you hit an energy-saving target as a way to thank you for effort and input</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit other buildings to learn on energy saving opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit educational websites on energy efficiency to learn more on energy saving tips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A competition and team building events such as quizzes or poster design between departments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have external speakers invited to talk about energy or the environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you have any other suggestions on strategies to reduce energy usage, please write in the space below.
27. Would you be interested to participate further in this research?

- Yes
- No
Appendix E: Questionnaire for building occupants (Malay Version)
Title of project: Influences of Human Behaviour on Energy Efficiency in Green Buildings

Name of researcher: Nurul Sakina Mokhtar Azizi

Degree: PhD in Civil Engineering

Department: Civil and Environmental Engineering

Research Supervisors: Dr. Elizabeth Fassman and Assoc. Prof Suzanne Wilkinson

Participation

A major part of this investigation is to gather information about how people use energy in their place of work. For this purpose, your participation is a vital contribution to the successful outcome of this research. The questionnaire will take approximately 10 minutes to answer and will be sent via email, fax, or printed hardcopy depending on your preferences. Your participation is entirely voluntary. Interested participants shall make direct contact with the researcher. It is confirmed by the authorized manager that your participation or non-participation will not affect your employment status. Upon consent from the participants, the questionnaire survey will be sent via email, fax, or printed hardcopy depending on your preferences.

Ethics, data storage, and anonymity

This questionnaire has been given permission from the University of Auckland Human Participants Ethics Committee (UAHPEC). You have the right to withdraw from participation at any time you wish. Withdrawal of data provided can be done up to one month after undertaking the survey. All raw data (soft copy and hard copy) will be kept confidential stored in a secured authorized access only by the researcher and supervisors via hard disk drives, data store websites, and locked cabinet. These data will be stored with the researcher for 6 years, after which will be destroyed permanently by deleting the saved files from all storage, and hard copies will be shredded and sent for recycling. All data will be used only for the purpose of this doctoral research and subsequent publications in academic journals. For both purposes, all data from participants will be analysed and presented in a way that does not identify the source either by name and inference. In addition to this, the organisation/name will be kept confidential. A draft of summary findings will be made available upon request.

Contact details

Should you have any queries regarding the same detailed below are the persons to be contacted:

Researcher: Nurul Sakina Mokhtar Azizi
Mobile: +64 226809427 (New Zealand) +60176807941 (Malaysia)
Email: s.mokhtar@auckland.ac.nz

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Head of the Department: Prof. Pierre Quenneville
Phone: 64 09 3737599 ext 87920
Email: p.quenneville@auckland.ac
1. With the statements above...

2. Do you wish to receive the summary findings?

   - Yes
   - No

3. E-mail anda

4. Apakah perkerjaan anda?

   - Perempuan
   - Lelaki

5. Umur

   - <20
   - 20-30
   - 31-40
   - 41-50
   - >50

6. Jantina

   - Perempuan
   - Lelaki

7. Sila pilih diskripsi ruang tempat anda berkerja yang paling tepat

   - Bilik pejabat persendirian
   - Bilik pejabat yang dikongsi bersama 5 orang kakitangan atau kurang dari 5 orang
   - Ruang berkerja yang dikongsi melebihi 5 orang kakitangan
   - Ruang berkerja yang berurusan dengan orang awam (i.e lobi, kaunter pertanyaan, dan sbg)
   - Lain-lain

   - Lain-lain (sila nyatakan)

2. Sila nyatakan lokasi ruang berkerja anda di dalam bangunan ini (contohn: tingkat 2, bilik no 3).

3. Berapa jam anda biasa meluangkan waktu di dalam pejabat?

4. Sila pilih barang elektrik apa yang anda ada di dalam ruang pejabat anda, DAN pilih tindakan apa yang anda biasa ambil setelah menggunakannya.

   - Alat elektrik yang anda ada dalam ruang pejabat anda

<table>
<thead>
<tr>
<th>Barang Elektrik</th>
<th>Tidak</th>
<th>Ada</th>
<th>Dalam Soket</th>
<th>Di Luar Soket</th>
<th>ON</th>
<th>OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Printer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fridge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microwave</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toaster</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other personal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Personal Appliances (you own)

   - Personal Fan
   - Personal Printer
   - Personal Kettle
   - Personal Coffee Maker
   - Personal Discwasher
   - Personal Toaster
   - Personal Radio
   - Personal Laptop
   - Personal Mobile Phone Charger
   - Personal Phone
   - Personal Oven
   - Other

6. Office Appliances

   - Office Fan
   - Office Coffee Maker
   - Office Toaster
   - Office Microwave
   - Office Dishwasher
   - Office Printer
   - Office Fridge
   - Office Oven
   - Other

7. Eda ad

8. Eda ad

9. Eda ad

10. Eda ad
11. Adakah anda membuat tindakan seperti dibawah?

- [ ] Saya sangat jarang buat ini
- [ ] Saya jarang buat ini
- [ ] Saya kadang-kadang buat ini
- [ ] Saya selalu buat ini
- [ ] Saya kerap buat ini
- [ ] Saya TIDAK

- [ ] Hanya menggunakan "dishwasher" apabila ia penuh dengan pinggan mangkuk
- [ ] Memanaskan air di dalam cerek dengan kadar kuantiti yang hanya diperlukan
- [ ] Membaca dokumen di skrin komputer tanpa mencetak
- [ ] Mencetak di dua belah muka surat
- [ ] Memilih untuk menggunakan satu skrin komputer sekiranya diberi peluang untuk guna melebihi satu
- [ ] Memilih untuk membuat kerja menggunakan "laptop" daripada komputer desktop
- [ ] Mengurangkan penggunaan cahaya di skrin komputer
- [ ] Menggunakan "sleep mode" daripada "screen saver" di komputer
- [ ] Menutup komputer
- [ ] Menutup komputer rakan sekerja jika nampak terbiar ON
- [ ] Menutup skrin komputer sahaja
- [ ] Menutup skrin komputer rakan sekerja jika nampak terbiar ON
- [ ] Menggunakan lampu meja dalam keadaan mana yang bersesuaian, dan menutup lampu utama
- [ ] Menutup lampu apabila kelihatan tiada orang di dalam ruang tersebut
- [ ] Menggunakan cahaya matahari dalam keadaan mana yang bersesuaian, dan menutup lampu.
- [ ] Menutup tingkap dan pintu external di kawasan yang terdapat hawadingin

Apakah tindakan anda selain daripada di atas yang membantu untuk menjimatkan tenaga?
13. Berapa kerap anda pernah menyaksikan situasi di bawah di pejabat anda?

<table>
<thead>
<tr>
<th>Situasi</th>
<th>Kerap</th>
<th>Kadang-kadang</th>
<th>Selalu</th>
<th>Jarang</th>
<th>Tidak pernah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menutup lampu swiss bila tidak ada orang di ruang itu</td>
<td>Diberhentikan</td>
<td>10 minit</td>
<td>Di hujung hari</td>
<td>Jika “away” untuk kadar masa kurang dari 10 minit</td>
<td>Jika “away” utuk kadar masa melebihi 10 minit</td>
</tr>
<tr>
<td>Membuka/menutup pintu</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Menutup skrin komputer</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Menutup komputer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mengubah suhu penghawadingin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Menutup dan membuka tingkap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soket dibiarkan “ON”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lain-lain (sila nyatakan apa-apa tindakan yang tidak dicantumkan di atas)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14. Adakah anda mempunyai akses terhadap tindakan dibawah ini dan tidak dikaitkan dengan ruang berkerja anda?

<table>
<thead>
<tr>
<th>Tindakan</th>
<th>Dapat akses</th>
<th>Dapat akses tetapi tidak pernah digunakan</th>
<th>Akses tidak dapat dicapai</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;OK&quot; takut</td>
<td>Saya tidak mengambil ketidakselesaan bekerja untuk mengelakkan kesesuaian corak baju saya</td>
<td>Saya mengubah masa yang hangat</td>
<td>Saya berpindah ke tempat yang lebih sejuk</td>
</tr>
<tr>
<td>&quot;OK&quot; takut</td>
<td>Saya mengubah masa yang hangat</td>
<td>Saya berpindah ke tempat yang lebih sejuk</td>
<td>Saya memakai baju sejuk untuk memanaskan badan saya</td>
</tr>
<tr>
<td>&quot;OK&quot; takut</td>
<td>Saya mengubah masa yang hangat</td>
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</tr>
<tr>
<td>&quot;OK&quot; takut</td>
<td>Saya mengubah masa yang hangat</td>
<td>Saya berpindah ke tempat yang lebih sejuk</td>
<td>Saya memakai baju sejuk untuk memanaskan badan saya</td>
</tr>
</tbody>
</table>

15. Bilaa anda kesedihan di ruang tempat bekerja anda, apa yang anda lakukan untuk mengelakkan kesedihan anda?

<table>
<thead>
<tr>
<th>Tindakan</th>
<th>Saya sentiasa</th>
<th>Saya kadang-kadang</th>
<th>Saya jarang</th>
<th>Saya tidak pernah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menutup lampu swiss bila tidak ada orang di ruang itu</td>
<td>Diberhentikan</td>
<td>10 minit</td>
<td>Di hujung hari</td>
<td>Jika “away” untuk kadar masa kurang dari 10 minit</td>
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<td>Membuka/menutup pintu</td>
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<tr>
<td>Mengubah suhu penghawadingin</td>
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<td>Soket dibiarkan “ON”</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
20. Sila perhatikan gambar di atas dan tandakan jawapan yang paling tepat menggambarkan persepsi anda.

A
B
C

21. Bagaimana anda menilai diri anda dari segi mengamalkan tingkah laku penjimatan tenaga di tempat kerja?

Sangat lemah  Lemah  Sederhana  Baik  Sangat baik

22. Adakah anda menganggap bangunan ini sebagai bangunan "hijau"?

Ya  Tidak  Saya tidak tahu

23. Sejauh mana anda fikir prestasi bangunan ini dalam kecekapan penggunaan tenaga elektrik?

Sangat lemah  Lemah  Sederhana  Baik  Sangat baik

24. Apakah persepsi gaya hidup "hijau" anda untuk mengurangkan penggunaan tenaga elektrik?
Kettha. Sejauh manakah anda effisyen dalam pengunaan tenaga?

24. Sila tandakan pendapat anda ke atas penyataan-penyataan berikut

- Sangat tidak setuju
- Tidak setuju
- Tidak tahu
- Setuju
- Sangat setuju

Menutup dan membuka lampu tidak menjimatkan tenaga elektrik

SEMUA perkakas berada dalam mod "stand-by" bila soket 'nyala', tetapi swiss di perkakas 'tutup'

Penggunaan tenaga pada peringkat awal untuk membuka komputer banyak menggunakan tenaga, oleh itu lebih jimat sekiranya dibiarkan terbuka daripada kerap menutupnya

Meletakkan skrin untuk tidur dan bukannya menggunakan gambar skrin tidak akan banyak menjimatkan tenaga

Menukar mode skrin ke mode hibernasi berbanding menggunakan "screen saver" tidak mengoptimumkan penggunaan tenaga

Bekerja di bangunan hijau berarti saya perlu mengorbankan keselesaan saya dan mengubah gaya hidup untuk menjimatkan tenaga elektrik

Saya tidak perlu mengurangkan penggunaan tenaga elektrik di dalam bangunan ini kerana ia sudah sememangnya direka dengan konsep kecekapan tenaga elektrik

Saya sering terlupa untuk mematikan suis lampu dan perkakas elektrik apabila tidak digunakan

25. Sila susun atur pernyataan di bawah mengikut kepentingan yang anda pilih semasa anda menjimatkan penggunaan tenaga elektrik?

- Mengetahui bahawa sumer tenaga terhad menjadi isu global
- Mengetahui bahawa saya dapat menjimatkan kos tenaga elektrik
- Saya ingin menunjukkan contoh yang baik kepada orang lain
- Bekerja dalam bangunan yang diktiraf oleh Green Building Council (GBC)
- Mengetahui tentang konsep reka cipta bangunan yang menerapkan nilai-nilai kecekapan tenaga tanpa pengiktirafan rasmi GBC
- Lain-lain (sila nyatakan)
Kettha. Sejauh manakah anda effisyen dalam pengunaan tenaga?

26. Berikut merupakan strategi untuk menggalakkan kelakuan penjimatan tenaga. Sila tandakan yang mana anda rasa terbaik untuk diri anda. Sebarang pendapat tambahan anda dialu-alukan

- Sangat tidak berminat
- Tidak berminat
- Neutral
- Sedikit minat
- Amat berminat

Strategi ini sudah dilaksanakan dalam bangunan ini


- Sentiasa mengemaskini maklumat berkenaan penjimatan tenaga elektrik yang tercapai di laman web, risalah, laporan dan lain-lain kaedah komunikasi
- Memberi maklumat terkini berkenaan penggunaan tenaga elektrik
- Memberi maklumat terkini berkenaan perbandingan penggunaan tenaga elektrik di bangunan ini berbanding dengan bangunan lain
- Mengadakan paparan digital sistem berkenaan penggunaan tenaga pada peralatan elektrik
- Mengadakan platform dalam organisasi anda untuk membuat cadangan dan sumbangan memberi buah fikiran dan balasan
- Memberi ganjaran/hadiah kepada buah fikiran terbaik dalam cara-cara penjimatan tenaga
- Mengadakan sesi minum pagi yang dihoskan apabila mencapai sasaran penjimatan tenaga sebagai satu cara untuk mengucapkan terima kasih atas usaha dan input
- Melawat bangunan-bangunan lain untuk belajar mengenai cara-cara penjimatan tenaga

Melawat laman web pendidikan mengenai kecekapan tenaga untuk mengetahui lebih lanjut mengenai tips penjimatan tenaga

Sebuah bangunan acara pertandingan dan pasukan seperti kuiz atau reka bentuk poster antara jabatan-jabatan

Mengadakan pertandingan seperti kuiz, reka cipta poster antara jabatan ke jabatan di dalam sebuah organisasi

Menjemput penceramah luar untuk memberi ucapan tentang alam persekitaran dan tenaga elektrik

Pendapat tambahan?

Undang-undang Perusahaan

Undang-undang Persekutuan

Undang-undang Persekutuan

Undang-undang Perlindungan Perorangan

Dokumen Perniagaan

Membuat laporan

Membuat laporan

Membuat laporan
27. Adakah anda berminat untuk menyertai dalam susulan kajian ini?

- [ ] Ya
- [ ] Tidak
Appendix F: Questions for discussion with Building managers
RESEARCH PROJECT

TITLE: INFLUENCES OF HUMAN BEHAVIOR IN ENERGY EFFICIENCY PERFORMANCE.

COMPARISON OF GREEN OFFICE BUILDINGS VS CONVENTIONAL OFFICE BUILDINGS

INTERVIEW QUESTIONS

FACILITY MANAGEMENT (Q1 – Q 16)

Name : NURUL SAKINA BINTI MOKHTAR AZIZI
Student ID : 2548763              NRIC : 860402-87-5062
Tel. No. : 017-8824692              / Fax no: 03-61512220
Email : sakinamokhtar@gmail.com
FACILITY MANAGEMENT

What is the current energy performance status?
How different has it been from the design stage to the operation stage?
What are the common causes for the energy consumption to exceed?
Could you please explain what strategies (technology and management) are used to reduce energy use in lighting, cooling/heating and plugload system?
What technology did not work well? (i.e occupancy/daylight sensor malfunction)
How often do occupants complain on the temperature of the building?
Do you have a yearly record of complaint by the occupants on temperature and lighting inside building that you could provide me with?
How often does the technology cause problem in the building? How was the problem solved?
What items in the building that required constant maintenance?
What new technologies that are difficult to deal with or that did not work?
Does your organization have further planning to improve energy efficiency performance?
In your opinion, does it require additional training to manage a green building?
What kind of human behaviours are expected or required of building occupants in green building?

-Thank you for your cooperation-
Appendix G: Questions for discussion on building design
RESEARCH PROJECT

TITLE: INFLUENCES OF HUMAN BEHAVIOR IN ENERGY EFFICIENCY PERFORMANCE.
COMPARISON OF GREEN OFFICE BUILDINGS VS CONVENTIONAL OFFICE BUILDINGS

INTERVIEW QUESTIONS

INFORMATION ON BUILDING DESIGN OF BUILDING (Q1- Q6)

Name: NURUL SAKINA BINTI MOKHTAR AZIZI
Student ID: 2548763            NRIC: 860402-87-5062
Tel. No.: 017-8824692          /    Fax no: 03-61512220
Email: sakinamokhtar@gmail.com
BACKGROUND INFORMATION ON BUILDING DESIGN OF BUILDING

1. GFA _______m²  
2. Storeys ___________  
3. Occupancy rate ______

4. Was energy efficiency design incorporated in the building?
   - Yes (please proceed to Q5)
   - No

5. Table below is a list of energy efficiency active design features. Please identify and describe features that this building incorporates

<table>
<thead>
<tr>
<th>Features</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic External Louvers</td>
<td></td>
</tr>
<tr>
<td>Active chilled beam air conditioning</td>
<td></td>
</tr>
<tr>
<td>Thermal Zoning</td>
<td></td>
</tr>
<tr>
<td>Use of renewable Gas (…) Solar (…) Wind Turbines (…)</td>
<td></td>
</tr>
<tr>
<td>Light zoning &amp;/ or light sensors</td>
<td></td>
</tr>
<tr>
<td>Low Ozone Depleting Potential refrigerants</td>
<td></td>
</tr>
<tr>
<td>Low E glazing/ double glazing</td>
<td></td>
</tr>
<tr>
<td>Solar hot water systems</td>
<td></td>
</tr>
<tr>
<td>Others, Please specify</td>
<td></td>
</tr>
</tbody>
</table>

5. Please explain passive features of the building that is design intended for energy efficiency?
   i.e layout plan

---

6. Do you have any documents which describe the building design of the building?
   - Yes (please attach the copy of the document)
   - No

- THANK YOU VERY MUCH-
Appendix H: Poster
Research Invitation to Staff in Owen G Glenn Building (Questionnaire Survey)

Hi there!

Would you like to help improve energy efficiency performance in your building? You can do so by helping to complete a questionnaire made available via online or hardcopy that will only take 20 minutes of your time to answer.

Staff who are interested please kindly sign the consent form available at the desk counter and fill in the questionnaire by 10th June. Questionnaire is made available online and hardcopy.

Please grab on the link below for the online survey

https://www.surveymonkey.com/s/OwenGGlennBuilding

OR

Please go to the desk counter for the hardcopy

Please don’t forget to retrieve your goodie bag at the desk as a token of thank you for your cooperation!

Feel free to contact me if you have any questions
Sakina Mokhtar, e-mail: s.mokhtar@auckland.ac.nz
Appendix I: Website Logo design
Please help in an energy efficiency research

Questionnaire survey (5-10) minutes

https://www.surveymonkey.com/s/FEngineering
Appendix J: Questions for discussion on Risks Associated with Implementation of Green Buildings
RISKS ASSOCIATED IN IMPLEMENTATION OF GREEN BUILDINGS

Design Stage (GB vs CB)
What motivated project owners to build a green building.

What are the costs to implement Green Building in comparison to a Conventional Building?

How much time was spent on designing a Green Building? Did it take up more time as compared to a Conventional Building?

Which sustainable rating tool did you use and why?

Construction Stage
What were the problems that you saw in delivering a Green Building?(i.e supply of materials that caused delay)

How complicated was it to achieve a certain percentage of waste construction and demolition (to get credits following the GB checklist)

Does a Green Building require special skilled labour?

Did the project have variation of work to meet the sustainable guideline?

As built/ Operation
Are the buildings really performing to how it was designed to be?
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