Assessing the Pre-occupancy and Post-occupancy Baseline Sustainability Practices of Multiple Tenants in a Zero-Carbon Office Building

by

Olivia Paxton-Beesley

A thesis

presented to the University of Waterloo

in fulfilment of the

thesis requirement for the degree of

Master of Environmental Studies

in

Sustainability Management

Waterloo, Ontario, Canada 2019

AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

ABSTRACT

This research assesses the baseline sustainable lifestyle patterns of occupants in a multi-tenant office building in Waterloo, ON designed for next-generation sustainability standards. The building is designed to be zero-carbon and 'net energy positive', to generate more energy than it requires to operate annually. This research explores the influence of sustainable and energy efficient designs on lifestyle choices of the zero-carbon building tenants. The thesis seeks to extend the vision of this zero-carbon building as an innovative office building by exploring the pro-environmental awareness and behaviour of its tenants. Data contained within this study indicates a positive relationship between attitudes and behaviours among tenants. This specialized study can help emphasize the significance of this link. The data might in turn contribute to new operating standards for commercial office tenant buildings, supporting improved energy and sustainability performance in workspaces.

The building sector is one of the major contributors to carbon emissions in the world, and the effective reduction of emissions requires significant change in the building industry. Sustainable building design can dramatically reduce carbon emissions associated with the construction and operation of buildings, minimizing harmful environmental impacts. However, there are often performance gaps where the modeled energy performance shown in designs and actual energy performance of occupied buildings do not match. While the building's energy-positive features help solve the global sustainability challenge, achieving high performance also depends on deliberate patterns of use by tenants and management, requiring elevated awareness among occupants.

This research identifies the self-reported behaviours of the future tenants of the zero-carbon office building prior to the occupancy of the sustainable building, providing a baseline to compare the lifestyle patterns of tenants as they are exposed to a sustainably designed workspace. The study focuses on baseline lifestyle choices by collecting information about commuting choices, diet, and waste habits through an online survey, and on parking lot composition through an observational survey. The study compares patterns among tenants from environmental, information technology, education and accounting industries. In parallel, the study considers the influence of the zero-carbon office building's architectural features, including geothermal heating, triple-glazed windows, a solar carport, and 28 electric charging stations in its parking lot, together with the location of the development next to a light rail transit station which supports the option of low-carbon mass transportation.

Literature cited within this study includes recent papers that discuss opportunities to engage the occupants of sustainable buildings, and for satisfaction and comfort of occupants in their new spaces. Researchers highlight that behavioural factors are a major contributor to performance gaps, particularly if the lifestyle patterns of occupants are not complemented by the design of the building. Key studies including Carmichael, Preble, Randall, and Steiner, (2017) and Edwards and Kumphai, (2012) demonstrate that widely varying interests in sustainability and energy requirements seen within multi-tenant environments can create difficulty in achieving reductions in energy usage. This thesis contributes to this literature by emphasizing the importance of occupant awareness of sustainability and sustainable behaviours.

ACKNOWLEDGEMENTS

I would like to acknowledge that as a University of Waterloo student, I work on the traditional territory of the Neutral, Anishinaabeg and Haudenosaunee peoples. The University of Waterloo is situated on the Haldimand Tract, the land promised to the Six Nations that includes ten kilometres on each side of the Grand River.

I would like to thank my supervisor, Paul Parker, whose expertise and guidance has supported me throughout the process of developing the research plan and continued to encourage me throughout the writing and editing process. I would also like to thank the Wilfrid Laurier research team for including me as part of their long term research study.

I would like to thank the fellow students in my SUSM program and congratulate you all in your successes. I would especially like to thank Sarah Fries, whose friendship and humor has been a huge support throughout this process.

I would like to thank my family, Anne, Philip, Robin, Ali, Tommy, David, Maritza, Brianne, Orlando and Omi, who have given me constant love and encouragement. I would like to especially acknowledge my dad, who constantly inspires me to work towards my passions in life, and to never let anything hold me back. Lastly, I would like to thank my friends who have given so much moral support, even when I've doubted myself.

I am so grateful to have all of you in my life, and to have had your support throughout the process of this study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1: INTRODUCTION

There has recently been a worldwide movement to integrate sustainability into society, balancing the needs of the economy with the environment and resource usage (Lindsey, 2011). The ever-growing concerns about climate change have specifically caused pressure on the building sector to reduce its carbon emissions and improve efficiency in building operations and resource use. The building sector is currently one of the major contributors to carbon emissions in the world and is projected to increase in emissions as the growing population leads to higher demand for buildings (Cranz, Lindsay, Morhayim, and Lin, 2014). Arguably, it is one of the most resource-intensive industries through its energy use during construction and operation, building material production, raw material consumption, and waste creation (Akadiri, Chinyio, and Olomolaiye, 2012). According to the Government of Canada, the building sector accounted for 82 megatonnes of CO_2 equivalent (12% of total emissions) in 2017.

The integration of sustainable technologies and energy efficient designs into new buildings and retrofits provides a promising solution to reduce the environmental impact of the building sector. While current sustainable buildings already contribute to the reduction of resources and energy efficiency through design, occupancy of these buildings also presents an opportunity for education and change in cultural norms (Guy and Farmer, 2001). The use of buildings to increase awareness of sustainable behaviours among occupants could be a notable step towards achieving environmental, economic, and social sustainability (Cranz et al., 2014). By decreasing the greenhouse gas emissions from the building sector, this will directly contribute to the goals set out in Canada's Federal Sustainable Development Strategy to create a low carbon economy that will limit the global temperature rise to below 2 degrees Celsius and reduce Canada's greenhouse

gas (GHG) emissions to 30% below 2005 levels, by 2030 (Canada, Environment and Climate Change, 2007). Overall, there is increasing pressure to reduce carbon emissions to alleviate climate change and rising concerns about the destructive energy and resource use from the building sector (Cranz et al., 2014).

Sustainable building projects are carefully designed to minimize resource and energy use, while also creating a healthy environment for occupants. The objectives of a sustainable building project should include energy efficient technologies, improved resource efficiency, GHG and CO_2 emission reduction, air quality improvement, and incorporation of natural resources including windows for daylight, or geothermal heating (John, Clements-Croome and Jeronimidis, 2005). These projects should be built to last, with limited maintenance, and should contribute to positive social, environmental, and economic conditions (Reffat, 2004).

Research catalyst

Constructing sustainable buildings should be attractive to developers and operators as they can offer improved long-term economic performance through decreased energy use, and improved maintenance and operation costs. It is also the industry's responsibility to take into account environmental, social, and economic issues when designing, constructing and operating these projects, as a part of the overall effort to reduce global carbon emissions (Akadiri et al., 2012). However, while the environmental and economic concerns are often well defined in sustainable design, complex social impacts that incorporate occupants' personal responsibilities, health and well-being, productivity, community participation and overall quality of life are not

well understood. The current study offers a contribution by providing baseline data that identifies specific links between tenant attitudes and pro-environmental behaviours.

Researchers recognize that while design of workplaces and green building design are often regarded as separate issues they are dependent on each other (Heerwagen, 2000). While design of workplaces considers the comfort and productivity of workers and the flexibility of spaces, building design is often separately measured by the efficiency of technology and envelope design, and building operation. The positive impacts of sustainability within these buildings can be increased by connecting environmental and social aspects with sustainable designs and spatial arrangements. Adoption of sustainable buildings in the office building industry has been supported by increased environmental stewardship among businesses, green building certification, reduction in resource and energy use, and societal influence. However, while energy efficient designs have gained traction in this industry, the success of these designs relies heavily on sustainable behaviours and interactions of the occupants with the building (Day, 2014).

Problem statement

It can be challenging to influence occupants' behaviours and to bring about a change towards long-term, pro-environmental behaviours (Lilley, 2009). One of the main factors affecting sustainable performance is appropriate operation of building control systems. Effective operation of buildings and their energy efficient technologies is closely related to occupant understanding and convenient access to controls (Akadiri et al., 2012). If design components and technologies are unfamiliar to the occupants, this can lead to a performance gap (Coleman and

Robinson, 2017). The performance gap of buildings is the difference between the modeled energy performance and the measured energy use. Major factors that influence the performance gap in buildings include behavioural and organizational factors. Studies found that the greatest waste of energy in office buildings was during non-working hours, as a result of occupants leaving lights and equipment on (Masoso and Grobler, 2010). Other behavioural factors can include clothing choices that lead to increased energy consumption with heating or cooling, and use of personal appliances including refrigerators, space heaters, fans and printers (Akadiri et al., 2012). Energy efficient passive designs in buildings that take advantage of natural ventilation and daylight can be integrated. However, if occupants are unaware of these design strategies or misuse building features, resulting behaviour can impact building energy use. Energy reducing behaviours may not be reflected in an individual's workplace since they are not typically responsible for paying utility bills (Ehrhardt-Martinez, 2011). It is therefore important that new energy efficient buildings integrate the value of sustainability into the social culture of their occupants in order to minimize potential performance gaps.

> "Human beings don't have a pollution problem; they have a design problem. If humans were to devise products, tools, furniture, homes, factories, and cities more intelligently from the start, they wouldn't even need to think in terms of waste, or contamination, or scarcity. Good design would allow for abundance, endless reuse, and pleasure."
> – The Upcycle, Braungart and McDonough, 2013.

Buildings have the possibility to embody values through their design and structure, where certain features can advertise social norms or cues within the building. Sustainable buildings

specifically have the potential to reinforce the occupant's connection to the environment and sustainable living patterns, while also fostering a sense of responsibility and care towards their immediate environment (Brown and Gorgolewski, 2014). It is not sufficient to create buildings with energy efficient technologies and low resource usage without also integrating enlightening features that influence the occupant's values and daily behaviours. The integration of sustainable design into new buildings can solve energy-efficiency and resource depletion problems associated with the building performance gap, and significantly reduce the carbon emission impact of the building sector. Additionally, building design can help to integrate sustainable values into the occupants' attitudes and behaviours and contribute to the shift to a lower carbon society (Cranz et al., 2014).

Purpose of the research

This research collects baseline information on pro-environmental behaviours, including the diet, waste, and commuting patterns, and attitudes of the tenants of an innovative zero-carbon building developed and owned by the CORA Group as a multi-tenant commercial building located in Waterloo, Ontario, Canada. By measuring baseline lifestyle practices, future researchers may be able to track whether the development of a culture of sustainability is achieved within the zero-carbon building. Based on the literature, sustainable building design is a solution to minimize the environmental impacts of buildings, through reduced resource usage and social influence. One of the integral aspects of sustainable design is the educational effect on the occupants and an increase in awareness of sustainable building use (Cranz et al., 2014).

The case study building is designed to create more energy than it requires for operation and incorporates both active and passive systems for optimal energy efficiency and resiliency. The building design elements include a high-performance building envelope, geo-exchange heating ventilation and air conditioning, triple-glazed windows, a solar wall for heating, three-storey living wall, and a solar panel carport. The building's location also supports sustainable transportation as it is adjacent to the Region of Waterloo's ION Light Rail Transit system, thereby improving the accessibility of building occupants to public transportation, and adjacent to bicycle paths for active transportation. The parking lot has 28 electric vehicle (EV) charging stations. Throughout the design process, one of the main focuses was to ensure that everyone involved was aligned in their visions for the project, where sustainable designs decrease the resource usage, but also contribute to the productivity of workers and functionality of the office space. The sustainable nature of the building also creates an opportunity for employers to attract environmentally conscious workers (Lewington, 2018). Ideally, the zero-carbon building establishes a progressive standard for sustainable construction and influences future tenants to prioritize zero-carbon buildings when searching for office spaces.

The case study building is the first of its kind in Canada. This development provides an opportunity to study potential changes in lifestyle practices of its occupants. Findings of this study could assist developers of sustainable buildings and sustainability building officers in attempts to support effective operation of sustainable buildings by occupants. Baseline lifestyle practices of future occupants of the building provide an essential reference that can support evaluation of effective designs (Thompson, 2017)

Research objectives

The goal of this study is to establish a baseline of sustainability practices of multiple tenants in a zero-carbon office building. The study includes the following objectives:

- Establish the baseline of selected pro-environmental behaviours among tenants prior to moving into a zero-carbon office building (commuting mode choice, food, waste).
- Establish baseline of self-reported pro-environmental attitudes (actions, feelings, and emotions) among tenants.
- Measure correlations between self-reported pro-environmental attitudes and self-reported pro-environment behaviours among tenants.
- Measure initial changes in commuting choices among tenants following the move into a zero-carbon office building (pre and post-occupancy parking lot observation).
- Test whether structures, such as change in parking cost, or structures such as zero-carbon office building influences commuting choice (parking lot observation).

Research context

This research is part of a five-year mixed-methods study that will explore the human factors that contribute to a gap between the design performance and the actual performance of high-performance green office buildings (Dreyer, Coulombe, Whitney, Riemer, and Labbé, 2018). This study specifically focuses on the context of human factors in a net-positive energy building. The long-term study is based on the hypothesis that a culture of sustainability may develop among the occupants as they spend time in the building, with a positive impact on building performance. The first stage of this research involves collecting the baseline data using

a survey to collect the self-reported lifestyle practices of tenants and observational study of the parking lot composition at the zero-carbon energy building to determine the commuting choices of tenants pre and post-occupancy.

Thesis structure

This thesis measures baseline data on future tenants' behaviours and attitudes prior to their move into this zero-carbon office building. It explores the current literature related to sustainable buildings, culture of sustainability and pro-environmental behaviours. Methods are presented, and the results and discussion explore attitudinal, behavioural and observational data from the various tenants during pre and post occupation of the building. This study follows four sections, outlined below:

Chapter 2 Literature Review: Summary of the reviewed literature including historical background, theoretical literature, empirical literature, and gaps in the literature.
Chapter 3 Research Methodology and Methods: Description of research approach for quantitative survey collection and parking lot observations, and statistical analysis of results.
Chapter 4 Results and Discussion: Review of attitudinal and behavioural surveys, and parking lot observations from pre-occupancy and post-occupancy, comparing results among tenants, including statistical analysis and comparison with relevant theoretical and empirical literature.
Chapter 5 Conclusion: Data contained within this study indicates a distinct correlation between attitudes and behaviours among tenants.

CHAPTER 2: LITERATURE REVIEW

This chapter aims to explore the literature and identify research gaps. The literature review is divided into three parts. First is a review of the history of sustainable buildings and building research. The second section is the exploration of theories that relate to the research objectives proposed. This section focuses on the theory of planned behaviour, and the value belief norm theory. The final section is a review of empirical research relating to surveys of tenants in sustainable buildings.

Sustainable buildings

Sustainable buildings differ from conventional structures as they increasingly act as a closed loop system, compared to a conventional building that is a linear system. A conventional building processes natural resources into waste, whereas a sustainable building is more self-sufficient by recovering energy and water and reducing waste. The progression from conventional buildings to sustainable structures began with low energy buildings, then buildings that contributed to the environment and society, and now the development of zero energy and net energy producing buildings (Bonenberg and Kapliński, 2018).

The National Research Council of Canada (NRCC) established the first division of building research in 1947, focusing primarily on house construction and providing research to assist decisions on the National Building Code of Canada. Considering the weather conditions in Canada, the NRCC's building division studied the relationship between climate conditions and building problems. Following this, building research was impacted in the 1950s by the increase in energy production and consumption after World War II (Legget, 1966). The emergence of air

conditioning, low-watt fluorescent lighting and reflective glass led to the introduction of the modern building during the 1960s, and designers had little consideration for the environmental footprint of these modern features. The first wave of environmental architecture occurred during this time due to the growing concern of environmental issues, and lead to more building research that focused on the built environment and its impact on environmental pollution. Throughout the 1970s, rising fuel costs caused by the oil crisis of 1972 led to reduced energy consumption and the passive redesign of conventional buildings, including insulation and operable window strategies. However, these building strategies were directed mainly towards residential buildings as larger buildings continued to follow conventional designs ("A brief history of green building," 2003).

In 1981, Natural Resources Canada launched the R-2000 program that presented new technologies and design elements that would increase the energy efficiency of homes. The green building movement began to grow throughout the 1990s, and in 1993 the C-2000 program was launched which extended the program to include commercial buildings. The YMCA Environmental Learning Centre in St. Clements, Ontario and the Boyne Conservation Centre, in Shelburne, Ontario were two notable projects that introduced the public to sustainable design, and integrated passive ventilation, solar heating, and greywater treatment systems into their designs. The green building movement continued to grow as a number of Canadian developers and architects took interest in the sustainable projects (Boake, n.d.). The United States Green Building Council (USGBC) was developed during the mid-1990's, to evaluate the level of sustainability in buildings. The USGBC launched the LEED certification program and rating system for building sustainability in 1998 and created a common standard among environmental

buildings. The Canada Green Building Council (CaGBC) was created in 2003 to expand green buildings in Canada and accelerate the transformation of sustainable communities (CaGBC, 2018).

Sustainable buildings are gaining more interest as they can add value by reducing energy demand, generating renewable energy and raising awareness of pro-environmental behaviours. These buildings can contribute to sustainable development, as they establish precedents in the building sector. They are increasingly valuable as they can contribute to social, environmental and economic capital (Guell, Panter, Jones, and Ogilvie, 2012). Birkeland (2008), discusses how these new structures have the possibility of improving the ecological environment to better than before the building development. The assessment of sustainable buildings should broaden the scope of analysis, not only assessing the direct environmental impact, but also including the social and economic environments (Birkeland, 2008). As it relates to the general goal of sustainability, the transition towards sustainable development does not proceed towards an end goal, but rather is a process of change that is constantly evolving towards positive and healthy development (Stefanovic, 2000). Sustainable building projects often have an additional goal for the building industry, which is developing a new culture within these buildings. The development of a culture can contribute to sustainable development and the goals of sustainable buildings as it will connect the occupants to their surrounding environment (Birkeland, 2008)

CaGBC (2014) distributed an online survey to building owners, architects and contractors in 2014, which found that over half of Canadian respondents reported that over 30% of their current building projects are sustainable. The results from this survey suggested that the sustainable

building construction market will see significant increases. These respondents reported to see significant decreases in operating costs within the first year after development of sustainable buildings, with 82% of building owners reporting decreases in energy consumption, and 68% of owners reporting decreases in water consumption. One of the top triggers for sustainable buildings in Canada is client demands, where sustainable buildings were one of their top three choices. The survey also showed that 60% of respondents chose the ability of sustainable buildings to promote greater health and well-being in occupants as the top social reason for their investments. Building owners noted the benefits that they gained from their sustainable buildings included tenant engagement and attraction, as well as recognized leadership in the building industry. Owners frequently reported their ability to lead by example and influence the market by investing in green buildings (CaGBC, 2014). A study by USGBC (1999) stated that many of its members agreed that sustainable buildings would become a more common pursuit once the human benefits were identified, including the productivity and well-being associated with the improved interior environment. Some business leaders believe their building environments are an important aspect of achieving their corporate strategic goals (USGBC, 1999). It is evident that some Canadian developers are inclined to invest in green building projects as they contribute to environmental health and tenant well-being, and allow them to gain leadership in the building industry (CaGBC, 2014).

While there is a low share of existing sustainable buildings, the percentage of sustainable features in new developments and retrofits is anticipated to significantly increase (CaGBC, 2014). The growth of sustainable buildings is also stimulated by incentives as some governments are piloting sustainable projects to promote the development and uptake of sustainable buildings

into the building industry. An interesting concept discussed by Zhao, He, Johnson and Mou (2015) is the influence of social acceptance on market acceptance, whereby occupants of sustainable buildings can influence the success of a sustainable building market. If the sustainable buildings perform well, this will contribute to the demand for sustainable buildings and influence market acceptance. As the sustainable building market further develops, government incentives can be used to encourage developers to take on these projects. The researchers discuss the need for more research in market acceptance of sustainable buildings (Zhao et al., 2015).

Theories related to pro-environmental behaviours

Sustainable behaviours are defined as behaviours that seek to minimize negative impacts with an action on the environment, whereas pro-environmental behaviours can be defined as activities with an intention to contribute positively to the environment. Both terms are used in the context of describing environmentally conscious actions and motivations. In the workplace, these environmental activities are often not part of an employee's job description and are generally voluntary and motivated by self-interest or social influence. Researchers support these motivations using rational choice models including the theory of planned behaviour and the value belief norm (Ture and Ganesh, 2014). These theories discuss the influences that may result in particular behaviours, thereby explaining the cause of sustainable or pro-environmental behaviours. Individuals may have independent values and beliefs or shared norms and attitudes that may influence them to behave distinctly (Aguilar-Luzón, García-Martínez, Calvo-Salguero and Salinas, 2012). Previous studies have discussed these theories in explanation for

environmental behaviours, describing the intention behind an individual's actions and the factors that could guide these responses.

Value belief norm theory

The value belief norm theory is one of the most popular research paradigms to explain the motivation behind environmental behaviours. Previous literature by Aguilar-Luzón et al., (2012) describes the influence of values that guide actions and decisions that are made. An individual with certain beliefs regarding the environment, depending on if they believe it is a moral norm or is aware of the consequences, will behave in a certain way. The value belief norm theory is explained through the awareness of the effects of specific behaviours, and the understanding of the level of responsibility that an individual has over their actions. It is therefore essential to distinguish the specific beliefs associated with the behaviour and the method in which the individual gained those beliefs (Aguilar-Luzón et al., 2012).

A value can be defined as an individual's principles or standards of behaviour that guide what is important to that individual. These values can be categorized under egoistic, altruistic, and biospheric, and are based on the costs and benefits of certain sustainable acts. Individuals that have egoistic values consider the costs and benefits of a pro-environmental behaviour that will personally affect them. Whereas individuals with altruistic values determine their sustainable behaviours from the cost and benefits for other people, and biospheric is the costs and benefits towards the environment. A norm is an expectation of how an individual should behave, and can arise from social influence or from a personal norm (Ture and Ganesh, 2014). In a workplace setting, individuals may behave differently than in a household setting, due to the

influence from organizational variables (Stern, Dietz, Abel, Guagnano, and Kalof, 1999) Also, the importance that an organization gives to environmental issues can influence employees to take up pro-environmental initiatives. Organizations that incorporate sustainability into their business strategies, and orient their businesses towards environmental issues will likely expect a certain level of pro-environmental behaviours within their workplaces (Ture and Ganesh, 2014).

Stern (2000), developed a causal chain to describe value belief norm theory in the context of pro-environmental behaviours, as seen in Figure 1. It begins with an individual's values and how those influence their beliefs specifically about human- environment relations. From there the chain moves into consequences of these human-environmental relations and the individual's responsibility to take action to reduce the threat to the environment. Individuals who care about others well-being, will be concerned about the environmental conditions that pose a threat to them. There is an important link in the value belief norm theory, between individual values and environmentalism, that is caused by particular beliefs about the individuals that are affected by environmental conditions, or the types of actions that could alleviate the threats to these individuals. These beliefs are shaped by information, including education of environmental science, or public knowledge and influence, which will in turn affect an individual's values and environmentalism. Environmental behaviours can be influenced by personal habits, as discussed previously. These behaviours can also be hindered by income or infrastructure, for example, the cost of an EV, or a lack of public transit infrastructure (Stern, 2000). Some environmental behaviours may transpire from non-environmental intentions, for example, an individual may have a desire to save money when commuting and will take public transit over driving a personal car.

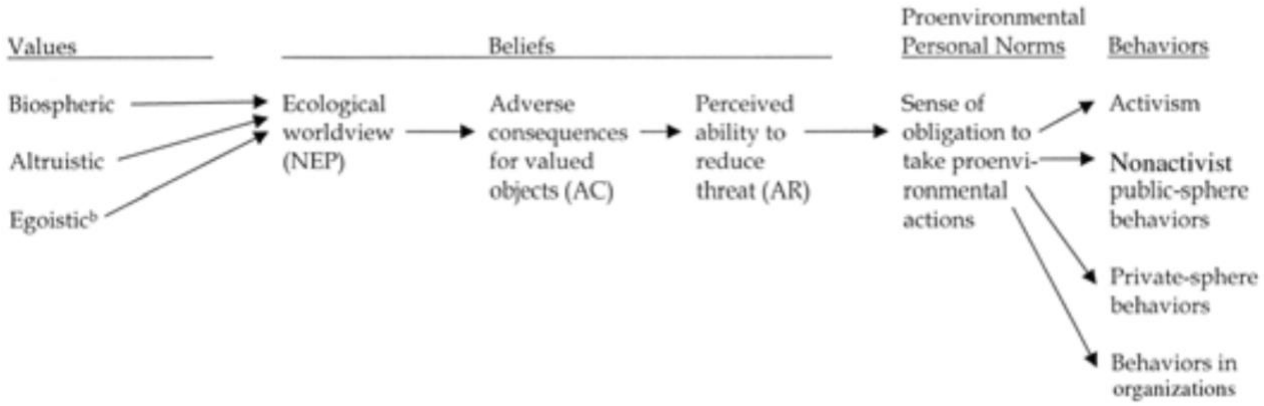

Figure 1. Schematic representation of value belief norm theory. Reprinted from "New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behaviour", by P. Stern, 2000, *Journal of Social Issues 56* (3), page 412. Copyright 2000 by The Society for the Psychological Study of Social Issues.

Theory of planned behaviour

The theory of planned behaviour was first introduced by Ajzen (1985), and since then has become one of the most frequently cited theories to describe human social behaviour. The theory of planned behaviour discusses the attitudes of individuals affecting their environmental behaviours, and is useful in explaining current behaviours, as well as future behaviours (Ajzen, 1985). The theory uses a person's behaviour, normative and control beliefs to gather information about the determinants of an individual's behaviours (Ajzen, 2011). Control beliefs are an individual's beliefs of the factors that influence the outcome of their behaviours. These beliefs can be based on previous experiences, or secondary information from peers, that influence the perceived difficulty of the behaviour. As individuals possess more experiences, they anticipate fewer obstacles and difficulties in performing the behaviour (Ajzen, 1991). A study by Joachim,

Kamarudin, Aliagha, and Ufere (2015), describes the theory of planned behaviour as a theory that links practices of individuals and their beliefs, and will explain the intentions and motivations that influence them to act in a certain way. An individual's behaviour is subject to external pressures that may influence their decisions, such as family members, spouses or co-workers, leading an increased strength of normative beliefs. An individual's behaviour will then have the motivation to comply with these beliefs. Additionally, it is important to acknowledge any understanding of environmental preservation or conservation may cause an individual to be more inclined to have specific behaviours (Joachim et al., 2015). The theory of planned behaviour is an extension of the theory of reasoned action, which describes that a person's intention to perform or not perform a behaviour is the control of the action. An individual's intention is based on two influences, personal nature and social influence. The personal factor is the individual's judgement (whether positive or negative) towards performing a certain behaviour, whereas the social influence is the awareness of social pressure to perform a certain behaviour. In general, individuals are more likely to perform a behaviour if they have a positive opinion towards performing and if they believe there is pressure from important social influencers (Ajzen, 1985). This theory explains an attitude towards a behaviour as a learned inclination when responding in a particular situation. The opinions of individuals are shaped by their beliefs and values about the particular behaviour (Aguilar-Luzón et al., 2012).

Ajzen (1991), discusses the determinants of the intentions behind individuals' actions, including the attitude towards the behaviour, the perceived social pressure of the behaviours and the ease or difficulty of performing the behaviour. In general, when an individual has a favourable attitude towards the behaviour, the stronger the intention to perform the behaviour

will be. This is similar to social norm, where a greater perceived social pressure to perform an action, will result in greater intent (Ajzen, 1991). Guell, Panter, Jones and Ogilvie (2012) discuss how the theory of planned behaviour can shape the attitudes of individuals based on social norms associated with the healthy commuting behaviours of walking or cycling, and the unhealthy behaviours of commuting by car. Another concept of the theory that Guell et al. (2012) discuss is the concept of habit, where commuters may have developed a habitual routine which overshadows the influence of societal norms. Habitual routines can be performed almost automatically and therefore do not require a conscious formulation of a plan (Guell et al. 2012). In the study, Guell et al. (2012) had one participant who used a combination of bicycle and car usage to commute to work. She regarded her car usage as a bad habit and was hoping to increase her use of her bicycle. Her feelings of guilt towards using her car may have been from the influence of growing up in a community that often used bicycles and the attitudes and behaviours of her peers (Guell et al., 2012).

Frank and Stanszus (2019) discuss the intention-behaviour gap whereby individuals do not act in fulfillment of their intentions. A previous survey in Germany discovered that most participants agreed that environmental protection is important and were willing to decrease their personal consumer behaviours to prioritize this issue. However, there are few individuals that act according to their reported attitudes towards environmental issues. One aspect that affects an individual's decision to act is the accompanying emotions. Therefore, if a consumer carries out a sustainable behaviour, and it is accompanied by positive emotion, there is a likely chance of the individual repeating this action. Furthermore, if an individual feels guilt or shame when they act in an unsustainable way, this may encourage the individual to avoid repeating the action.

However, the knowledge of climate change can feel overwhelming, which may lead to some individuals to repress their emotions, and justifying their small contribution to the continuous degradation of the earth (Ture and Ganesh, 2014). A study by Brundiers, and Wiek (2017) described the importance of cognitive learning in the educational approach to sustainable consumption. This could address the emotional challenges that occur from the knowledge of climate change, and encourage individuals to become more resilient to the discomfort and unhappiness they feel when addressing the topic (Brundiers and Wiek, 2017)

Empirical literature

Buildings can influence human values, as seen in historic buildings such as churches or libraries. These structures are built in a way that will teach the occupants specific values, and designers and architects can use building design to communicate principles and help model certain behaviours. Sustainable buildings can teach the occupants environmental awareness by improving resource use efficiency and reducing impact (Cranz et al., 2014). While the structures have integrated technical design to minimize energy use, it is also crucial to incorporate environmental stewardship among the occupants. Masoso and Grobler (2010) describe occupant's behaviour as one of the main aspects of energy efficiency and conservation in buildings, but one that is not well researched. The main literature on this topic focuses on thermal comfort, lighting, acoustics, windows, and perception of sustainable features.

The most advanced sustainable building designs aim to be self-sufficient and operate in a closed cycle. Previous building designs have strived for low energy use and to be environmentally friendly. Advanced sustainable buildings have net-zero energy design,

generating enough energy for the building's operation. Other buildings strive for net positive energy, where the structures produce more energy than the building uses. However, the shift towards sustainable building design involves continuous revision and assessment (Bonenberg and Kapliński, 2018). The future carbon reduction goals will require that all new buildings conform to sustainable design, in order to reduce their energy demands. Development of renewable energy systems are also quickly progressing, and sustainable buildings can accommodate these technologies. There is a growing expectation for sustainable design in new buildings as sustainable development becomes increasingly popular across the world (Cole and Fedoruk, 2015).

Surveying occupants of sustainable buildings

The current literature includes multiple studies researching the success of sustainable buildings in engaging occupants and the surrounding community in environmental and social sustainability. Many studies promote sustainable building design as a solution to the intensive resource use by the building industry and study the comfort and satisfaction of occupants within the building environment (Jailani, Reed, and James, 2015; Cranz et al., 2014; Zhao, He, Johnson, and Mou, 2015; Brown, Cole, Robinson, and Dowlatabadi, 2010; Gou and Siu-Yu Lau, 2013; Shika, Sapri, Jibril, Sipan, and Abdullah, 2012). However, there seems to be a gap in research where researchers focus on the direct impact of sustainable design in buildings, and how it will promote environmental behaviours of tenants and the community within the building. For example, commuting methods of occupants that display a lower frequency of car use, and a higher use of public transit.

A study in Melbourne, Australia, conducted by Jailani, Reed, and James (2015), addressed the gap between the occupant's expectations of a sustainable building compared to the actual perceptions of the building. This study used a focus group to collect the occupant's levels of satisfaction in relation to the thermal comfort and air quality, aesthetics, lighting and acoustics, personal control over air and light, and overall space design. The results from the focus group showed a large gap between the occupants' expectations and the perceptions, confirming that the sustainable buildings were not performing as they were expected. The researchers highlighted the importance of the post-occupancy assessment from the tenants, instead of relying solely on the design features of the building (Jailani et al., 2015).

The David Brower Center, located in Berkeley, California, is multi-tenant building that aimed to inspire sustainability through its green building technology, offering office space to tenants that are involved in sustainability, and engaging the community through public exhibits. Researchers used the building technologies and design aesthetics to determine the building's success in fostering community and tenant engagement in sustainability. Participants were asked a variety of questions to answer the overarching question if the building successfully communicates sustainability through its general appearance and green features. The researchers gained their most important findings in the feedback from participants. While some elements communicated that the building was green to the public, other spaces did not effectively communicate the sustainable features or standards (for example, LEED certification). In general, researchers suggested that increasing recognizable symbols throughout sustainable buildings will promote the development of a culture of sustainability (Cranz et al. 2014).

A study by Zhao et al. (2015) distributed a questionnaire to the general public asking the influence of certain factors on their purchasing decision for a property. The participants rated saving energy, saving land, saving water, saving construction materials, and having better ventilation and lighting. In general, respondents indicated that these factors would have significant influence over their purchasing decision. However, when respondents were asked their familiarity with green buildings, more than half disclosed that they were unfamiliar with them. The population sample responses from this study indicated that participants are accepting of sustainable buildings when they are informed of the environmental features. Common topics of sustainable building research include environmental impacts, however the study by Zhao et al. (2015) highlights the need for greater awareness of the potential social benefits of sustainable buildings. From the results of their survey, the researchers indicated that the public is unable to make rational decisions regarding green buildings if they are unaware of the design and purpose of these buildings. They discuss the need for user-oriented research in research on green buildings, as they can contribute to occupant's satisfaction and productivity, as well as motivation for developers to take on these projects (Zhao et al. 2015).

Miller and Buys (2008) conducted a qualitative study in Melbourne, Australia, where they studied a multi-tenant building undergoing sustainable retrofitting to achieve a 40% reduction in water use, and 20% reduction in energy consumption. Seven interviews were conducted over email and phone to discuss their experience in the refurbishment process, sustainability designs and initiatives, the appeal of sustainability and their expectations for the future of the building. In general participants discussed the shift in behaviours and community activities, and there was an expectation for greater awareness of environmentally friendly behaviours at work and at home.

The researchers found there was a difference between large organization tenants and smaller organizations, as they viewed sustainability differently when considering workspace locations. The organizations that were large scale, including government organizations, described that working in a sustainable building was non-negotiable, and sustainability was a strong priority when choosing a workspace. Smaller organizations discussed that location and cost were the major deciding factors when choosing a workspace, although they agreed that sustainability was important. In general, the researchers found that tenants were engaged in discussing sustainable retrofits and the impact of sustainable design, however they were not confident that they would pay for the sustainable features as their knowledge was limited. Miller and Buys (2008) indicate that there should be more work in educating work groups and tenants of the long-term building outcomes, and the cost/benefit analysis of sustainable features.

Researchers, Brown, Cole, Robinson, and Dowlatabadi (2010), followed the move of a company between two headquarter buildings located in Toronto, Ontario, to compare human and environmental performance between the old and new office buildings. The researchers distributed a building use occupant questionnaire to give occupants an opportunity to rate building factors including design, comfort, and productivity. This specific survey is used to create a benchmark that can be used to establish a greater context of building performance. This study was done pre and post-move, allowing the survey to show the comparison in employee satisfaction, comfort, productivity, and well-being between the two office buildings. The results reflected an overall positive increase in occupant's satisfaction with the new headquarters, with an increase in comfort levels, a greater sense of well-being and feeling healthy, and improved productivity. This research raised some questions relating to the overall increase in employee

satisfaction, as they were unsure of the direct cause of the increase, whether it was the green building design or workplace design. Additionally, the researchers queried whether the green building design is better suited to certain workplace cultures over others (Brown et al., 2010).

Researchers, Brown and Gorgolewski, (2014), in Toronto, Ontario found that four LEED Gold certified high-rise residential buildings did not perform as they were expected. This study used a post-occupancy questionnaire from 165 respondents to examine indoor environmental quality, energy use, and overall satisfaction. The questions asked participants to rate an aspect of the building on a scale of satisfaction, with some opportunities for participants to give comments on their answers. Overall, the researchers found that the occupants were generally satisfied with the building's design, but some insights into design decisions suggested deficiencies in energy use and indoor environmental quality. Examples of these design decisions included noise from the HVAC systems which discouraged residents from using ventilation systems. Additionally, some residents used windows and balconies to get fresh air in the cold seasons, instead of using their ventilation systems (Brown and Gorgolewski, 2014).

A study conducted in China by Gou and Siu-Yu Lau (2013), used a survey and temperature measurement within the green office building. The survey received a 73% response rate from occupants and indicated that generally occupants were satisfied with the indoor temperature. However, some areas of discomfort from occupants were indicated by low temperatures nearby air outlets, and in the winter. These findings suggested that the temperature levels were not an effective indicator of the building performance, as the facility managers followed the building's temperature protocol, but did not expect discomfort from the occupants. The researchers

proposed that post-occupancy evaluation was necessary to provide feedback on the occupants perceived comfort and satisfaction within a green building (Gou and Siu-Yu Lau, 2013).

Similarly, a previous study by Shika et al. (2012) developed a sustainability assessment framework for the post-occupancy of office buildings, to provide information to retrofit office buildings in Malaysia. The researchers discuss how building assessment typically encapsulates the environmental impacts and the contribution to some health-related elements, but many overlook the social contributions. They express the importance of a post-occupancy assessment, where the occupant satisfaction acts as a key performance indicator. The researchers found that there was a close correlation between the economic and social aspects of sustainable developments, and the well-being and productivity of tenants related to the tenant's satisfaction with their office space (Shika et al. 2012).

Commuting behaviours

A study by Heinen, Maat, and van Wee (2011) analyzed commuter's attitudes towards bicycle transportation to work. Researchers distributed an online survey among a sample of employees from various companies and residents in the Netherlands, which asked the opinions on cycling to work, the importance of cycling to work, and the attitudes towards bicycling. The researchers expected an inverse interest in bicycling with increased distance, however results indicated that individuals who commuted longer distances were more inclined to choose bicycle commuting, than those who commuted shorter distances. Researchers found that attitudes towards bicycling to work were the most influential towards the commuting choice. The direct

benefits that the commuter would receive, in terms of time, comfort and flexibility, were significant factors in this commuting decision (Heinen et al., 2011).

Changes in transportation methods towards active travel, including walking and bicycling, are associated with improvements in health and wellness, and a decrease in carbon emissions (Heinen and Ogilvie, 2016; Guell, et al., 2012). Previous studies have suggested that by collecting the baseline of current behaviours, we can then predict future behaviours. Heinen and Ogilvie (2016) studied the connection between baseline variability in commuting choice and the likelihood of changing commuting behaviours during the implementation of a new transportation road feature. The researchers distributed a questionnaire in four stages, throughout the implementation of a new busway, which included an off-road track for buses, a path for walking and cycling, three park-and-ride sites. Their study displayed that individuals with high baseline variability in transportation mode had greater likelihood of changing their travel behaviour, and increase their active transportation modes (walking, cycling). Possible explanations for this association included the willingness of commuters with high baseline variability having a greater inclination to change their commuting mode. Furthermore, these commuters may have higher self-efficacy than those with low baseline variability, and therefore may feel more comfortable in changing transportation modes (Heinen and Ogilvie, 2016).

Heinen and Ogilvie (2016) describe the association between self-efficacy, the increased confidence in performing a behaviour by having a knowledge of the outcome, and the change in behaviours. Where commuters may display a change in modes of transport as they become more confident in the mode of transportation. Greater variability in transportation mode choice, where there is higher variation in the modes of transport by one individual, may correspond with higher

tendency to shift transportation modes, whether away or towards a certain transportation mode throughout time (Heinen and Ogilvie, 2016). Heinen and Ogilvie (2016) also describe the influence of the transportation infrastructure within different environments on the transportation modes and variability by commuters. Where some environments cannot support certain transportation modes, or do not generate high self-efficacy in transportation modes. Researchers suggested that commuters that displayed greater baseline variability would be likely to change their transportation modes based on a change in environmental conditions, more so than commuters that displayed less baseline variability (Heinen and Ogilvie. 2016). Similarly, Guell et al. (2012) discuss the influence of environment composition and neighborhood accessibility and safety on travel behaviour, where some areas may have appropriate infrastructure for certain commuting modes, such as bicycling or public transit.

A study by Susilo et al. (2011) tested the relationship between travel behaviours and the influence of urban design features. It is believed that certain urban environments that are designed to influence environmental behaviours may encourage individuals to choose sustainable methods of travel and reduce car use. The researchers distributed a questionnaire to residents of 13 developments with sustainable features in the UK. The questionnaires asked questions about individual travel choices, including travel mode and trip frequency, as well as environmental and sustainable behaviours. Most of the respondents were aware of environmental issues, however their chosen travel method did not necessarily match their concerns. The study found that some respondents felt that they needed to change their travel behaviour to be more sustainable, but almost all respondents believed that other people needed to change their behaviours to contribute to a sustainable future. This is indicative that the respondents did not necessarily feel responsible for their own actions but were aware of the need for a change in commuting behaviours in

general. The only strong relationship between commuting and the environment was found between individuals with strong environmental concerns and those who primarily walked within their neighbourhoods (Susilo et al., 2011).

Multi-tenant office buildings

Multi-tenant sustainable office buildings are particularly interesting, as they require financial investment and understanding of the building performance goals, from all tenants. In a property that is owner occupied, it is straightforward to see the justification to make energy efficient improvements. As the owner is the occupier of a building, they will see the direct benefits in the energy savings and financial benefits. The environmental and economic benefits of an energy efficient building often increase the competition for the property, and the inherent property value (Barbu, Griffiths, Morton, and European Environment Agency, 2013).

These sustainable buildings require engagement from tenants in the project, especially in addressing the common performance gap that occurs between the expected and actual building performance (Edwards and Kumphai, 2012). As stated by Carmichael, Preble, Randall, and Steiner, (2017), achieving net zero energy can be very difficult in a multi-tenant building as all the tenants occupying the building must be aligned. It is common that multi-tenant buildings be occupied by tenants with different interests in sustainability and the overall goals of the building performance. The various tenants may also consume different levels of energy through their various industries and operations within the building. Engaging the occupants and employees with the building performance and monitoring their own organizational energy use is a crucial aspect of achieving the sustainable building goals (Carmichael et al., 2017).

Sustainable behaviours and environmental concern

According to researchers, the attitudes of individuals can be inconsistent with shifts in behaviours, where pro-environmental attitudes may not result in an explicit change in behaviour. There are many factors that influence behaviours, including awareness, commitment, price and a sense of moral obligation. There is a significant influence from cultural norms, daily routines, social networks and popular trends that can contribute to the shown behaviours of an individual (Owens and Driffill, 2008). Birkeland (2012) discusses how personal sustainable behavioural change relies heavily on the existing environments and their influence on consumption, and how public decisions are influenced by institutions that encourage heavy resource use. The comfort and convenience of certain behaviours also significantly contribute, where an individual may believe that they do not have a fundamental responsibility to change their actions or will not contribute a significant effect (Owens and Driffill, 2008). Researchers discuss how a positive attitude towards the environment and sustainability must be encouraged in the public in order to achieve energy efficiency (Birkeland, 2012). It has been found that some individuals that adopt sustainable behaviours are more forgiving when it comes to the indoor building environments, for example a higher indoor temperature to lower the use of air conditioning. These pro-environmental attitudes of building occupants are powerful in terms of energy efficiency (Li, Yang, and Lam, 2013).

Wang (2017) conducted a survey that asked the respondent's special efforts to actively engage in specific behaviours including: sorting waste for recycling, buying fruits and vegetables free of pesticides, reducing the amount of fuel used at home, saving water, or avoiding buying products. The researchers also surveyed the levels of concern for environmental issues using a

scale. The researchers found there was no attitude- behaviour gap in their sampled population, as they found that individuals who had greater concern for environmental issues, also actively engaged in sustainable behaviours (Wang, 2017).

As stated before, environmentally friendly behaviours are those that an individual will voluntarily engage in. In recent decades this concept has emerged, as opposed to individuals being regulated to behave environmentally friendly due to government policy. The focus on these green consumers has been to examine the lifestyles and consumption of individuals who are engaged in environmental activism in any way. A study by Connolly and Prothero (2008) aimed to seek the answers to how green consumers engage with environmental issues on a daily level using a set of 14 qualitative interviews conducted in Dublin, Ireland. Their assumption was that if consumers gain relevant information, that they will use this information to alter their own behaviours and act in a more environmentally friendly way (Connolly and Prothero, 2008).In general, all participants partook in recycling, and those who had gardens used compost for organic waste. Participants also preferred to grocery shop at organic markets, health food stores, small and local producers, and some grew their own organic produce. However, all participants still reported to engage in shopping at large commercial business, including large grocery chains. The researchers found that although consumers reported that they had a strong concern for the environment, they were sometimes forgetful of sustainable behaviours due to common dilemmas. Green consumption and environmentally friendly behaviours can be challenged in different social relations. For example, individuals with young children may face the dilemma of material consumption, such as clothing or toys. Other dilemmas may include the need for a large car such as a truck or van, if an individual has a large family (Connolly and Prothero, 2008).

There are different variations of sustainable practices, where some people may deliberately institute some environmental practices or rules into their lives, they may act ambivalently towards consumption habits. The study by Connoly and Prothero (2008) had multiple participants who claimed to follow specific environmental beliefs but contradicted themselves when it came to actual consumption habits. For example, one individual labeled themselves as a radical environmentalist, and lived in a low-impact community but flew regularly. In general, there was an acceptance that compromise was inevitable, where a completely green life was highly unlikely. Connoly and Prothero (2008) call attention to the individualization of sustainable behaviours, where individuals feel connected and responsible for their surrounding environments. Giddens (1991) argues that increased globalization, where individuals are more aware of global environmental problems and feel more interconnected with issues, has led to a greater awareness of environmentalism in western industrial nations (Giddens, 1991). Researchers suggest that instead of discussing environmental behaviours as a strategy, to study the influence and processes that lead individuals to feel engaged in environmental behaviours and individually contributing to environmental sustainability (Connolly and Prothero 2008).

Final thoughts

Occupant behaviour and its effect on the performance of the building is discussed quite thoroughly in the literature, however, the influence of sustainable design on the pro-environmental behaviours of occupants, in general, are not discussed. While many researchers focus on the direct energy impact of occupants (performance gap, energy usage), it is also important to examine general lifestyle choices that may not necessarily cause a change in the

energy usage within a building, but will contribute to, and develop from a culture of sustainability. The influence of sustainable design can extend beyond energy reduction and has the potential to influence the occupants to act in environmentally conscious ways.

The literature review provided a historical background on the growth of sustainable design in the building industry, and the influence of design on environmental awareness. The uptake of sustainable buildings by architects and developers is expected to increase in Canada as one of the top drivers is client demands (CaGBC, 2014).

The theory of value belief norm and theory of planned behaviour present explanations for pro-environmental behaviours. The two theories discuss the influence of values and beliefs that guide an individual's behaviours, and how the intentions and motivations will guide an individual to behave in a certain way (Joachim et al., 2015; Stern et al., 1999).

The results from the literature review were used to combine the topics of this study, including attitudes towards environmental issues and behaviours including commuting, diet and waste disposal. The literature that discusses commuting suggests a correlation between variability in commuting with a higher willingness to uptake more environmentally friendly commuting methods. Some literature discusses the contrast between environmental attitudes and commuting methods, where some individuals are aware of environmental issues but do not reflect their attitude in their commuting method. Lastly, literature that reviews multi-tenant buildings describes the difficulties of developing shared values among different tenants within a building.

CHAPTER 3: RESEARCH METHODS AND METHODOLOGY

Methodological approach

This research followed a descriptive non-experimental, quantitative method, to collect baseline data using two surveys distributed online through email. The purpose of the approach is to collect baseline data and compare the correlation between attitudinal factors and self-reported lifestyle choices of tenants in the pre-occupancy stage of a zero-carbon building. The study follows a descriptive design as it aimed to describe the patterns in the data. The research seeks to examine a preliminary causal relationship and future studies will seek to compare the results from the same surveys administered annually. The methods for the current study were designed using previous research methods and gaps in the literature. Previous studies have assessed the success of sustainable building design as a solution to intensive resource use, and the perceived satisfaction of the occupants. It has been suggested that researchers should not only discuss environmental behaviours as a strategy for sustainable development, but also to study the process that leads individuals to contribute to environmental sustainability and engage in sustainable actions (Connolly and Prothero, 2008). This leaves a gap in the research to address the direct impacts of sustainable design in buildings, and how it affects the attitudes of occupants and promotes environmental behaviours. To achieve the research objectives, two surveys were distributed to the employees of future tenants of a zero-carbon building, prior to their move into the new building. This baseline data initiates a five year research project that will compare the differences in lifestyle choices as the tenants change from their previous conventional office buildings to a sustainable office building. Future studies are expected to follow similar research methods, to compare the quantitative data between the pre-occupancy and post-occupancy of a zero-carbon building.

In order to establish the baseline lifestyle patterns of the occupants of a zero-carbon building, two pre-occupancy surveys were distributed to the tenants. In the process of the survey design, a literature review was conducted to determine the appropriate questions to cover the topics of diet, commuting, and waste habits, as well as cognitive, emotional and behavioural questions. The questions were developed by the evolvGREEN research team.

Participants

The surveyed companies included a local office of a Big Four accounting firm, a mid-size technology company, an environmental non-profit, offices for researchers from two universities, and a clean technology incubator. Some of the participating companies proclaim they are dedicated to sustainability, as Tenant 4 has adopted sustainability reporting, Tenant 3 publishes annual environmental sustainability reports, and Tenant 1 follows their sustainable values to promote local sustainability programs. Tenant 2 has not yet adopted sustainability reporting. To protect confidentiality, the specific companies were not named, however, during analysis the results were grouped by industry for comparison. The incubator's participants included the staff, in-house mentors and advisory committees. The participants from the two universities included the employees associated with the groups moving to the new building. When grouping the companies by industry, the accounting firm, environmental non-profit and technology firm stood alone in their own industries, whereas the incubator, and two universities were grouped as part of the education industry. The incubator was included in this category as it is affiliated with one of the universities.

The respondents are all employees of future tenants of a zero-carbon office building. The tenants and number of respondents are: behavioural survey, Tenant 1 (N=22), Tenant 2 (N=36), Tenant 3 (N=11), and Tenant 4 (N=80), and for attitudinal survey, Tenant 1 (N=33), Tenant 2 (N=57), Tenant 3 (N=16), and Tenant 4 (N=122).

Methods of data collection

To study the baseline data of self-reported lifestyle choices of tenants of a zero-carbon building, an online survey was distributed using Qualtrics software while tenants were in their previous locations. The attitudinal and the behavioural surveys were distributed in May and August 2018, respectively. The intention was to reach all future potential building occupants in order to have the same cohort of participants the following year. An initial recruitment email was sent to a contact person in each of the organizations intended to move into the zero-carbon office building in fall 2018. The contact person of each organization then sent the email to their staff, the future occupants of the zero-carbon office building, inviting them to participate in the first survey. The tenants were initially invited to participate in "Pre-occupancy Assessment Attitudinal Survey", which asked questions relating to participant's environmental awareness, action, and attitudes. Tenants were later invited to participate in "Pre-occupancy Assessment Behavioural Survey", which included questions regarding the participant's lifestyle choices, diet, commuting, and general sustainability practices.

The future tenants of the zero-carbon office building, who were 18+ years old, were invited to participate in the research study through an email invitation. The tenants were sent online consent forms informing them of the voluntary participation, compensation, possible

risks, benefits, and confidentiality notice. Participants were asked to complete background information, to give better context to the results, including information regarding their work organization, job title, experience, and work hours. Participants were then asked a set of questions that provide each respondent with a unique survey identifier, allowing their responses to be connected if they choose to participate in future surveys. The tenants were given an opportunity to provide their email to receive a copy of the final report and contact information to allow for future information of the next phases of the study. The participants were asked to give consent by either clicking the link that directed them to the survey or to click a link to exit. The survey remained open to participants for two weeks after the email was sent out. Participants were asked to provide their email, separate to the survey answers, to receive an e-gift card and the information about the results of the research. Once the data was received, the raw data underwent a cleaning process, where incomplete entries were deleted and relevant data was organized, in order to provide a more accurate analysis.

Waste, commuting, diet and sustainability practices

The participants were asked questions in the behavioural survey associated with their personal commuting, waste, and diet consumption habits. Some questions in the behavioural survey were excluded for this research. A copy of the "Pre-occupancy Behavioural Survey" is attached in Appendix A. First, the participants were asked to indicate the percentage level of waste choices at work and at home, on a scale of 100 (Ex. percentage of waste paper that goes to recycling at work). Each category of waste, paper/cardboard, plastic/glass, and food scraps/organics had each two sliders, one for work and one for home, where participants could indicate the level of waste diversion. The results displayed the difference in the average

percentage of waste diversion between home and work (home-work) for each tenant category (Tenant 1, Tenant 2, Tenant 3, and Tenant 4).

The participants were then asked to specify the types of transportation used to commute to work throughout the year. If the participants used the same transportation throughout the year, they were asked to specify the approximate percentage for each type, totaling 100%. The options for transportation types were: Car, SUV/van/ truck, Bus/LRT, Walk, Bike, Carpool, EV/hybrid, and Other. The participants were also asked to specify the length of their one-way commute to work in kilometers or minutes. If the participants used different types of transportation throughout the year, they were asked to specify the approximate percentage for each transportation type during the warmer seasons (May to October) and the colder seasons (November to April). The results displayed the average percentage of each commuting type for each tenant category and displayed in a stacked bar graph.

The participants were asked to provide the biggest factors, in text, that influence their current commuting choices. Participants were also asked a series of yes/ no questions regarding the factors influencing their future commuting choices. The results compared the percentage of respondents that answered “yes” with those that answered “no”, by tenant.

The participants were asked to report the number of times they ate beef in a week, and how often they bought locally produced food, reported on a scale (A lot of the food I buy is locally sourced, some of the food I buy is locally sourced, almost none of the food I buy is locally sourced, I do not pay attention to the source of the food I buy). To present the data, the

average number of times per week that tenants ate beef, and the average frequency that tenants bought locally produced food were calculated and each displayed in a bar graph.

Attitudes towards environmental issues and sustainability

The participants were asked questions in the attitudinal survey that related to their experience in their current workspace, their perceived well-being and productivity, interest in environmental sustainability and some basic demographic questions. For the purpose of this research, only those questions relating to participant's feelings, thoughts and engagement in environmental sustainability were considered. A copy of the "Pre-occupancy Attitudinal Survey" is attached in Appendix B. The questions relating to environmental behaviours and attitudes were grouped into three sections (Behaviour, emotion, cognitive), each with four questions under each category. The first set of questions, related to behaviour, asked participants to "rate the extent to which you engage in the following behaviours at work", using a Likert scale from 0-never to 4-always. The second set of questions, related to emotion, asked participants to "rate the extent to which the following items reflect how you feel about environmental sustainability" and used a Likert scale 0- not at all how I feel, to 4- very much how I feel. The third set of questions, related to cognitive thinking, asked participants to "rate the extent to which the following items reflect how you think about environmental issues" and used a Likert scale of 0- not at all how I think, to 4- very much like I think. The average rating was calculated for each category of questions and for each individual question. The data was then organized into the relevant tenant groups.

Parking lot observation

To collect the baseline data of the commuting choices from tenants, an observational study was completed in the respective parking lots of the future tenants, during the pre-occupancy and post-occupancy of a zero-carbon office building.

Commuting pre-occupancy

Parking lot data was collected once or twice a day for a total of 4 days. The parking lots of the tenants' previous locations were observed to identify vehicle composition and commuting choices. The parking lots were observed once on the first day, August 21, beginning at 10:30 am, and once on the second day, August 22, beginning at 11:00 am. The third and fourth observations occurred twice a day on August 23rd beginning at 10:30, and again at 2:10pm, and on August 24th beginning at 11:00pm and again at 2:45 pm. The parking lot data collection of Tenant 3 occurred on campus. The data collection began at 10:00 am, and again at 2:00 pm. The size of the car was noted (either a small car/sedan or a large car/SUV/van/truck), as well as if it was gas powered, hybrid, or EV. The number of motorcycles and bicycles on the bicycle racks in the parking lot, or outside the building were also recorded. To present this data, the average number of each commuting type at each tenant location was calculated between the observation days and times from summer 2018.

Commuting post-occupancy

The post-occupancy parking lot data was collected over three different collection periods, December 2018, January 2019 and August 2019. The same collection methods were used as the pre-occupancy data collection, however, only the parking lot of the zero-carbon office building

was observed. The parking lot collection in December 2018 occurred over three days, December 4th, 5th and 6th, with two observations per day, 10:00 am and 3:30 pm. Similarly, the parking lot collection in January 2019 occurred over three days, January 21st, 22nd and 24th, with two observations per day, 10:00 am and 3:30 pm. The final parking lot collection in August 2019 occurred over two days, August 19th and August 20th, with two observations per day, 10:00 am and 3:30 pm. The parking lot data collection occurred during the final fitout of the zero-carbon office building, and some construction worker's vehicles were present in the parking lot. Those vehicles that were obvious to belong to contracting services were not counted. The number of bicycles and motorcycles in the parking lot, or outside the building were also recorded. To present the data, the average percentage composition of each commuting type was calculated between the observation days and times from winter 2018 and summer 2019.

Data analysis

The statistical significance of the results was compared using various models. The responses from each individual were first tested, prior to the comparison between different tenant cohorts. The calculation of the significance with the individual responses identified the attitudinal statements that were the most influential on the reported behaviours. The calculation of the significance with tenant cohorts identified the difference in the average responses between the tenants.

Pre-occupancy behavioural survey

A two-sample t-test assuming unequal variance was used to compare the means of answers to the waste-related questions from the behavioural survey. The answers were compared

between ‘home’ and ‘work’ for each category: waste paper/cardboard to recycling, plastic/glass to recycling, and food scraps/organics to compost. The p-value for the two-tail analysis was compared to the significance level (0.05), and if it was less, the null hypothesis was rejected.

A one way ANOVA was used to compare the significance between the means from the yearly commuting methods of the four tenants. The significance test was done for each commuting method (Car, SUV/van/truck, EV/hybrid, etc.), to determine the p-value. If the p-value was less than the significance level (0.05), the null hypothesis was rejected.

A paired t-test was conducted to determine the significance between the means of answers to the commuting related questions for warmer and colder seasons from the behavioural survey. The participants’ answers were not separated by tenants for this significance test, as the purpose was only to compare the answers between the seasons. Each commuting category (Car, SUV/van/truck, EV/hybrid, etc.) was compared between the warmer and colder seasons. The p-value was compared to the significance level (0.05), and if it was less, the null hypothesis was rejected.

A one-way ANOVA was used to compare the significance between the means of the likelihood of changing commuting methods with the integration of certain building features (proximity to public transit, bicycle routes, onsite showers, EV charging stations). The significance testing was done for each commuting factor between the four tenants to determine the p-value. If the p-value was less than significance level (0.05), the null hypothesis was rejected.

Two one-way ANOVAs were used to compare the means of answers to the frequency of beef consumption, and frequency that participants bought locally produced food (on a scale). The means of the four tenants were compared to determine the p-value. If the p-value was greater than the significance level (0.05), the null hypothesis was rejected.

Pre-occupancy attitudinal survey

A one-way ANOVA was used to calculate the difference in the average response from each tenant to the behaviour, emotion and cognitive category. The p-value was determined, and if it was greater than the significance level (0.05), the null hypothesis was rejected. The responses from Tenant 1 were not included for the statement "promoting impact reduction within organization", as they acted as a pilot for the attitudinal survey and were not given one of the statements. As such, the missing data from Tenant 1 required their responses to be omitted from the significance test of the statement in the behavioural category.

Multiple one-way ANOVA test were used to calculate the significance in the difference between the average response from the four tenants for each statement within the behavioural category from the attitudinal survey. The ANOVA tested the null hypothesis stating there was no difference in the average rating for each statement in the behavioural category between the tenants of the zero-carbon building. The F-value was determined, and if it was greater than the F-critical value, the null hypothesis was rejected.

Two one-way MANOVAs were conducted to test the significance in the difference between the average response from the four tenants for each statement within the emotional and

cognitive categories from the attitudinal survey. The p-value was calculated, and if it was lower than the significance level (0.05), then the null hypothesis was rejected.

Comparison between pre-occupancy behavioural survey and attitudinal survey

A multiple linear regression was used to compare the individual responses of the influence of attitudes towards environmental issues and sustainability (independent variables) on commuting choices (dependent variable) throughout the year. The significance of the correlation between the reported attitudes and each commuting choice was presented in a correlation matrix which indicated a positive or negative correlation between the variables. Using the Type III sum of squares calculation, the independent variables (attitudes) were identified that brought significant information to explain the variability in dependent variables (commuting). The R_2 value was presented to explain the variability of the dependent variable.

A log-linear regression was used to compare the individual responses of the influence of attitudes towards environmental issues and sustainability (independent variables) with the weekly frequency of beef consumption (dependent variable). This significance test differed from the multiple linear regression as the consumption responses were fixed intervals. The $Pr>Chi_2$ value was compared to the significance level (0.05), and if it was greater, then the null hypothesis failed to be rejected.

Limitations

The following are the outlined methodological limitations within the current study.

- Missing data: While the surveys were sent out to all employees of the participating tenants, the surveys were not mandatory. Therefore, the study did not receive a complete response from all of the future employees (approximately 200), but rather a self-selected cohort of potential occupants. It is possible that the results are not representative of those occupants that did not participate in the study. Some respondents participated in one survey but not the other, requiring their data to be deleted for some statistical tests. In future studies it would be useful to require respondents to participate in both surveys through a participation contract.

- Self- reported data: The data from the attitudinal and behavioural surveys are based on self-reported information from participants. The self- reported data are limited as it cannot be independently verified and must be accepted whether true or not. There are some biases associated with this data as it is based on participant's selective memory, honesty, and exaggeration. The bias of selective memory means that some participants may remember some events and not others, which may result in skewed answers that are not reflective of actual events. The bias of honesty results in some participants' answers to questions based on answers that are more acceptable, rather than answers that are truthful. Additionally, some aspects of the survey may have influenced participants to respond in a certain way. For example, in the behavioural survey, the prelude to the beef consumption question notes the global greenhouse gas emissions from cattle. Some efforts were made by making the surveys anonymous to avoid publicizing participant's answers, however some participants may still skew answers for this purpose. Another

bias of self-reported data could be exaggeration where a participant embellishes an event as being more significant than it actually is (Brutus, Aguinis, and Wassmer, 2013).

- Measures used to collect data: During the pre-occupancy parking lot observations, there were some pre-occupancy office buildings that did not have bike racks outside, impacting the observation of bikes. It is possible that the tenants who did bike took their bikes inside their offices, however it was not possible to account for these per the observation method. In future studies, researchers may provide an opportunity for participants to tell the researchers if they bring their bicycles inside. Additionally, during the pre-occupancy parking lot observations, the vehicle counts were taken from the parking lots adjacent to the tenant's building. These parking lots were often shared by occupants of multiple buildings and therefore contained vehicles from people working in organizations not affiliated with the zero-carbon building. During the parking lot observations, the parking spots labeled visitors were excluded from the parking lot count, however it is possible that some regular tenants parked in these spots. Furthermore, during the initial post-occupancy observations the zero-carbon building was still undergoing fit-out construction and there were some trucks in the parking lot belonging to construction workers. The trucks that clearly belonged to construction workers (visible construction company branding, tools in back) were excluded from the vehicle counts, however it is possible that some workers drove cars that could not be distinguished. Therefore, some visitor vehicles may have been included in the parking lot observations. In future research it would be best to identify exactly which vehicles belonged to building visitors by requiring a parking pass identifier from all regular building occupants.

- Statistical inferences: The missing data in the attitudinal and behavioural surveys led to a small sample size for statistical tests, increasing the margin of error (Brutus et al., 2013). Additionally, the limitations of the one-way ANOVA test include the inability to distinguish the differences between specific tenants, only the tenants as a whole. The limitations of a two-sample t-test include the inability to reveal if one mean is greater or lesser than the other, rather it can only show if the means are significantly different across all of the tenants between work and home.

CHAPTER 4: RESULTS AND DISCUSSION

This chapter presents the results and analyzes the data to achieve the research objectives regarding the baseline behaviours and attitudes of tenants in a zero-carbon building. Previous research has stated the importance of sustainable buildings in their contribution to economic, environmental and social capital. Sustainable building development should include extensive research into the assessment of a sustainable culture within these buildings (Birkeland and Newton, 2008).

Hypotheses

Throughout history, buildings have been designed and built to communicate certain principles and values (Cranz et al., 2014). It was expected that the zero-carbon, net positive energy building would inspire its occupants to mirror the intention of the sustainable building, through its physical influence as well as educational workshops and interventions. Therefore, over time, it is expected that a culture of sustainability will develop among the tenants that encourages sustainable lifestyle patterns. The culture of sustainability should inspire the tenants to reduce energy and resource use that directly affect the building's operation, including the use of lights, heating, cooling, and elevator use. In addition, the building's culture may influence its tenant's general lifestyle patterns, including their diet, commuting, and waste patterns. The change in behaviours can be described as incorporating more pro-environmental behaviours into their lives, caused by the influence of an increased environmental awareness (Aguilar-Luzon at al., 2012). As the tenants are exposed to the building, and as the culture of sustainability develops among the organizations, the tenants may shift towards more sustainable commuting styles, including carpooling, or using the bus/LRT during the colder months, and walking, or

bicycling during the warmer months. The parking lot composition of the sustainable office building is expected to change from a gas or diesel car and SUV dominant composition, to a larger percentage of EV/hybrids, bicycles, and overall, fewer motorized vehicles. Lastly, the tenants are expected to improve the diversion rates of waste to the proper receptacles at work, and at home. However, before the changes in culture are observed, it is important to establish the baseline behaviours and attitudes.

The findings from the results of the attitudinal and behavioural survey provide insight into the baseline behaviours and attitudes of the future tenants of a zero-carbon office building. The theory of planned behaviour links an individual's previous experiences or knowledge with the likelihood of carrying out future behaviour, as well as their attitude towards performing a behaviour. Tenants may gain further information regarding pro-environmental lifestyle choices as they work within a zero-carbon office building, which may influence their future behaviours. As exhibited in the study by Miller and Buys (2008), the tenants reported a change in behaviours and environmental awareness after the retrofitting of their workspaces. It is expected that a similar succession would occur as the tenants are exposed to the zero-carbon office building and sustainable workspace. The value belief norm theory describes how an individual's values can influence their actions and decisions (Aguilar-Luzon et al., 2012). In this specific research, this theory applies to the participant's feelings, emotions, and thoughts towards environmental issues and sustainability and their self-reported diet, waste, and commuting habits. Based on this theory, those participants that report high engagement in environmental behaviours, thoughts, and feelings, have egoistic values that consider the costs and benefits of pro-environmental behaviours.

Pre-occupancy behaviour survey results

The "Pre-occupancy Behavioural Survey" was distributed to the employees of future tenants of a zero-carbon office building to examine lifestyle, diet, commuting and sustainability practices. The results are presented in the order of questions from the behavioural survey, seen in Appendix A.

Waste diversion

Waste management practices and diversion rates represent the amount of waste that is diverted from landfills and goes into proper disposal receptacles. These results were collected during the pre-occupancy stage, therefore the management systems in the tenant's buildings differed. The survey examined three categories of waste: paper/cardboard, plastic/glass containers, and food scraps/organics. The diversion rate was requested for each of the three waste categories and for average practices at home and work. In general, the participants reported a higher mean diversion rate at home (waste paper/cardboard=90%, plastic/glass=91%, food scraps/organics=79%) than at work (waste paper/cardboard=86%, plastic/glass=84%, food scraps/organics=67%). Therefore, while in their pre-occupancy office buildings, participants were more likely to dispose of waste in the proper receptacles at home than at work.

Figure 2 displays the tenant breakdown of the difference between the average self-reported diversion rates of waste at home and at work. Negative values describe a larger average diversion rate of waste at work than at home, whereas positive values describe a larger average diversion rate of waste at home than at work.

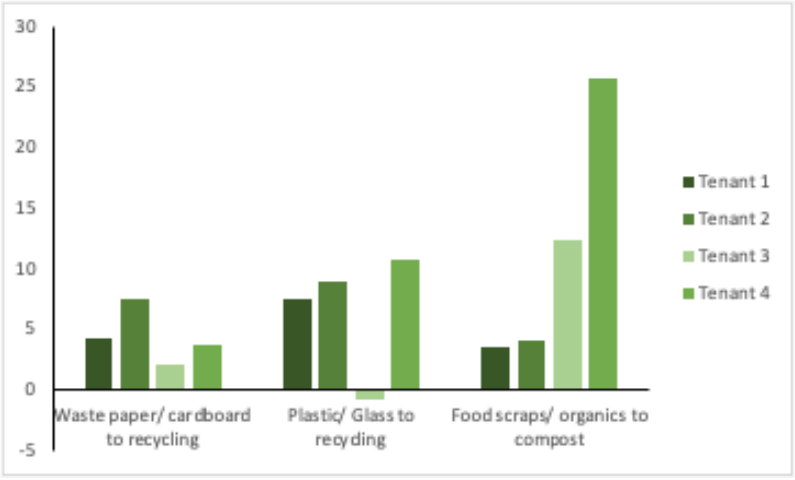

Figure 2. Average percentage difference (home-work) between waste diversion rate at home and work, Tenant 1 (N=18), Tenant 2 (N=31), Tenant 3 (N=11), and Tenant 4 (N=79).

Tenant 3 reported the lowest difference in diversion rate of paper and carboard to recycling between home and work (2%), whereas Tenant 2 reported the highest difference in diversion rate (8%). Tenant 3 reported the highest average diversion rate of paper and cardboard to recycling at home (95%) and work (93%), whereas Tenant 4 reported the lowest average percentage at home (85%) and work (81%). Tenant 3 reported the lowest difference in diversion rate of plastic and glass to recycling between home and work (-1%), whereas Tenant 4 reported the highest difference in diversion rate (11%). Tenant 3 reported the highest average diversion rate of plastic and glass to recycling at home (95%) and at work (96%), whereas Tenant 4 reported the lowest average percentage at home (87%) and work (76%).Tenant 1 reported the lowest difference in diversion rate of food scraps and organics to compost between home and work (3%), whereas Tenant 4 reported the highest difference in diversion rate (26%). Tenant 3 reported the highest average diversion rate of food scraps and organics to compost at home

(92%) and at work (80%), whereas Tenant 4 reported the lowest average percentage at home (65%) and work (39%).

The difference in means of diversion rates of Tenant 1, Tenant 2 and Tenant 3 for the three waste categories between home and work were not statistically significant. This was because the p-values for Tenant 1 (paper/cardboard=0.18, plastic/glass=0.10, food scraps/ organics=0.57), Tenant 2 (paper/cardboard=0.071, plastic/glass=0.052, food scraps/ organics=0.62) and Tenant 3 (paper/cardboard=0.54, plastic/glass=0.55, food scraps/ organics=0.26) were greater than the alpha value (0.05). Therefore, the null hypothesis stating there is no difference between the means of the waste diversion between home and work of Tenant 1, Tenant 2 and Tenant 3 cannot be rejected. Additionally, the difference in means of diversion rates of Tenant 4 of paper/cardboard disposal to recycling between home and work were not statistically significant due to the higher p-value (0.23) than the alpha (0.05). However, the difference in means of diversion rates of plastic/glass to recycling and food scraps and organics to compost between home and work for Tenant 4 were statistically significant, as the p-values (plastic/glass=0.000023, food scraps/organics=0.00079) were lower than the alpha (0.05).

Tenant 4 displayed the greatest difference in diversion rate of food scraps and organics to compost between home than at work. This could signify that the waste disposal systems at work are less comprehensible for organic matter than at home. Furthermore, Tenant 4 may not have distinct compost bins at work, leaving employees to throw away organic waste in the trash bin.

Waste management systems may be similar for all tenants in each disposal category, where tenants may be accustomed to using one trash bin for all waste. Often in office spaces, each desk will have a personal trash bin which collects all trash including recyclables and organics. Therefore, some tenants may be habitual in using their personal trash bins instead of using the shared office waste disposal. The post-occupancy zero-carbon office building is managed with central bins instead of individual bins, as per the building management policy. Therefore, in the future, tenants may not have individual bins available, and will have to follow the building policies.

As discussed by Birkeland (2012), the convenience and comfort of certain actions can heavily influence the likelihood of performing an action, in this case disposing of waste in the shared waste disposal, instead of under their personal desk. In the pre-occupancy stage, the tenants may have various disposal systems, however with a new comprehensive disposal system in the zero-carbon office building, it is expected that the average percentage of diversion rates for each waste category will increase. Based on the organization values and sustainability commitment, the high diversion rate for all three waste categories from Tenant 1 was expected. However, it is unexpected that the average percentage of diversion rates for all three waste categories was greater for Tenant 2 than Tenant 4, as Tenant 4 has integrated sustainability into their operations and Tenant 2 has not. Additionally, it was unexpected that Tenant 3 had a high difference in diversion rate of food scraps and organics to compost between home and work, as it was expected that they would follow the same pattern as the previous waste categories. In general, the tenants in the pre-occupancy stage report better waste diversion at home than at

work, and more frequent diversion of waste paper and cardboard, and plastic and glass to recycling, than food scraps and organics to compost.

Commuting

Commuting practices display the average type of chosen transportation methods used throughout the year to commute to work. The survey examined the one way commuting distance of respondents from home to work, in kilometres. Over half of respondents (53% of respondents) reported that they live within 10 km of the zero-carbon office building, and of these respondents, 8 reported that they lived within walking distance (less than 2 km). There were 65 respondents (45% of respondents) that reported living more than 11 kilometres away from work, with 37 of these participants living more than 21 kilometres away. The survey also examined the commuting practices through the percentage composition of common forms of transportation over the past year, including car (gas/diesel), SUV/van/truck (gas/diesel), EV/hybrid, bus/LRT, walk, bike, carpool, and other. Respondents were asked if they use the same transportation methods throughout the entire year, and if not, to distinguish between transportation methods in warmer and colder seasons.

In general, respondents reported that their primary commuting method to work was by car, throughout both the warmer (32%) and colder seasons (47%). According to the National Household Survey from 2011 (Statistics Canada, 2018), the majority of the employed population of Waterloo used cars, trucks or vans as their primary commuting choice (82%). In this study, the combined usage of car/SUV/van/truck, including EV/hybrids, was 78% throughout the year. In the National Household Survey, 5% of the population reported using transit, 7% reported

carpooling, 4% reported walking, 1% reported cycling and 1% reported "other" transportation (Statistics Canada, 2018). In comparison, 10% of the current study's respondents reported using the bus and light rail transit, 4% reported carpooling, 4% reported walking, 2% reported cycling, and 2% reported "other" transportation. The future occupants of the zero-carbon office building report a smaller frequency of car/truck/van usage, and a greater use of bus and light rail as commuting methods to work. However, the national study does not distinguish between vehicle types and the car category includes hybrid and EVs, which provide a more sustainable commuting option, and are supported by the new infrastructure of the zero-carbon office building.

Figure 3 displays the tenant breakdown of the average composition of forms of transportation over the past year, for those respondents that reported to use the same transportation methods over the entire year. There were 138 respondents (Tenant 1 N=18, Tenant 2 N=31, Tenant 3 N=10, and Tenant 4 N=79) that reported to use the same type of transportation throughout the year to commute to work, while 8 respondents reported that they use different types of commuting methods during warmer and colder seasons. In general, all respondents reported car usage as one of their greatest percentage of transportation method to work throughout the year, and during the warmer and colder seasons. Tenants that included "other" in their transportation composition reported to use commuting methods including "working from home", "go train", and "via train". Tenant 1 displayed the smallest average car usage (34%), and the highest average bus/LRT usage (32%). Tenant 1 also reported the highest average usage of biking (10%) and walking (14%) as commuting types throughout the year. Tenant 2 and Tenant 4 displayed similar commuting frequency as they reported car usage (Tenant 2=62%, Tenant

4=74%) as their most frequent commuting type and SUV/van/truck as the second highest commuting type (Tenant 2=14%, Tenant 4=13%). Tenant 3 reported the highest frequency of carpool usage (16%) throughout the year among the four tenants. Lastly, Tenant 1 and Tenant 2 displayed the greatest frequency of EV/hybrid (Tenant 1=5%, Tenant 2=3%) usage throughout the year.

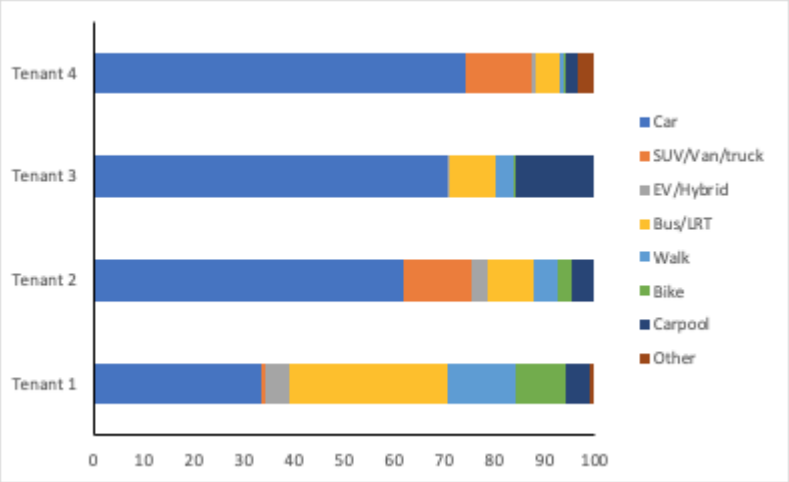

Figure 3. Average percentage composition of commuting modes from tenants that reported no seasonal change. Tenant 1(N=18), Tenant 2 (N=31), Tenant 3 (N=10) and Tenant 4 (N=79).

The difference in calculated means between the tenant's frequency of commuting by car, bus/LRT, walking, and biking throughout the year was statistically significant as the p-value (car=0.003, bus/LRT=0.00028, walk=0.0052, bike=0.00081) was less than the alpha (0.05). Therefore, the null hypothesis stating there is no difference between the calculated means of tenant's frequency of commuting by car, bus/LRT, walking or biking, can be rejected. The difference in calculated means between the tenant's frequency of commuting by SUV/van/truck, EV/hybrid, and carpooling throughout the year were not statistically significant as the p-value

(SUV/van/truck=0.22, EV/hybrid=0.55, carpool=0.36) was greater than the alpha (0.05). Consequently, we fail to reject the null hypothesis stating there is no difference in the calculated means between the tenant's frequency of commuting by SUV/van/truck, EV/hybrid, and carpooling.

The majority of participants reported to use the same method of transportation throughout the year, with only 8 respondents (5%) choosing different commuting types between the warmer and colder seasons. Figure 4 and Figure 5 display the average percentage composition of forms of transportation used by respondents during the warmer (Figure 4) and colder (Figure 5) seasons.

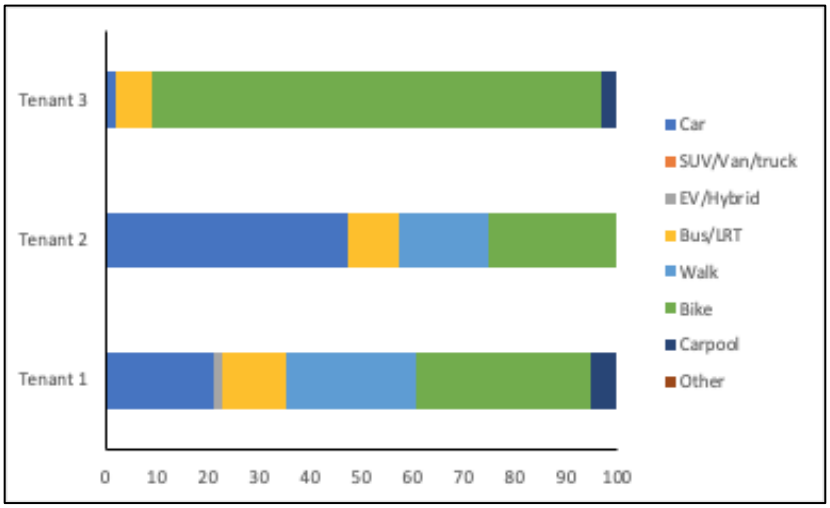

Figure 4. Average percentage composition of commuting modes during warmer season (May to October), by tenant. Tenant 1 (N=3), Tenant 2 (N=4), Tenant 3 (N=1), and Tenant 4 (N=0).

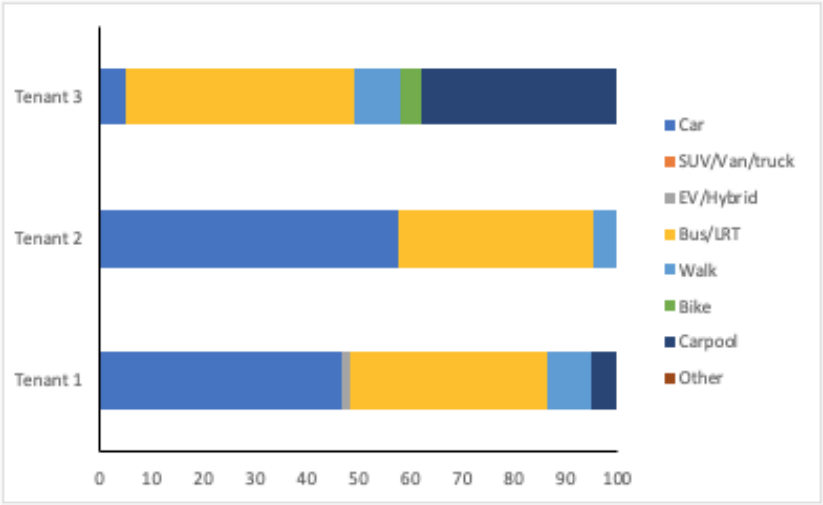

Figure 5. Average percentage composition of commuting modes during colder season (November to April), by tenant. Tenant 1 (N=3), Tenant 2 (N=4), Tenant 3 (N=1), and Tenant 4 (N=0).

These 8 respondents reported that they do not use the same methods of transportation throughout the year to commute to work (Tenant 1 N=3, Tenant 2 N=4, Tenant 3 N=1, Tenant 4 N=0). Tenant 2 (Warmer=48%, Colder=58%) reported car usage as the primary source of commuting type between the two seasons. Tenant 1 reported the highest use of car commuting in colder seasons (47%), compared to the highest use of biking in warmer seasons (34%). Tenant 3 reported to use primarly bus/LRT in the colder seasons (44%), and biking in the warmer seasons (88%). There was a distinct increase in bike usage in the warmer season (Tenant 1=34%, Tenant 2=25%, Tenant 3=88%), compared to an increased reporting of bus/LRT usage in the colder season (Tenant 1=38%, Tenant 2=36%, Tenant 3=44%). Tenant 3 also reported an increased usage of carpooling throughout the colder season (38%) compared to the warmer season (3%). Surprisingly, Tenant 3 reported a higher frequency of walking in the colder season (9%) than in

the warmer season (0%). There were no respondents that reported to use “other” transportation methods in their transportation composition throughout the warmer and colder seasons. There were no respondents that reported to use a different level of EV/hybrids, and no respondents that reported to use an SUV/van/truck/truck in the warmer or colder seasons.

The difference in calculated means of the composition of car, walk and carpool between the warmer and colder months were not statistically significant as the p-values (car=0.28, walk=0.14, carpool=0.34) were greater than the alpha (0.05). Therefore, the null hypothesis stating that there is no difference between the means of car, walking, and carpooling frequency between warmer and colder seasons, cannot be rejected. However, the difference in calculated means of the frequency of bus/LRT and bike usage are statistically significant as the p-values (bus/LRT=0.20, bike=0.032) are less than the alpha (0.05). Therefore, the null hypothesis stating there is no difference between the means of the bus/LRT and bike values from warmer and colder seasons can be rejected. Based on the results, it seems that bikes are more likely to be used in the warmer season and transit is more likely to be used during the colder season.

Some respondents noted that they were unable to use public transit, or other short-distance commuting methods as they lived far away. However, for those tenants that live within a 10-kilometre distance from their workplace, the use of biking, or public transit is much more viable. As described by Heinen et al. (2011) reported participants that responded to a commuting survey in the Netherlands were strongly influenced by their attitudes towards bicycling to work on the commuting choice. Therefore, it is possible that the distance that tenants live from their workplace is not the deciding factor of their commuting type, within reason. The distance of

travel did not have an effect on the commuting choice, as the attitudes towards bicycling outweigh this factor.

Parking fees are another factor than can influence commuting choices. The pre-occupancy parking costs for Tenant 3 ranged from $42 to $63 monthly and Tenant 1 parking costs were about $150 monthly. In contrast, parking costs for Tenant 2 and Tenant 4 were $0. The monthly parking fees may have a significant influence on the likelihood of using a car as a primary commuting choice to work.

Tenant 1 reported to use the most sustainable commuting methods, as they reported the lowest car usage (34%), and highest bus/LRT (32%), biking (10%) and walking (14%) use throughout the year. However, it was unexpected that Tenant 3 had a primary commuting method of cars throughout the year and reported higher car usage than Tenant 2. The respondents within Tenant 3 that distinguished between warmer and colder seasons reported high frequency of biking, carpooling and bussing, and low frequency of car and SUV/van/truck usage. Tenant 4 was the only tenant with all respondents reporting the same commuting choices throughout the year. Therefore, it can be said that the respondents from Tenant 4 are more fixed in their commuting methods as they do not vary throughout the seasons.

Tenant 1 had the greatest variation in commuting types, including car and bus usage in the colder seasons, and car, bus, walking and biking in the warmer seasons. As discussed by Heinen and Ogilvie (2015), individuals that display the highest variation in the modes of transportation are expected to exhibit the greatest shift in transportation modes over time.

Therefore, the respondents from Tenant 1 are already used to a large variation in commuting types, therefore are more open to altering their daily commute to and from work. Furthermore, these respondents are open to shifting their commuting type to bicycling and public transit with the addition of better accessibility such as transit stops and bike routes and building features such as showers. An increased confidence in performing a behaviour, and being able to anticipate the outcome, may also encourage individuals to perform the behaviour more often (Heinen and Ogilvie, 2015). Tenants that have a greater variation in their commuting types, may become more confident in these commuting types as they use them more frequently. However, individuals that have less variability in their commuting types, such as a high frequency of car or SUV usage, do not have the opportunity to become more confident in biking, walking or using public transit, and therefore are less likely to adopt these commuting types.

Diet

The questions related to diet displays the average frequency of beef consumption and purchasing locally sourced foods. In general, Tenant 1 and Tenant 3 reported the most sustainable diet patterns, as they reported the lowest weekly consumption of beef, and most frequent purchase of locally sourced foods.

Figure 6 displays the average number of times tenants ate beef in a week. In general, the self-reported weekly consumption from tenants' range between 0.6 to 2.5 times per week, with an average consumption of 1.5 times per week. Tenant 2 and Tenant 4 reported more beef consumption, than Tenant 1 and Tenant 3. Tenant 1 reported consuming beef the least often (0.6 times per week), whereas Tenant 2 reported consuming beef four times as often (2.5 times per

week). It should be mentioned that Tenant 2 received a daily catered lunch. Therefore, it may be easier for those tenants to access a lunch that includes beef and they may choose that option without assessing their environmental impact. Statistically, the calculated mean of the number of times respondents eat beef in a week is significantly different between at least two tenants. From this test, the p-value (0.038) is less than the alpha (0.05). Therefore, there is evidence to reject the null hypothesis stating that there is no difference in the average number of times respondents eat beef each week, between the tenants.

An explanatory sentence was used to introduce the topic of food so that participants would understand why we were asking about their diet. “The type of **food** we eat also has different impacts on the environment. For example, cattle account for nearly 10% of global greenhouse gas emissions, primarily methane from their digestive system.”. This explanation might create a bias as respondents could assume what response might be desired by the researchers. However, the statistically significant differences found among at least two of the tenants indicates evidence that respondents reported different diets, despite the potential associated bias.

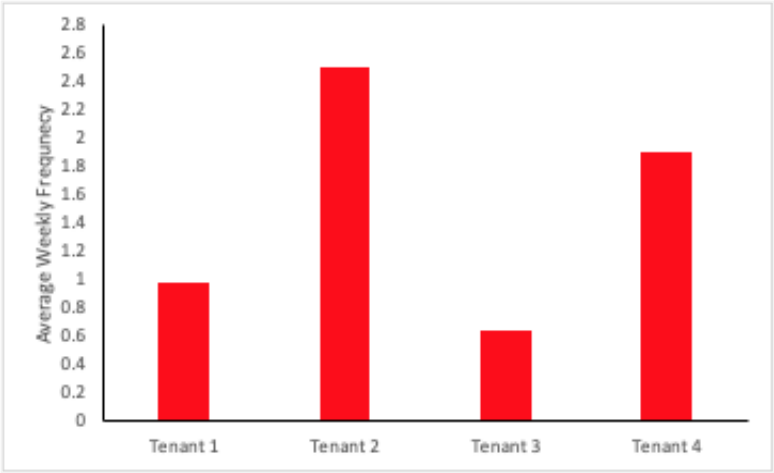

Figure 6. Average weekly frequency that tenants eat beef. Tenant 1 (N=20), Tenant 2 (N=33), Tenant 3 (N=11), and Tenant 4 (N=77).

Figure 7 displays the frequency that tenants purchase locally (Ontario) sourced food, on a scale from "A lot of the food I buy is locally sourced" (1), "Some of the food I buy is locally sourced" (2), "Almost no food I buy is locally sourced" (3), "I do not pay attention to the source of food I buy" (4), and "Prefer not to say" (5). Overall, the respondents reported an average rating closest to "Some of the food I buy is locally sourced" (2.09). In general, Tenant 2 and Tenant 4 reported purchasing locally sourced foods less frequently than Tenant 1 and Tenant 3. Tenant 4 reported the highest average rating (2.37), whereas Tenant 3 reported the lowest average rating (1.78). The calculated mean of the frequency that respondents purchased locally sourced food is not significantly different between the four tenants, as the p-value (0.087) is greater than the alpha (0.05). Therefore, the null hypothesis stating there is no difference in the average response to the frequency that respondents purchase locally sourced food cannot be rejected. Two one-way ANOVAs were used to calculate the difference in means between the four tenants for the two questions related to diet.

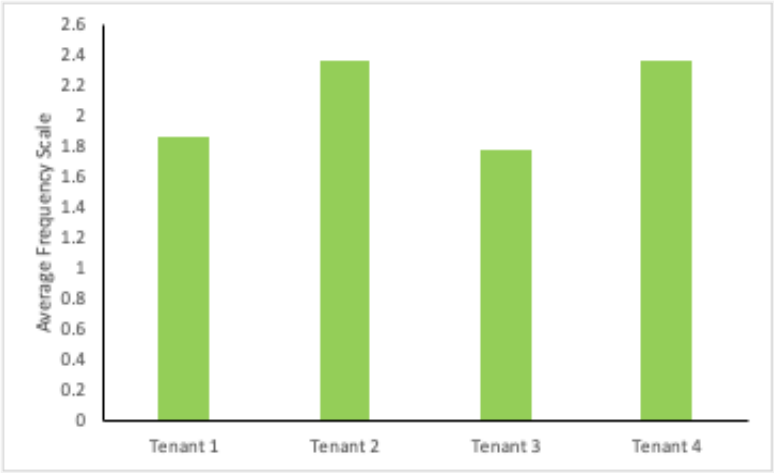

Figure 7. Average frequency that tenants buy locally sourced food on scale " a lot of the food I buy is locally sourced" (1), "Some of the food I buy is locally sourced" (2), "Almost no food I buys is locally sourced" (3), " I do not pay attention to the source of the food I buy" (4) and "prefer not to say" (5). Tenant 1 (N=21), Tenant 2 (N=33) Tenant 3 (N=11), and Tenant 4 (N=79).

Commuting factors

The commuting factors represent the factors that may influence a change in commuting choice, including building design components, and structural additions. Figures 8, 9, 10, and 11 display the factors that influence the respondents commuting choices from each tenant of the zero-carbon office building. These graphs show the percentage of responses to a series of yes/no questions, that propose different scenarios that may affect the respondents commuting choice. Respondents were first asked if they were interested in changing their commuting method to work. There were 45% of respondents that responded 'yes', 52% of respondents that responded 'no', and 3% of respondents that responded, 'not applicable'. In general, the proximity of the workplace next to a transit stop and the availability of a good bike route are the most important factors for Tenant 1 to alter their commuting methods. The availability of EV charging stations is

the most important factor for Tenant 2, to increase the likelihood of purchasing an EV. The availability of showers in the workplace is the most important factor for Tenant 3 to influence the likelihood of bicycling to work.

Figure 8 displays responses to “Would you be more likely to take public transit if your workplace was next to a transit stop?”. Overall, 49% of all participants responded ‘yes’, 40% responded ‘no’, and 11% responded ‘not applicable’. Tenant 1 reported the greatest percentage of respondents that reported to be more likely to take public transit if their workplace were next to a transit stop. Tenant 1 (yes=59%, no=18%), Tenant 3 (yes=53%, no=10%) and Tenant 4 (yes=48%, no=46%) had a greater percentage of respondents that responded ‘yes’ than those that responded ‘no’. However, Tenant 2 had a greater percentage of respondents that responded ‘no’ (49%) than those that responded ‘yes’(37%) to a likelihood of taking public transit if their workplace was next to a transit stop.

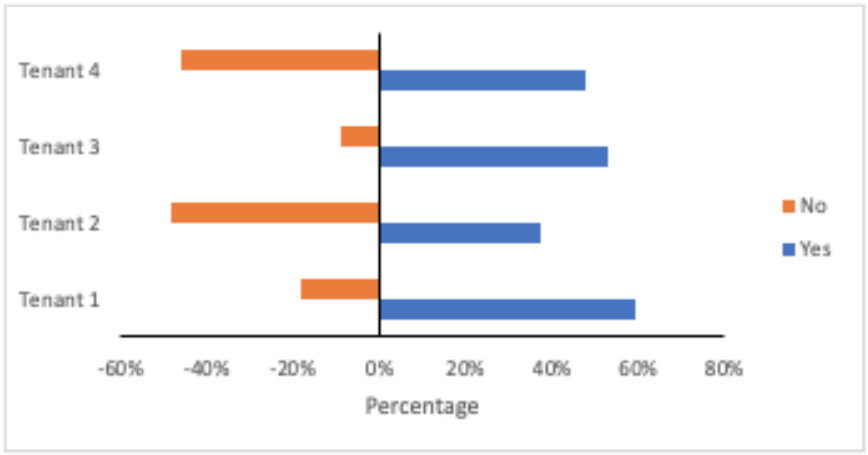

Figure 8. Percentage of responses to “Would you be more likely to take public transit if your workplace was next to a transit stop?”. Tenant 1 (N=22), Tenant 2 (N=35), Tenant 3 (N=11), and Tenant 4 (N=80).

A one-way ANOVA was used to calculate the difference in means between the four tenants for the likelihood of taking public transit if their workplace were next to a transit stop. The calculated mean of the likelihood that respondents would take public transit between the four tenants is not significantly different, as the p-value (0.32) is greater than the alpha (0.05). Therefore, the null hypothesis stating there is no difference between the tenant's average responses to the likelihood of taking public transit if the workplace is next to a transit stop cannot be rejected.

Figure 9 displays tenant's answers to "Would you be more likely to purchase an electric vehicle if there were charging stations at your workplace?". There were 55% of participants that responded 'yes', 40% of participants that responded 'no' and 5% of participants that responded 'not applicable'. Tenant 2 reported the greatest percentage of respondents that reported to be more likely to purchase an EV if there were charging stations available at their workplace. Tenant 1 (yes=55%, no=41%), Tenant 2 (yes=60%, no=34%), and Tenant 4 (yes=53%, no=43%) reported a higher percentage of respondents that responded 'yes' than those that responded 'no'. Tenant 3 reported a higher number of respondents that would not be more likely (59%) to purchase an EV if there were charging stations at their workplace, than those that would (41%).

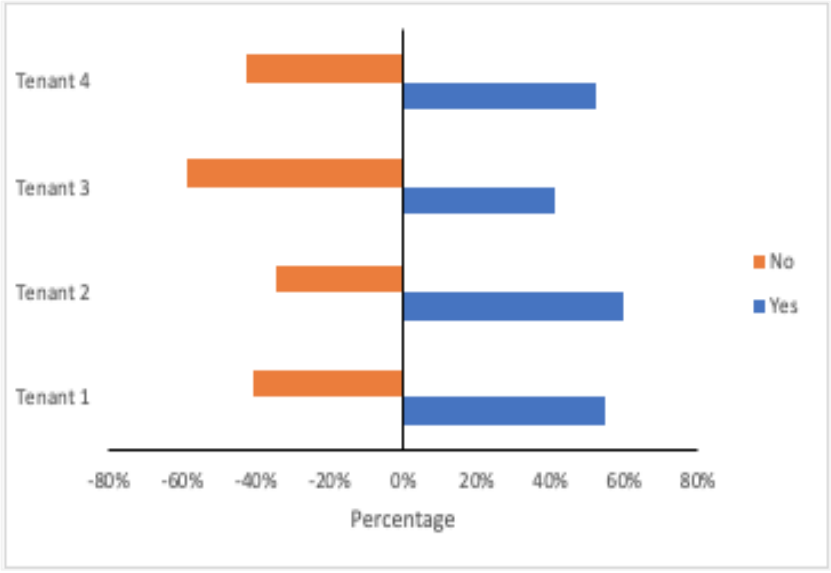

Figure 9. Percentage of responses to "Would you be more likely to purchase an electric vehicle (EV) if there were charging stations at your workplace?". Tenant 1 (N=22), Tenant 2 (N=35), Tenant 3 (N=11), and Tenant 4 (N=80).

A one-way ANOVA was used to calculate the difference in means between the four tenants for the likelihood of purchasing an EV if there were charging stations at their workplace. The calculated mean of the likelihood that respondents would purchase an EV between the four tenants is not significantly different, as the p-value (0.94) is greater than the alpha (0.05). Therefore, the null hypothesis stating there is no difference between the tenant's average responses to the likelihood of purchasing an EV if there are charging stations at the workplace cannot be rejected.

Figure 10 displays answers to "Would you be more likely to bicycle to work if showers were available at your workplace?". Overall, 47% of participants responded 'yes', 45% of participants responded 'no' and 8% responded 'not applicable'. Tenant 3 reported the highest

percentage of respondents that reported to be more likely to bicycle to work if showers were at their workplace. Tenant 1 (yes=73%, no=14%) and Tenant 3 (yes=95%, no=5%) display a higher number of respondents that responded ‘yes’, than those that responded ‘no’. In contrast, Tenant 2 (yes=42%, no=47%) and Tenant 4 (yes=36%, no=56%) had a higher percentage of respondents that did not agree that they would be more likely to bicycle to work if there were showers available, than those that would.

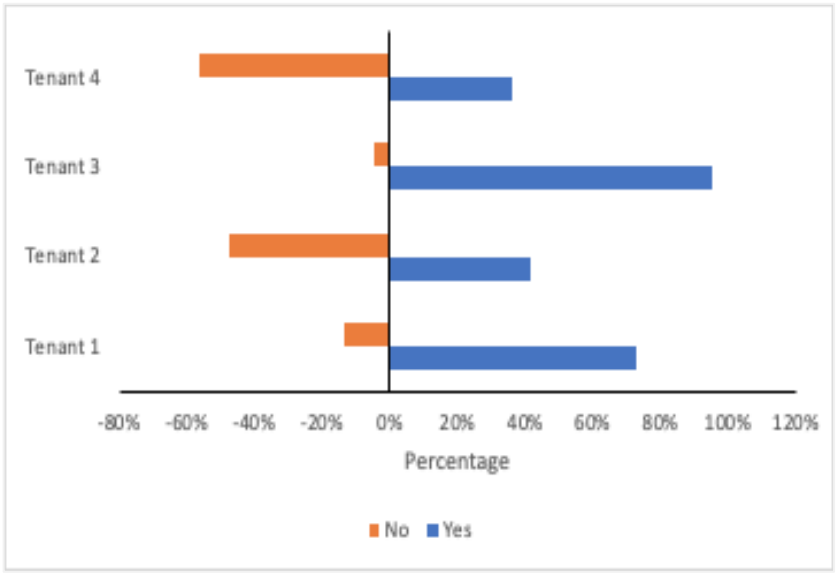

Figure 10. Percentage of responses to “Would you be more likely to bicycle to work if showers were available at your workplace?”. Tenant 1 (N=22), Tenant 2 (N=36), Tenant 3 (N=11), and Tenant 4 (N=80).

A one-way ANOVA was used to calculate the difference in means between the four tenants for the likelihood of biking to work if showers were available at their workplace. The calculated mean of the likelihood that respondents would bicycle to work between the four tenants is significantly different, as the p-value (0.0070) is less than the alpha (0.05). Therefore,

there is evidence to suggest that there is a significant difference between the mean answers between the four tenants. The null hypothesis stating there is no difference between the tenants' average response to the likelihood of biking to work if showers were available at the workplace can be rejected.

Lastly, Figure 11 displays answers to "Would you be more likely to bicycle to work if there were a better bike route to your workplace?". There were 59% of participants that responded 'yes', 35% of participants that responded 'no' and 6% that responded 'not applicable'. All of the tenants had a higher percentage of respondents that agreed that they would be more likely to bicycle to work if there were a better bike route, compared to those respondents that disagreed. Tenant 1 reported the highest percentage of respondents that reported to be more likely to bicycle to work if showers were at their workplace. Tenant 1 and Tenant 3 displayed a more drastic difference between respondents that answered 'yes' (Tenant 1=71%, Tenant 3=63%) to those that answered 'no' (Tenant 1=8%, Tenant 3=5%), whereas Tenant 2 and Tenant 4 displayed a less skewed divide between respondents that answered 'yes' (Tenant 2=58%, Tenant 4=49%) to those that answered 'no' (Tenant 2=33%, Tenant 4=46%).

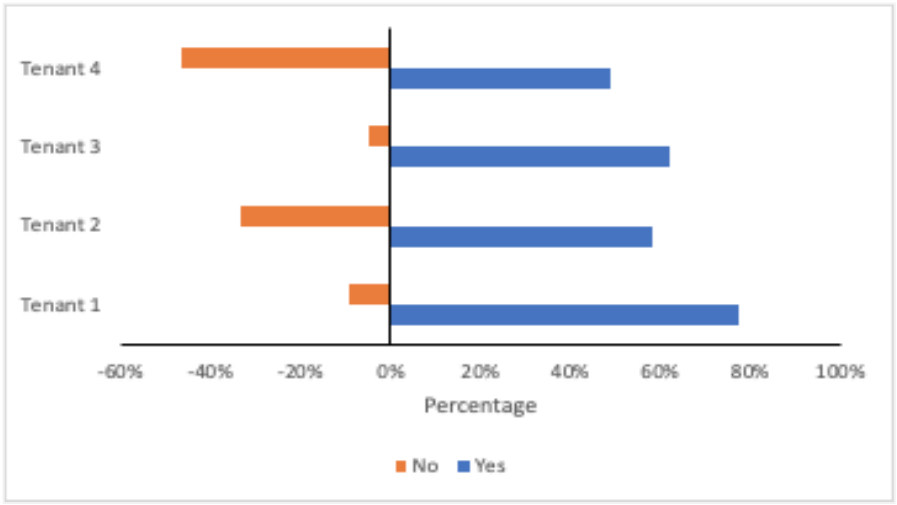

Figure 11. Percentage of responses to "Would you be more likely to bicycle to work if there were a better bike route to your workplace?". Tenant 1 (N=22), Tenant 2 (N=36), Tenant 3 (N=11), and Tenant 4 (N=80).

A one-way ANOVA was used to calculate the difference in means between the four tenants for the likelihood of biking to work if there were a better bike route to their workplace. The calculated mean of the likelihood that respondents bike to work between the four tenants is not significantly different, as the p-value (0.079) is greater than the alpha (0.05). Therefore, the null hypothesis stating there is no difference in the average response, between the four tenants, to the likelihood of biking to work if there is a better bike route cannot be rejected.

When respondents were asked to comment on the biggest factors that influenced their commuting choices, many participants noted the influence of distance and time it takes to get to work. Respondents indicated the unreliable bus times and the lack of bus routes outside of the City of Waterloo were barriers to change. Respondents that live out of town discuss the

unavailability of public transit and the added commuting time associated with taking public transit from out of the city.

> *"It is possible for me to take GRT on the 200 iXpress, however my commute would be 1.5 hours and the timing of busses into subdivisions is horrible. I would add an extra 2 hours to commute over driving".*

Respondents also commented on the convenience of their chosen commuting method as they must use their cars multiple times throughout their day due to the nature of their work, or outside life.

> *"Travel to the office is short but I have to drive my kids to daycare and I'm often travelling to clients and may visit multiple client sites in a day, so walking isn't feasible".*

Some respondents commented on the influence of commuting cost on the choice to use public transit, bicycle, walk or carpool, as it is less expensive than driving.

> *"... convenience of having family member drive to work in a similar direction for carpooling, and convenience of bus routes and stops with no transfers".*
>
> *"price, it's cheaper to use transit".*

Respondents also commented on the influence of weather on their commuting type, particularly during the colder seasons.

> *"It depends if I am rushing/ have enough time to walk. Otherwise, I will try to plan to take the bus and if I am running late, I will drive. If it is bad weather, I am more likely to drive than to walk or take the bus".*

Some respondents discussed that they would like to own an EV, however there were concerns regarding the cost of the EV at the moment, or access to chargers on trips.

> *"At this point in my life, being a student, purchasing an EV is not possible for me, but is on my radar".*
>
> *"Regarding EV- while having a charger at home and at work prove extremely valuable, I would feel comfortable investing in an EV when they are more accessible for other important trips e.g. camping, shopping centre, parking lots, hospitals".*

Pre-occupancy attitudinal survey results

The "Pre-occupancy Attitudinal Survey" was distributed to future tenants of a zero-carbon office building and asked questions relating to participant's well-being, productivity and environmental engagement. The results are presented in the order of questions from the attitudinal survey, see Appendix B.

Figure 12 exhibits the average responses from questions related to engaging in environmental behaviours at work (Behaviours), feelings towards environmental sustainability (Feelings), and thoughts towards environmental issues (Thoughts). The average response to questions under the behavioural (2.33) components of environmental engagement related closest to "Sometimes" on the Likert scale, whereas the average response to questions under the emotional (3.02) and cognitive (2.61) components of environmental engagement were between "Sometimes" and "Always". In general, the tenants reported the strongest answers to the statements relating to feelings towards environmental sustainability, whereas they felt the least

engaged in environmental behaviours at work. Therefore, it can be said that the tenants are aware of their environmental impacts and their ability to reduce their environmental impact but may not always actively engage in environmental behaviours.

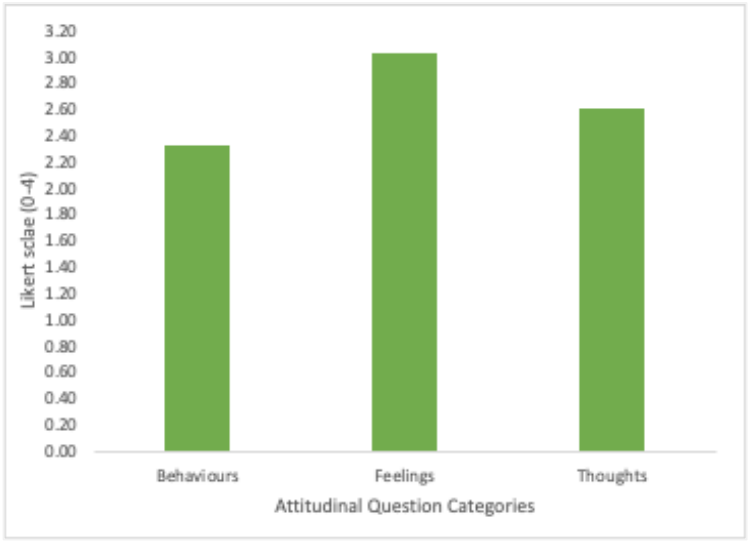

Figure 12. Average responses on a Likert scale of 0 to 4, from questions related to environmental behaviours (2.33), feelings (3.02), and thoughts (2.61) (N=232).

Figure 13 displays the tenant breakdown of the responses from the subscale of the environmental engagement scale, exhibiting the average answer from each tenant (Tenant 1, Tenant 2, Tenant 3, Tenant 4) to behaviour, emotion and cognitive questions. Tenant 1 exhibited the highest average response for each of the three question categories related to behaviour (2.88), feelings (3.52) and thoughts (3.45), whereas Tenant 2 displayed the lowest average responses for the behaviour (1.84), feelings (2.54), and thoughts (2.21) categories. Tenant 1, Tenant 2, and Tenant 4 reported lower average responses for the questions related to environmental behaviours and thoughts towards environmental issues, than the average responses to the questions related to feelings towards environmental sustainability. However, Tenant 3 reported a higher average

rating for questions related to environmental behaviours and feelings towards environmental sustainability, compared to a lower average of thoughts towards environmental issues.

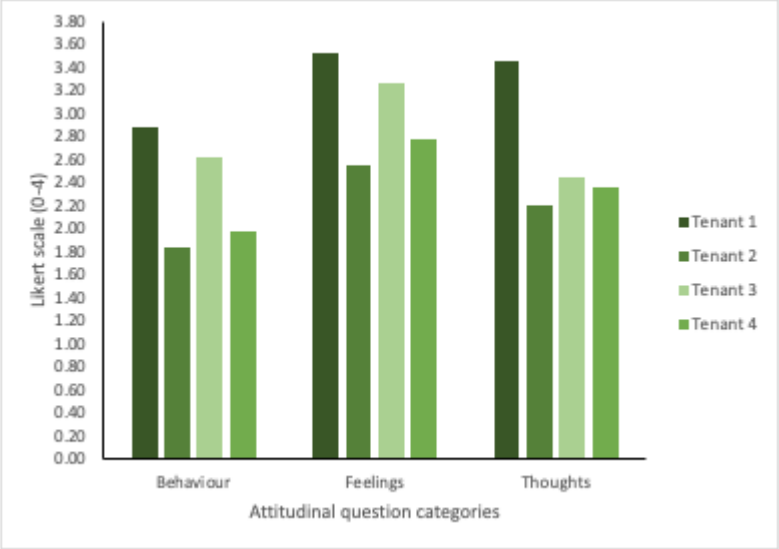

Figure 13. Average response by tenant, for questions related to environmental behaviours, feelings, and thoughts. Tenant 1 (N=31), Tenant 2 (N=57), Tenant 3 (N=16), and Tenant 4 (N=122)

A one-way ANOVA was used to test the significance of difference between the average value from each tenant for each response category. The p-value (behaviour=0.014, feelings=0.0018, thoughts=0.014) from each one-way ANOVA test is less than the alpha (0.05. Therefore, the null hypothesis stating there is no difference between the means of the average response from questions related to behaviour, feelings, thoughts, and overall from each tenant can be rejected. The calculated mean of the average response from each question category is significantly different between at least two of the four tenants.

Figure 14 displays the average response for each question in the behavioural thinking section of the survey, and how the respondents engage in certain behaviours at work on a scale of 0 (Never) to 4 (Always). Tenant 1 (3.13) displayed the highest average rating response to the first statement "I conserve the amount of materials I use at work", whereas Tenant 4 (2.25) displayed the lowest average rating response, as the average response was "Sometimes". A one-way ANOVA was used to compare the significance in difference between answers from the tenants. The calculated mean of the answers for the first statement is significantly different between at least two tenants. From this test, it can be seen that the F-value (7.15) is greater than the F-critical value (2.65). Therefore, there is evidence to reject the null hypothesis stating that there is no difference between the tenants. The p-value (0.00013) is also less than the alpha level (0.05), therefore the null hypothesis can be rejected. The results from the second third and fourth statements displayed similar patterns of response reporting. Tenant 1 (2.74) had the highest rating response to the second statement "I promote environmentally friendly behaviours amongst my coworkers", whereas Tenant 2 (1.56) reported the lowest response to the statement. The average mean is significantly different between the answers for the second statement between at least two tenants. The F-value (10.93) is greater than the F-critical value (2.65), therefore we can reject the null hypothesis stating there is no difference between the calculated mean of all the tenants. The third statement "At work, I reduce the amount of energy I use" displayed similar patterns as Tenant 1 (2.77) reported the highest average response rating, and Tenant 2 (1.61) responded the lowest average response rating. The average mean is significantly different between the answers for the third statement between at least two tenants. The F-value (8.83) is greater than the F-critical value (2.41), therefore we can reject the null hypothesis stating there is no difference between the calculated mean of all the tenants. The fourth statement "I encourage

my organization to reduce its environmental impact" displayed high average responses from Tenant 3 (2.04) and low average responses from Tenant 2 (1.32). Tenant 1 served as a pilot for the survey, therefore the last statement of the behaviour category was not included in their survey.

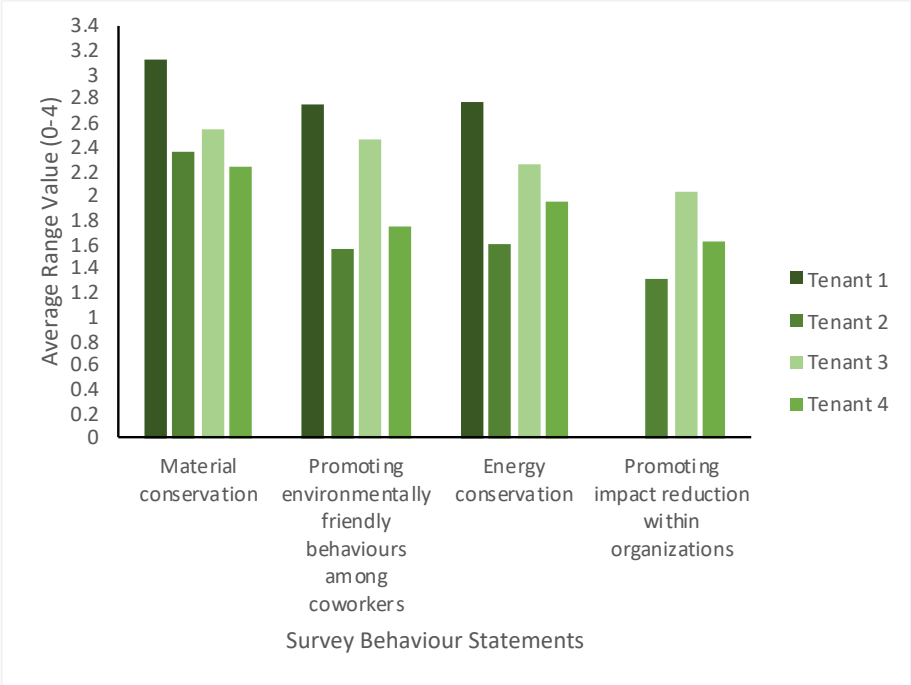

Figure 14. Average response by tenant, for behavioural statements related to material conservation, promoting environmentally friendly behaviours among coworkers, energy conservation, and encouraging organizations to reduce their impact. Tenant 1 (N=30), Tenant 2 (N=56), Tenant 3 (N=16), and Tenant 4 (N=120).

Figure 15 displays the average rating responses for each tenant in the category of emotional questions, where respondents rated statements that reflected the way that they felt about environmental sustainability on a scale of 0 (not at all how I feel) to 4 (very much how I feel). A one-way MANOVA was conducted to test the significance of difference between each

of the tenants (independent variable) for each statement within the emotional category (dependent variable). The computed p-value (<0.0001) is lower than the significance level (alpha=0.05), therefore we can reject the null hypothesis stating that the different tenants have no significant effect on the ratings from each statement in the emotional category. Overall, Tenant 1 had the highest rating for all four of the statements, and Tenant 2 reported the lowest ratings. The first statement "I feel guilty when I don't act in environmentally friendly ways", displayed the highest rating response from Tenant 1 (3.31), and the lowest average rating from Tenant 2 (2.44). Tenant 1 (3.40) reported the highest rating responses for the second statement "I worry about my environmental impact", and Tenant 2 (2.25) and Tenant 4 (2.30) reported the lowest average rating responses. Tenant 1 (3.72), and Tenant 3 (3.63) displayed the highest rating responses for the third statement, "I feel good when I do something positive for the environment", whereas Tenant 2 (2.79) reported the lowest average rating response. The fourth statement "I feel satisfied when I act in environmentally friendly ways" displayed the highest average rating from Tenant 1 (3.63) and Tenant 3 (3.54), and the lowest average rating response from Tenant 2 (2.70)

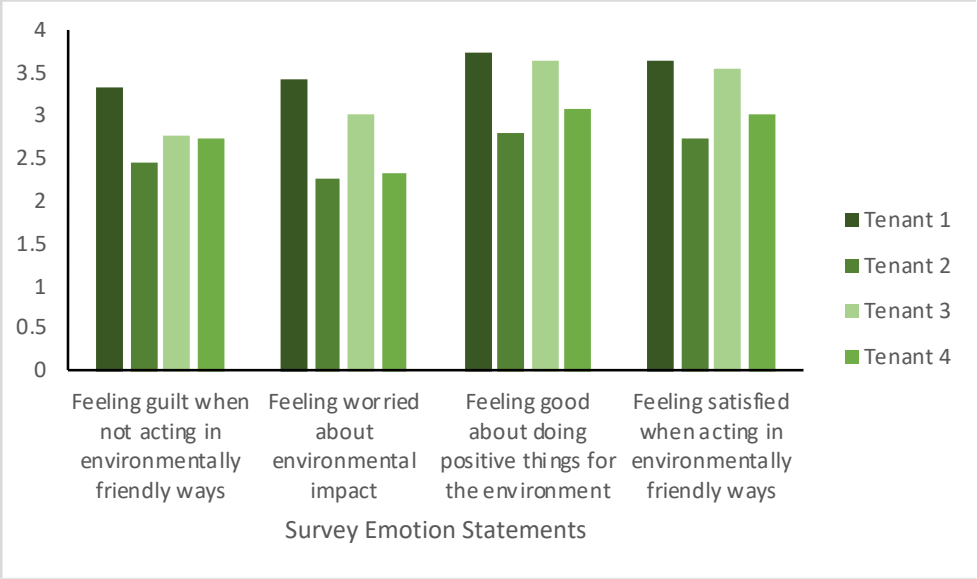

Figure 15. The average response by tenant, for emotional statements related to guilt, worrying about environmental impact, feeling good, and feeling satisfied when acting in environmental ways. Tenant 1 (N=29), Tenant 2 (N=56), Tenant 3 (N=16), and Tenant 4 (N=120).

Figure 16 exhibits the average rating response from questions in the cognitive category of the survey, where tenants were asked to rate statements in a way that reflected how they thought about environmental issues, on a scale of 0 (Not at all how I think) to 4 (Very much like I think). A one-way MANOVA was conducted to test the significance of difference between each of the tenants (independent variable) for each statement within the cognitive category (dependent variable). The computed p-value (<0.0001) is lower than the significance level (alpha=0.05), therefore we can reject the null hypothesis stating that the different tenants have no significant effect on the ratings from each statement in the cognitive category. The first statement "I feel guilty when I don't act in environmentally friendly ways", displayed the highest rating response from Tenant 1 (3.31), and the lowest average rating from Tenant 2 (2.44). Similarly, Tenant 1 (3.47) displayed the highest rating response to the second statement "I regularly think about

environmental issues", whereas Tenant 2 (2.02) displayed the lowest. The third statement "I consider environmental impact when I make decisions" displayed the highest average response from Tenant 1 (3.47) and the lowest average response from Tenant 2 (2.14). Tenant 1 (3.56) reported again as the highest response rating for the fourth statement, " I think about how I can reduce my environmental impact", whereas Tenant 2 (2.12) reported the lowest average response rating to the statement.

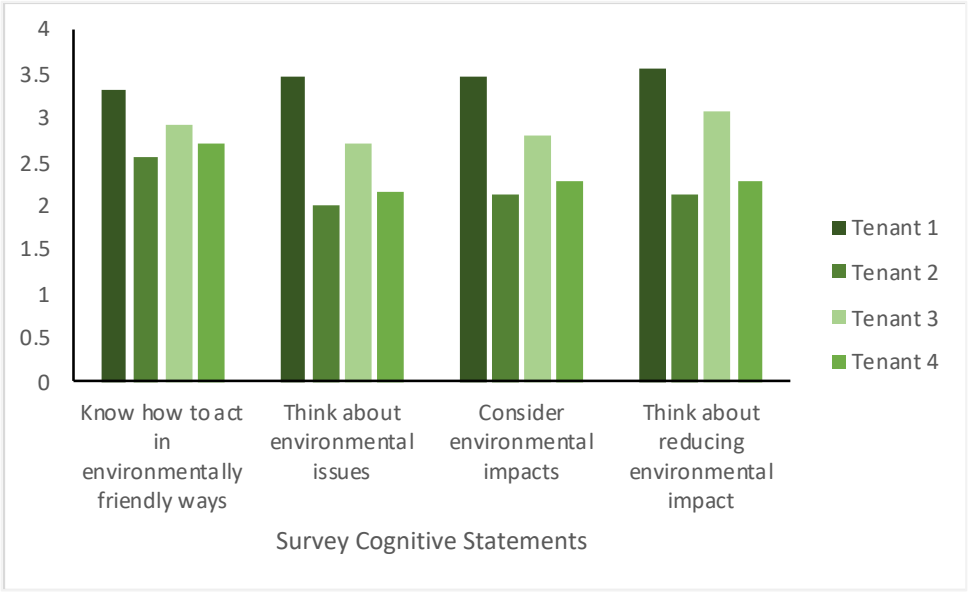

Figure 16. The average response of each tenant for cognitive statements related to acting in environmentally friendly ways, thinking about environmental issues, considering environmental impacts, and reducing environmental impacts. Tenant 1 (N=33), Tenant 2 (N=57), Tenant 3 (N=15), and Tenant 4 (N=121)

While the connection between pro-environmental attitudes and behaviours is desired, the awareness of environmental issues and sustainability may not always result in pro-environmental behaviours. The study by Wang (2017) compared the levels of concern for environmental issues

with engaging in pro-environmental behaviours and found that there was a positive correlation between the two factors. However, Susilo et al. (2011) found that their participants believed that other people needed to change their behaviours in order to contribute to sustainability but did not feel that they needed to change their own behaviours. Therefore, it is possible that some individuals feel disconnected from the need for change towards pro-environmental behaviours. This is supported in Figure 12, where the average ratings for feelings towards environmental sustainability and thoughts of Tenant 1, Tenant 2, and Tenant 4 are greater than the average ratings questions related to environmental behaviours. Connolly and Prothero (2008) found that some of their participants reported concern for environmental issues but did not always carry out environmental behaviours. Individualizing behaviours so that individuals feel responsible and connected to their environment can help to close the gap between attitudes and behaviours. On that account, organizations that do not engage in sustainable practices or promote environmental values may be less likely to stimulate pro-environmental behaviours and attitudes in their employees.

Comparison of individual responses from commuting and diet behaviours with attitudes towards environmental issues and sustainability

The correlation between the individual responses from the attitudinal survey and the behavioural survey were tested to determine any significant contributions, using a multiple linear regression model and a log-linear regression model. In order to compare the significance between the attitudinal and behavioural surveys, the tables were merged using the anonymized identifier from each respondent. Those respondents that only completed one survey were not included as the logistical regression requires the same participants throughout the comparison.

There were 100 participants that responded to both surveys, and 131 participants that responded to only either the attitudinal or behavioural survey. In these regressions, the attitudinal survey responses were considered the explanatory (independent) values, whereas the behavioural survey responses were considered the response (dependent) variables.

A multiple linear regression was conducted to test the influence of attitudes towards environmental issues and sustainability on commuting choices throughout the year. When comparing the correlation between the attitudinal questions with the variability of commuting types throughout warmer and colder seasons, and all year, there were 12 explanatory variables and 8 response variables. The linear regression distinguishes the explanatory variables from the attitudinal survey that do not bring significant information to explain the variability of cars, SUV/van/trucks, electric/ hybrid vehicles, walking, or "other" commuting methods. When running the multiple linear regression equation, the attitudinal statement "I feel satisfied when I act in environmentally friendly ways", was the only explanatory variable that brought significant information to explain the variability of carpooling. Therefore all other variables were removed. However, after the stepwise regression backwards elimination model, the R_2 indicated that only 2% of the variability of carpooling can be explained by "I feel satisfied when I act in environmentally friendly ways". Given that the p-value is less than the significance level (0.05) in the stepwise regression model, the information brought by this attitudinal statement is not significant.

The correlation coefficients between the responses from the attitudinal survey and the commuting types throughout the year from the behavioural survey are summarized in the

correlation matrix in Table 1. The reference table of attitudinal statements is summarized in Table 2. The correlation variables between the attitudinal statements and the frequency of SUV/van/truck usage are negative, indicating that an increase in pro-environmental attitudes leads to a decrease in the frequency of unsustainable commuting. Additionally, the correlation coefficient between the attitudinal statements and the frequency of bus/LRT usage is positive, indicating an increase in pro-environmental attitudes with an increase in sustainable commuting types. However, some correlation coefficients were unexpected as they do not follow the expected results based on the literature.

The correlation values between the frequency of EV/hybrids was positive, except for "I feel good when I do something positive for the environment". Therefore, a positive increase in all of the attitudinal variables, except feeling good when performing a pro-environmental behaviour, is associated with to an increase in the frequency of the pro-environmental behaviour of using an EV/hybrid.

The correlation values for the frequency of walking with the attitudinal statements was negative for statements including "I conserve the amount of materials I use at work", "I promote environmentally friendly behaviours amongst my coworkers", "At work, I reduce the amount of energy I use", and "I know how to act in environmentally friendly ways". However, there were positive correlations for all of the statements from the emotion category of the attitudinal statements including "I feel good when I do something positive for the environment".

The correlation values between the frequency of biking was positive for most attitudinal variables, excluding “I promote environmentally friendly behaviours amongst my coworkers”, “At work, I reduce the amount of energy I use”, and “I feel guilty when I don’t act in environmentally friendly ways”.

The correlation values between the frequency of carpooling and the attitudinal statements was positive, except for the attitudinal statements “I conserve the amount of materials I use at work”, “I encourage my organization to reduce its environmental impact”, “I know how to act in environmentally friendly ways” and “I consider environmental impact when I make decisions".

The correlation values between the frequency of car use and the attitudinal variables was positive for eight of the attitudinal statements. However, the coefficient was very small, therefore there was not a strong correlation between the variables. The strongest correlation coefficient for the frequency of car usage was with the emotion statement “I feel guilty when I don’t act in environmentally friendly ways”, which indicated a positive relationship between the statement and the frequency of commuting use.

Table 1.

Correlation matrix of attitudinal variables and commuting behaviour variables

	EE1	EE2	EE4	EE6	EE7	EE8	EE9	EE10	EE12	EE13	EE14	EE15	Car	SUV/van/Truck	EV/Hybrid	Bus/LRT	Walk	Bike	Carpool	Other
EE1	**1.00**	0.69	0.70	0.60	0.43	0.49	0.58	0.59	0.53	0.50	0.69	0.60	-0.02	-0.09	0.17	0.23	-0.06	0.10	-0.11	-0.07
EE2	0.69	**1.00**	0.71	0.74	0.55	0.51	0.66	0.65	0.35	0.55	0.65	0.60	-0.02	-0.07	0.12	0.19	-0.03	-0.10	0.08	-0.13
EE4	0.70	0.71	**1.00**	0.54	0.37	0.28	0.46	0.46	0.48	0.46	0.54	0.36	0.01	-0.03	0.00	0.14	-0.13	-0.07	0.02	-0.15
EE6	0.60	0.74	0.54	**1.00**	0.45	0.49	0.64	0.61	0.42	0.53	0.67	0.55	0.01	-0.17	0.19	0.16	0.08	0.16	-0.02	-0.09
EE7	0.43	0.55	0.37	0.45	**1.00**	0.52	0.66	0.65	0.15	0.44	0.58	0.57	0.14	-0.22	0.00	0.05	0.14	-0.19	0.01	-0.02
EE8	0.49	0.51	0.28	0.49	0.52	**1.00**	0.69	0.67	0.24	0.62	0.61	0.74	-0.08	-0.16	0.04	0.17	0.20	0.26	0.10	-0.13
EE9	0.58	0.66	0.46	0.64	0.66	0.69	**1.00**	0.89	0.22	0.60	0.71	0.74	-0.04	-0.08	-0.01	0.08	0.17	0.04	0.08	-0.11
EE10	0.59	0.65	0.46	0.61	0.65	0.67	0.89	**1.00**	0.18	0.59	0.71	0.65	0.00	-0.14	0.01	0.06	0.16	0.05	0.15	-0.09
EE12	0.53	0.35	0.48	0.42	0.15	0.24	0.22	0.18	**1.00**	0.46	0.58	0.39	0.04	-0.10	0.14	0.17	-0.04	0.09	-0.23	-0.15
EE13	0.50	0.55	0.46	0.53	0.44	0.62	0.60	0.59	0.46	**1.00**	0.71	0.70	0.07	-0.19	0.05	0.13	0.11	0.00	0.02	-0.11
EE14	0.69	0.65	0.54	0.67	0.58	0.61	0.71	0.71	0.58	0.71	**1.00**	0.71	0.03	-0.20	0.10	0.19	0.13	0.09	-0.14	-0.05
EE15	0.60	0.60	0.36	0.55	0.57	0.74	0.74	0.65	0.39	0.70	0.71	**1.00**	0.08	-0.21	0.04	0.07	0.08	0.11	0.07	-0.06
Car	-0.02	-0.02	0.01	0.01	0.14	-0.08	-0.04	0.00	0.04	0.07	0.03	0.08	**1.00**	-0.70	-0.11	-0.51	-0.35	-0.18	-0.04	0.02
SUV/van/truck	-0.09	-0.07	-0.03	-0.17	-0.22	-0.16	-0.08	-0.14	-0.10	-0.19	-0.20	-0.21	-0.70	**1.00**	-0.06	-0.11	-0.08	-0.08	-0.12	-0.06
Electric/Hybrid Vehicle	0.17	0.12	0.00	0.19	0.00	0.04	-0.01	0.01	0.14	0.05	0.10	0.04	-0.11	-0.06	**1.00**	0.18	0.04	0.06	-0.05	-0.03
Bus/LRT	0.23	0.19	0.14	0.16	0.05	0.17	0.08	0.06	0.17	0.13	0.19	0.07	-0.51	-0.11	0.18	**1.00**	0.20	0.16	-0.05	-0.05
Walk	-0.06	-0.03	-0.13	0.08	0.14	0.20	0.17	0.16	-0.04	0.11	0.13	0.08	-0.35	-0.08	0.04	0.20	**1.00**	-0.02	-0.04	-0.04
Bike	0.10	-0.10	-0.07	0.16	-0.19	0.26	0.04	0.05	0.09	0.00	0.09	0.11	-0.18	-0.08	0.06	0.16	-0.02	**1.00**	-0.07	-0.04
Carpool	-0.11	0.08	0.02	-0.02	0.01	0.10	0.08	0.15	-0.23	0.02	-0.14	0.07	-0.04	-0.12	-0.05	-0.05	-0.04	-0.07	**1.00**	-0.05
Other	-0.07	-0.13	-0.15	-0.09	-0.02	-0.13	-0.11	-0.09	-0.15	-0.11	-0.05	-0.06	0.02	-0.06	-0.03	-0.05	-0.04	-0.04	-0.05	**1.00**

Table 2.

Reference table of Attitudinal Statements

Attitudinal Categories	Reference	Attitudinal Statement
Behaviour	EE1	I conserve the amount of materials I use at work.
	EE2	I promote environmentally friendly behaviours amongst my coworkers.
	EE4	At work, I reduce the amount of energy I use.
	EE6	I encourage my organization to reduce its environmental impact.
Emotion	EE7	I feel guilty when I don't act in environmentally friendly ways.
	EE8	I worry about my environmental impact.
	EE8	I feel good when I do something positive for the environment.
	EE10	I feel satisfied when I act in environmentally friendly ways.
Cognitive	EE12	I know how to act in environmentally friendly ways.
	EE13	I regularly think about environmental issues.
	EE14	I consider environmental impact when I make decisions.
	EE15	I think about how I can reduce my environmental impact.

A multiple linear regression was conducted to test the influence of attitudes towards environmental issues and sustainability on commuting choices during the warmer and colder seasons. The type III sum of squares calculation in the regression indicated the attitudinal variables that did not bring significant information to explain the variability of the commuting types. Using the stepwise regression backwards elimination model, the attitudinal statement variable "I encourage my organization to reduce its environmental impact" was the most

influential on the variability of commuting by car between the warmer and colder seasons, and all other variables were removed from the model.

Given the R_2 value from the stepwise regression for the colder season, 3% of the variability of the frequency of car in the warmer months can be explained by the statement "I encourage my organization to reduce its environmental impact" (EE6). The relationship between the frequency of commuting by car in the warmer season and the attitudinal questions is summarized in the equation of the model below.

Equation of the model (Car (Warmer)):

Car (Warmer) =5.45-1.66*EE6

R_2=0.026

Therefore, a positive increase in the pro-environmental attitudinal statement, is weakly associated with a decrease in the frequency of car usage in the warmer months.

Given the R_2 value from the stepwise regression for the colder season, 4% of the variability of the frequency of car in the warmer months can be explained by the statement: "I encourage my organization to reduce its environmental impact" (EE6). The relationship between the frequency of commuting by car in the colder season and the attitudinal questions is summarized in the equation of the model below.

Equation of the model (Car (Colder)):

Car (Colder) =11.34-3.26*EE6

R_2=0.039

Overall, a positive increase in the pro-environmental attitudinal statement, is weakly

associated with a decrease in the frequency of car usage in the colder months.

A log-linear regression was conducted to test the correlation between the frequency of beef consumption (times per week) and attitudes towards environmental issues and sustainability. When comparing the correlation between the beef consumption, with the attitudinal questions, there were 12 explanatory variables and one response variable. As the Pr> Chi^2 is greater than the significance level (0.05) the attitudinal variables did not bring significant information to the frequency of beef consumption.

Sustainability Reporting

The baseline data provides a foundational comparison between the attitudes of tenants towards environmental issues with their self-reported lifestyle choices. At the baseline stage, it is expected that the tenants will have values that align with the values of their organizations, or with pre-existing values. Therefore, those tenants that are employed by organizations that do not integrate sustainability reporting or environmental values into their operations will be less likely to have sustainable values. Tung, Baird, and Schoch (2014) found that when employees were engaged in environmental initiatives set forth by their employers, they became more accountable for their environmental actions. Organizations that adopted an environmental management system were able to control and reduce the environmental impacts associated with their operations (Tung et al., 2014). This was supported by the current research as Tenant 1 and Tenant 3 most frequently reported pro-environmental attitudes and behaviours, and Tenant 1 promoted sustainability values and contributes to the sustainable development of the community, while Tenant 3 publishes annual sustainability reports. While the average responses from Tenant

4 are lower than Tenant 1 and 3 across the two surveys, this tenant has integrated corporate responsibility into their business operations and adopted sustainability reporting, and generally reports greater pro-environmental behaviours and attitudes than Tenant 2. Tenant 2 has not yet publicly committed to environmental reporting or integrating sustainable practices. Therefore, it can be said that those tenants, that have pre-existing pro-environmental values and have integrated sustainability into their operations, are expected to report higher levels of concern for environmental issues and actions.

Pre and post-occupancy parking lot composition

The parking lot composition displays the primary commuting choices at each of the tenant buildings, prior to moving into a zero-carbon building. By collecting these observations, the data can then be compared with the post-occupancy parking lot composition of the zero-carbon office building. This comparison may show preliminary changes in commuting choices of the occupants as they move into the zero-carbon office building.

To display the observations from pre-occupancy and post-occupancy stages, the percentages of each commuting choice were calculated from the average commuting type occurrence and the average N per observation. The average parking lot composition from the pre-occupancy stage can be seen in Table 3, and the post-occupancy stage in Table 4. The individual observations were recorded for each tenant in the pre-occupancy stage during summer 2018 for Tenant 2 (Table 6), Tenant 3 (Table 7, Table 8, Table 9, and Table 10) and Tenant 4 (Table 11). The observations from the zero-carbon office building in the post-occupancy stage was recorded individually for December 2018 (Table 12), January 2019 (Table 13), and August

2019 (Table 14). The pre-occupancy and post-occupancy data collection provides a general comparison for the initial change in commuting choices by tenants of a zero-carbon office building.

Pre-occupancy

As seen in Table 3, the general trend of parking lot composition in the pre-occupancy observation shows that the majority of vehicles are gas/diesel sedans (41-60%) and SUV/van/trucks (34-39%). Tenant 2 exhibited the only motorcycle observation during the pre-occupancy data collection, and the highest percentage of gas sedans (60%) out of the average 196 vehicles per observation. Tenant 3 shows the highest occurrence of bikes (3%), hybrid sedans (2%), EV sedans (2%), and the lowest level of gas/diesel sedans (41%) out of the average 373 vehicles per observation. Tenant 4 displays the highest occurrence of gas SUV/van/truck (39%), and the second highest occurrence of gas sedans (59%) out of 51 vehicles per observation. However, the total N for each observation should be considered, as there are notably fewer observations for Tenant 4 (total N=306), than Tenant 2 (total N=1177) and Tenant 3 (total N=2239).

Table 3.

Pre-occupancy Average Parking Lot Composition, by Tenant (Summer 2018).

	bikes	motor cycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		Average N per observation	Total N
			sedan	SUV/ Truck	sedan	SUV/ van/truck	sedan	SUV/ van/truck		
Tenant 2	2.8%	0.4%	60.1%	34.3%	1.5%	0.0%	0.8%	0.0%	196.2	1177
Tenant 3	3.3%	0.0%	40.8%	36.4%	2.0%	0.0%	1.5%	0.3%	373.2	2239
Tenant 4	0.0%	0.0%	59.2%	38.9%	0.7%	0.0%	1.3%	0.0%	51.0	306

Each of the individual observations from each tenant's carpark were recorded. The separate observations from Tenant 2 can be seen in Table 6, where the majority of observed vehicles were gas/diesel sedans (average 118) and SUV/van/trucks (average 67) out of a total of 1177 observations. The individual observations for Tenant 3 can be seen in Table 7, Table 8, Table 9, and Table 10, totalling to 2239 observed commuting vehicles. There did not seem to be an obvious pattern in observation count between times of day. The individual observation for Tenant 4 is seen in Table 11, totalling 306 observations. In general, observations of different vehicle types did not drastically change between each day. The number of vehicles observed between morning and afternoon fluctuated moderately between August 23rd, and 24th, 2018.

Post-occupancy

The post-occupancy parking lot composition, by monthly observation is seen in Table 4. The variation in commuting types does not change drastically between December 2018, January

2019, and August 2019, as there are at least 6 commuting types present during each observation. The number of observations (total N) remains similar between the December (896) and January (898) observations, however, it decreased during the August observation (552). The frequency of bike reporting increased from the winter (December 2018=0.4%, January 2019=0.6%), to summer months (August 2019=6%). The frequency of SUV/van/truck (December=39%, January=38%, August=30%) reporting decreased between the early winter months and the later summer months, whereas the frequency of hybrid sedans (December 2018=1.7%, January 2019=1.5%, August 2019=2.2%) and EV sedans (December 2018=1.8%, January 2019=2.7%, August 2019=2.9%) increased over the year. The percentage of EV trucks (December 2018=0.2%, January 2019=0.3%, August 2019=0%) remained very small. Lastly, the reporting of motorcycles increased between the winter (December 2018=0%, January 2019=0%) and summer months (August 2019=0.2%). Changes in the percentage of commuting type between colder and warmer seasons may be more pronounced due to a smaller observation number in August 2019, comparted to December 2018 and January 2019. The smaller observation number increases the effect of each vehicle counted.

Table 4.

Post-occupancy Parking Lot Composition, by Observation (December 2018 N=898, January 2019 N=896 and August 2019=552)

	bikes	motor cycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		Average N per day	Total N
			sedan	SUV/ van/truck	sedan	SUV/ van/truck	sedan	SUV/ van/truck		
December 2018	0.4%	0.0%	56.4%	39.4 %	1.7%	0.0%	1.8%	0.2%	149.7	896
January 2019	0.6%	0.0%	57.0%	38.0 %	1.5%	0.0%	2.7%	0.3%	149.3	898
August 2019	6.2%	0.2%	57.0%	30.2 %	2.2%	0.0%	2.9%	0.0%	138.0	552

Table 5 shows the comparison of the parking lots of the tenants that were in the same research park as the zero-carbon building prior to moving to the new building. Therefore those tenants have a similar parking arrangement (no fees) and commuting distance as the new office building. The frequency of hybrid and EV sedans increased slightly from the preoccupancy (hybrid=1.5%, 1.0%, EV=0.8%, 0.0%) and post occupancy stages (hybrid=1.8% EV=2.5%), whereas the frequency of sedans decreased slightly between the pre-occupancy (58.7%, 58.9%) and post-occupancy stages (56.8%). The frequency of SUV/van/trucks remain similar (preoccupancy=34.4%, 38.6%, post occupancy=35.9%). Any future changes in parking lot composition could be due to different transportation features available to building occupants, including charging stations for hybrid and EVs.

Table 5.

Comparison of Pre-occupancy nearby tenants to Post-occupancy Zero-Carbon Office Building Parking Lot Composition

	Vehicle types								Average N per day
	bikes	Motor cycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		
			sedan	SUV/ van/truck	sedan	SUV/ van/truck	sedan	SUV/ van/truck	
Pre-occupancy Tenant 2	4.1%	1.3%	60.1 %	34.3%	1.5%	0.0%	0.8%	0.0%	196
Pre-occupancy Tenant 3	0.8%	0.4%	58.9 %	38.6%	1.0%	0.0%	0.0%	0.3%	246
Post-occupancy	2.4%	0.1%	56.8 %	35.9%	1.8%	0.0%	2.5%	0.2%	146

An important feature of the parking arrangements in this commercial area is that it is free, and this may influence the commuting decisions of tenants moving there. Some observations were indicative of the future observations of the zero-carbon office building. The frequency of sedans decreased slightly between the pre-occupancy (Tenant 2=60%, Tenant 3=59%) in the pre-occupancy and post-occupancy stages (57%), but remained the dominant vehicle in observations within the R+T park. The frequency of SUV/van/trucks were similar between the average pre-occupancy (Tenant 2=34%, Tenant 3=39%) and post-occupancy (36%). There was an increased frequency of EV sedans (Tenant 2=0.8%, Tenant 3=0.0%, post-occupancy=2.5%) and slight

increase in hybrid sedans (Tenant 2=1.5%, Tenant 3=1.0%, and post-occupancy=1.8%) between the pre-occupancy and the post-occupancy observations. The comparison of the prevalence of bicycles is difficult to compare, as the average percentage of bicycles during pre-occupancy observations was done during the warmer season (August 2018), whereas the post-occupancy observations were done over two seasons (December 2018, January 2019, and August 2019). However, when comparing the post-occupancy observations (August 2019) of bicycles (6%), seen in Table 4, with the pre-occupancy observations of bicycles from Tenant 2 (4%), there is a similarity in the higher frequency. Therefore, the increase in EV and hybrid frequency between the pre-occupancy and post-occupancy parking lots may be due to the availability of charging stations in the zero-carbon building. As there was a short period of time between the observations, the building occupants may have not had enough time to modify their vehicle choices, based on the new features of the zero-carbon office building including the 28 electrical vehicle charging stations, bicycle storage, on-site showers, and LRT access. However, in the future, it is expected that the frequency of hybrid and EVs will increase, and the prevalence of gas/diesel sedans and SUV/van/trucks decrease. Additionally, it is expected that the frequency of bicycles increases, especially during the warmer months, and the overall sum of motorized vehicles decreases as building occupants use the LRT, walk, bike and carpool.

The findings from the observation survey of the parking lots in the pre-occupancy and post-occupancy stages provide a preliminary comparison in the change in commuting choice between the previous tenant's locations and the zero-carbon office building. It is possible that some tenants will alter their commuting choice in their new office space due to the availability of new modes of transportation that were not offered in their previous locations, including

proximity to public transit, new commuting routes, EV charging stations, secured bike parking, or onsite showers. The difference in observation numbers between morning and afternoon of gas sedans and SUV/van/trucks could imply that commuters who used those vehicles had more varied schedules throughout the day than those that did not. Some respondents indicated that they needed to use a car as a commuting method as they needed to travel to clients during their workdays. This could be the cause of varied sedan, SUV/van/truck, hybrid and EV counts throughout the day. Additionally, some tenants may have interspersed work schedules, where they are not required to not be in their offices continuously and may stay at work later than their coworkers. Visitors may also use the parking facilities and cause variations in numbers.

Comparison between self-reported commuting and parking lot observations

By comparing the self-reported commuting choices and the pre-occupancy parking lot observations, we can determine the general accuracy of self-reported commuting data. However, it must be noted that the frequency of bus trips, and carpooling could not be accounted for in the actual observation data. Based on the self-reported data (Figure 3), Tenant 2 was expected to have an average parking lot composition that would display commuting composition similar to 62% car, 13% SUV/van/truck, 3% EV/hybrid, and 3% bike. In comparison, Tenant 2 had a parking lot composition that displayed 60% cars, 34% SUV/van/truck, 2% EV/hybrid, and 4% bikes. It is possible that tenants may have been confused with crossover vehicles and included them in either the sedan or SUV/van/trucks category, or else did not account for the frequency that they used SUV/van/trucks as a commuting choice. Tenant 3 was expected to have parking lot composition of 56% car, 1% EV/Hybrid, and 1% bike and no SUV/van/trucks. However, the carpark adjacent to Tenant 3's office building displayed a parking lot composition of 41% cars,

36% SUV/van/truck, 4% EV/Hybrid, and 3% bike. Lastly, Tenant 4 was expected to display 73% car, 14% SUV/van/truck, 1% EV/Hybrid and 0.5% bike. In comparison, the carpark held 59% cars, 39% SUV/van/truck, 2.% Hybrid/Evs, and no bikes. Tenant 3 was the only tenant that reported a lower percentage of EV/Hybrid and bike commuting use than the actual pre-occupancy observation.

CHAPTER 5: CONCLUSION

Sustainable buildings present an opportunity to influence societal change through building design and increased environmental awareness. The impact of these buildings can extend beyond resource and energy reduction by connecting the environmental contributions with social sustainability. This study suggests that sustainable buildings should not only address energy and resource reduction in their design, but also recognise that the behaviour and attitude of occupants are essential factors to achieve sustainability.

This study contributes to the value belief norm theory, as reported values correlate with the behaviours and attitudes of the respondents. Individuals that have a greater understanding of the effects of their behaviours and feel a sense of responsibility over their actions will behave in a certain way. In this study, there is a link between individuals that report awareness and pro-environmental behaviours, compared to those respondents that report less awareness to environmental issues. As the value belief norm theory describes, respondents that report environmental awareness are likely to be shaped by information, including environmental education or public knowledge, which thereby leads to pro-environmental behaviours. Additionally, this study also contributes to the theory of planned behaviour, as an increased motivation to perform a behaviour, through subjective norms or personal judgement, will increase the likelihood of performing the behaviour. The social influence, or positive or negative attitude towards performing a certain behaviour will shape the intention to perform the behaviour. In this study, individuals that have a strong intention to perform an environmental behaviour are linked to a more sustainable lifestyle, including diet, waste, and commuting habits. Net-zero energy in a multi-tenant building can prove to be a challenging as the tenants occupying

the building may have different sustainability values (Edwards and Kumphai, 2012; Carmichael et al., 2017). Respondents who are employed by an organization that has integrated sustainability into their operations, or individual with prevalent environmental awareness, are likely to report more sustainable attitudes and behaviours (Aguilar-Luzon et al., 2012). Organizations that adopted sustainability or environmental values into their operations most frequently reported pro-environmental attitudes and behaviours. Tenants 1, 3, and 4 reported concern for environmental issues and actions through the surveys. Tenant 2, who has not yet publicly committed to environmental reporting or integrating sustainability into their operations, reported lower levels of pro-environmental attitudes in the pre-occupancy survey.

The observational research found that parking lot compositions of vehicle types by tenants located in the same commercial area in the pre-occupancy period displayed a small increase in EV and hybrid frequency. Future changes in parking lot composition and commuting types can imply that the building structure and sustainable features, including the EV charging stations, are influential towards commuting choice.

Through the empirical literature review, it is evident that sustainable building design is not sufficient on its own for maximum efficiency building performance. These studies indicated that many participants were unfamiliar with building features and were not aware of how to interact with the building in the intended sustainable manner. Therefore, it is possible that these buildings open up an opportunity for discussion about sustainability, leading to increased environmental awareness and influence among peers (Giddens, 1991). It is necessary to assess the occupant's engagement in sustainability. By assessing the pre-occupancy baseline attitudes

and behaviours of tenants, future studies can collect the post-occupancy data to determine if there is a correlation between the potential changes in attitudes and behaviours with the occupancy of a sustainable office building.

This study is grounded in surveying potential tenants in a zero carbon building. Further research would be required to compare the observations of tenants to their broader industries. Future long term studies should follow similar methods in collecting self-reported lifestyle choices and attitudes and continue to collect the same data each consecutive year. Future researchers should collect data from the same cohorts for each survey, for complete significance testing.

While this study does not make conclusions regarding the direct influence of sustainable buildings on the attitudes and behaviours of it's occupants, the identified link between the baseline attitudes and behaviours of the pre-occupancy tenants may be used in future research of sustainable developments. Based on the history of the influence of building design and the growth of the sustainable building industry, the development of a culture of sustainability and the potential increase in sustainable behaviours will contribute to the efficiency of sustainable buildings and overall sustainable development.

This study has practical contributions, as the self-reported lifestyle choices and attitudes towards environmental issues and sustainability can be helpful for sustainable building developers, architects and designers. In verifying the link between values and ethics with actions and behaviours, this thesis can contribute to government incentive programs, environmental

awareness campaigns and societal change. By presenting the comparison of attitudes and self-reported lifestyle choices among various tenant industries, sustainable building designers may understand new ways of active and passive interventions to influence their tenants to act in pro-environmental ways. As there is a growing pressure on the building industry to reduce carbon emissions, it is necessary to integrate sustainable building design and technologies into future developments. However, in order to achieve environmental, economic and social sustainability through the uptake of sustainable building design, it is necessary to also focus on the influence of sustainable design on the environmental awareness of their occupants.

REFERENCES

A brief history of green building. (2003). *Building Design and Construction; Arlington Heights*, 4–6.

Aguilar-Luzón, M. del C., García-Martínez, J. M. Á., Calvo-Salguero, A., and Salinas, J. M. (2012). Comparative Study Between the Theory of Planned Behavior and the Value-Belief-Norm Model Regarding the Environment, on Spanish Housewives' Recycling Behavior: Recycling Behavior of Spanish Housewives. *Journal of Applied Social Psychology*, *42*(11), 2797–2833. https://doi.org/10.1111/j.1559-1816.2012.00962.x

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In J. Kuhl and J. Beckmann (Eds.), *Action Control* (pp. 11–39). https://doi.org/10.1007/978-3-642-69746-3_2

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2011). The theory of planned behaviour: Reactions and reflections. *Psychology and Health*, *26*(9), 1113–1127. https://doi.org/10.1080/08870446.2011.613995

Akadiri, P. O., Chinyio, E. A., and Olomolaiye, P. O. (2012). Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector. *Buildings*, *2*(2), 126–152. https://doi.org/10.3390/buildings2020126

Barbu, A.-D., Griffiths, N., Morton, G., and European Environment Agency. (2013). *Achieving energy efficiency through behaviour change: What does it take?*. Retrieved from http://dx.publications.europa.eu/10.2800/49941

Birkeland, I. (2008). Cultural Sustainability: Industrialism, Placelessness and the Re-animation of Place. *Ethics, Place and Environment*, *11*(3), 283–297. https://doi.org/10.1080/13668790802559692

Birkeland, J. (2012). Positive Development from Vicious Circles to Virtuous Cycles Through Built Environment Design. *Positive Development: From Vicious Circles to Virtuous Cycles through Built Environment Design*. https://doi.org/10.4324/9781849772235

Birkeland, J., and Newton, P. (2008). *Positive development: From vicious circles to virtuous cycles through built environment design*. Retrieved from https://trove.nla.gov.au/version/45806664

Boake, T. (n.d.). Moving Towards Green, a Brief History of the Beginnings of Sustainable Design in Canada. *Canada Innovates: Sustainable Building Essays*, 4.

Bonenberg, W., and Kapliński, O. (2018). The Architect and the Paradigms of Sustainable Development: A Review of Dilemmas. *Sustainability*, *10*(1), 100. https://doi.org/10.3390/su10010100

Brown, C., and Gorgolewski, M. (2014). Assessing occupant satisfaction and energy behaviours in Toronto's LEED gold high-rise residential buildings. *International Journal of Energy Sector Management*. https://doi.org/10.1108/IJESM-11-2013-0007

Brown, Z., Cole, R. J., Robinson, J., and Dowlatabadi, H. (2010). Evaluating user experience in green buildings in relation to workplace culture and context. *Facilities*, *28*(3/4), 225–238. https://doi.org/10.1108/02632771011023168

Brundiers, K. and A. Wiek (2017). Beyond Interpersonal Competence: Teaching and Learning Professional Skills in Sustainability. | Field Guide to Sustainability. (n.d.). Retrieved November 28, 2019, from http://sustainability.psu.edu/fieldguide/resources/brundiers-k-

a-wiek-2017-beyond-interpersonal-competence-teaching-and-learning-professional-skills-in-sustainability/

Brutus, S., Aguinis, H., and Wassmer, U. (2013). Self-Reported Limitations and Future Directions in Scholarly Reports: Analysis and Recommendations. *Journal of Management*, *39*(1), 48–75. https://doi.org/10.1177/0149206312455245

CaGBC. (2018). LEED® Project Fees. Retrieved April 1, 2018, from https://www.cagbc.org/CAGBC/Programs/LEED/LEED_Project_Fees.aspx

Canada, E. and C. C. (2007, January 9). Greenhouse gas emissions [Research]. Retrieved June 3, 2019, from Aem website: https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

Canada Green Building Council. (2014). Canada Green Building Trends: Benefits Driving the New and Retrofit Market. Retrieved August 29, 2019, from https://www.cagbc.org/CAGBC/Resources/Green_Building_Marke.aspx

Carmichael, C. A., Preble, L. G., Randall, E. L., and Steiner, B. U. (2017, September). Sustainability Gets Serious: Drafting Multi-Tenant Office Leases for Net Zero Energy Buildings. *GP Solo EReport*. Retrieved from http%3A%2F%2Flink.galegroup.com%2Fapps%2Fdoc%2FA538249948%2FAONE%3Fu%3Duniwater%26sid%3DAONE%26xid%3D5bbd43f9

Cole, R. J., and Fedoruk, L. (2015). Shifting from net-zero to net-positive energy buildings. *Building Research and Information*, *43*(1), 111–120. https://doi.org/10.1080/09613218.2014.950452

Coleman, S., and Robinson, J. B. (2017). Introducing the qualitative performance gap: Stories about a sustainable building. *Building Research and Information*, *0*(0), 1–16. https://doi.org/10.1080/09613218.2017.1366138

Connolly, J., and Prothero, A. (2008). Green Consumption: Life-politics, risk and contradictions. *Journal of Consumer Culture*, *8*(1), 117–145. https://doi.org/10.1177/1469540507086422

Cranz, G., Lindsay, G., Morhayim, L., and Lin, A. (2014). Communicating Sustainability: A Postoccupancy Evaluation of the David Brower Center. *Environment and Behavior*, *46*(7), 826–847. https://doi.org/10.1177/0013916513475449

Day, J. (2014). Occupant Training in High Performance Buildings: An assessment of Environmental Satisfaction, Learning and Behaviors in Buildings. Retrieved from https://research.libraries.wsu.edu:8443/xmlui/handle/2376/5085

Dreyer, B. C., Coulombe, S., Whitney, S., Riemer, M., and Labbé, D. (2018). Beyond Exposure to Outdoor Nature: Exploration of the Benefits of a Green Building's Indoor Environment on Well-being. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01583

Edwards, T. J., and Kumphai, W. (2012). Sustainability in Multi-tenant Office Buildings: Anatomy of a LEED EBOM Program. *Energy Engineering*, *109*(2), 7–23. https://doi.org/10.1080/01998595.2012.10483744

Ehrhardt-Martinez, K. (2011). *Changing Habits, Lifestyles and Choices: The Behaviours that Drive Feedback-Induced Energy Savings*. 12.

Frank, P., and Stanszus, L. S. (2019). Transforming Consumer Behavior: Introducing Self-Inquiry-Based and Self-Experience-Based Learning for Building Personal Competencies

for Sustainable Consumption. *Sustainability*, *11*(9), 2550. https://doi.org/10.3390/su11092550

Giddens, A. (1991). *Modernity and Self-identity: Self and Society in the Late Modern Age*. Stanford University Press.

Gou, Z., and Siu-Yu Lau, S. (2013). Post-occupancy evaluation of the thermal environment in a green building. *Facilities*, *31*(7/8), 357–371. https://doi.org/10.1108/02632771311317493

Guell, C., Panter, J., Jones, N. R., and Ogilvie, D. (2012). Towards a differentiated understanding of active travel behaviour: Using social theory to explore everyday commuting. *Social Science and Medicine*, *75*(1), 233–239. https://doi.org/10.1016/j.socscimed.2012.01.038

Guy, S., and Farmer, G. (2001). Reinterpreting Sustainable Architecture: The Place of Technology. *Journal of Architectural Education*, *54*(3), 140–148. https://doi.org/10.1162/10464880152632451

Heerwagen, J. (2000). Green buildings, organizational success and occupant productivity. *Building Research and Information*, *28*(5–6), 353–367. https://doi.org/10.1080/096132100418500

Heinen, E., Maat, K., and van Wee, B. (2011). The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. *Transportation Research Part D: Transport and Environment*, *16*(2), 102–109. https://doi.org/10.1016/j.trd.2010.08.010

Heinen, E., and Ogilvie, D. (2016). Variability in baseline travel behaviour as a predictor of changes in commuting by active travel, car and public transport: A natural experimental

study. *Journal of Transport and Health*, *3*(1), 77–85. https://doi.org/10.1016/j.jth.2015.11.002

Jailani, J., Reed, R., and James, K. (2015). Examining the perception of tenants in sustainable office buildings. *Property Management*, *33*(4), 386–404. https://doi.org/10.1108/PM-05-2014-0022

Joachim, O. I., Kamarudin, N., Aliagha, G. U., and Ufere, K. J. (2015). Theoretical Explanations of Environmental Motivations and Expectations of Clients on Green Building Demand and Investment. *IOP Conference Series: Earth and Environmental Science*, *23*(1), 012010. https://doi.org/10.1088/1755-1315/23/1/012010

John, G., Clements-Croome, D., and Jeronimidis, G. (2005). Sustainable building solutions: A review of lessons from the natural world. *Building and Environment*, *40*(3), 319–328. https://doi.org/10.1016/j.buildenv.2004.05.011

Legget, R. F. (1966). *The national building code of Canada: A general review, by Robert F. Legget.* Ottawa, National Research Council, Canada, Division of Building Research, 1966: Ottawa, National Research Council, Canada, Division of Building Research.

Lewington, J. (2018, December 31). *Waterloo, Ont., office takes green development to new level*. Retrieved from https://www.theglobeandmail.com/business/industry-news/property-report/article-waterloo-ont-office-takes-green-development-to-new-level/

Li, D. H. W., Yang, L., and Lam, J. C. (2013). Zero energy buildings and sustainable development implications – A review. *Energy*, *54* (Complete), 1–10. https://doi.org/10.1016/j.energy.2013.01.070

Lilley, D. (2009). Design for sustainable behaviour: Strategies and perceptions. *Design Studies*, *30*(6), 704–720. https://doi.org/10.1016/j.destud.2009.05.001

Lindsey, T. C. (2011). Sustainable principles: Common values for achieving sustainability. *Journal of Cleaner Production*, *19*(5), 561–565. https://doi.org/10.1016/j.jclepro.2010.10.014

Masoso, O. T., and Grobler, L. J. (2010). The dark side of occupants' behaviour on building energy use. *Energy and Buildings*, *42*(2), 173–177. https://doi.org/10.1016/j.enbuild.2009.08.009

Miller, E., and Buys, L. (2008). Retrofitting commercial office buildings for sustainability: Tenants' perspectives. *Journal of Property Investment and Finance*. https://doi.org/10.1108/14635780810908398

Owens, S., and Driffill, L. (2008). How to change attitudes and behaviours in the context of energy. *Energy Policy*, *36*(12), 4412–4418. https://doi.org/10.1016/j.enpol.2008.09.031

Reffat, D. R. M. (2004). *Sustainable Development of Buildings and Environment*. 10.

Shika, S. A., Sapri, M., Jibril, J. D., Sipan, I., and Abdullah, S. (2012). Developing Post Occupancy Evaluation Sustainability Assessment Framework for Retrofitting Commercial Office Buildings: A Proposal. *Procedia - Social and Behavioral Sciences*, *65*, 644–649. https://doi.org/10.1016/j.sbspro.2012.11.178

Statistics Canada. (2018). Commuting to work. Retrieved January 17, 2020, from https://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-012-x/99-012-x2011003_1-eng.cfm

Stefanovic, I. L. (2000). *Safeguarding our common future rethinking sustainable development*. Retrieved from https://subzero.lib.uoguelph.ca/login?url=http://search.ebscohost.com.proxy.lib.uwaterloo.ca/login.aspx?direct=trueandscope=siteanddb=nlebkanddb=nlabkandAN=46857

Stern, P. (2000). *New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior*. https://doi.org/10.1111/0022-4537.00175

Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A., and Kalof, L. (1999). A Value-Belief-Norm Theory of Support for Social Movements: The Case of Environmentalism. *Human Ecology Review*, *6*(2), 81–97. Retrieved from JSTOR.

Thompson, C. (2017, February 16). An office building so green it actually produces energy. Retrieved March 15, 2018, from TheRecord.com website: https://www.therecord.com/news-story/7145313-an-office-building-so-green-it-actually-produces-energy/

Tung, A., Baird, K., and Schoch, H. (2014). The association between the adoption of an environmental management system with organizational environmental performance. *Australasian Journal of Environmental Management*, *21*(3), 281–296. https://doi.org/10.1080/14486563.2014.932721

Ture, R. S., and Ganesh, M. P. (2014). Understanding Pro-environmental Behaviours at Workplace: Proposal of a Model. *Asia-Pacific Journal of Management Research and Innovation*, *10*(2), 137–145. https://doi.org/10.1177/2319510X14536219

United States Green Building Council (USGBC) (1999). Membership survey, on the USGBC Home Page, www.usgbc.org.

Wang, Y. (2017). Promoting Sustainable Consumption Behaviors: The Impacts of Environmental Attitudes and Governance in a Cross-National Context. *Environment and Behavior*, *49*(10), 1128–1155. https://doi.org/10.1177/0013916516680264

Zhao, D.-X., He, B.-J., Johnson, C., and Mou, B. (2015). Social problems of green buildings: From the humanistic needs to social acceptance. *Renewable and Sustainable Energy Reviews*, *51*, 1594–1609. https://doi.org/10.1016/j.rser.2015.07.072

APPENDICES

A. Copy of Pre-occupancy Behavioural Survey

Pre-occupancy Behavioural Survey

Start of Block: Informed Consent

CONSENT_FORM **Pre-occupancy Assessment: Investigating human factors in green office buildings (REB #5720)** *Principal Investigator*: Dr. Manuel Riemer, Associate Professor Department of Psychology, Wilfrid Laurier University *Research Team:* Dr. Simon Coulombe (Laurier), Dr. Joel Marcus (York), Dr. Paul Parker (UW), Dr. Sean Geobey (UW), Bianca Dryer (Laurier), Andriana Vinnitchok (Laurier), Kai Reimer-Watts (Laurier), Brittany Spadafore (Laurier), Stephanie Whitney (UW), Olivia Paxton-Beesley (UW) and Zac Zhu (UW). **Informed Consent Statement – Pre-occupancy Survey** As a future citizen of the zero-carbon building, you are invited to participate in a psychology research study. The purpose of this study is to capture the experiences of those moving into this iconic building and the effect it has on their well-being, productivity, and environmental engagement. This Pre-occupancy survey is part of a larger three-year research project about sustainability in the zero-carbon building. **INFORMATION** You are invited to fill out a brief, 5-10-minute online survey that will ask questions about your lifestyle, diet, commuting and sustainability practices. Our goal is to gain a better understanding of the collective environmental footprint of the future zero-carbon building citizens. All future building citizens (i.e., 340 prospective participants), who are 18+ years of age, are invited to participate in this study. **The survey will remain open for two weeks.** **PARTICIPATION** Your participation in this study is voluntary. You may decline to participate without penalty. If you choose to participate, you may omit to answer any questions or withdraw from the study at any time without any penalty or loss of benefits to which you are otherwise entitled. Your decision to participate in this study will not impact your job or relationship with the organization with which you are involved/employed. If you withdraw from the study, every attempt will be made to remove your data from the study, and have it destroyed. Please note that your data cannot be withdrawn after data collection is complete because the data will be stored without identifiers. **COMPENSATION** To thank you for your participation in this study, **you are eligible to receive a $5 Starbucks e-gift card.** If you would like to receive the e-gift card, please provide us with your email on the form after the survey. The gift card will be sent to you electronically within four weeks after the survey closing date. If you choose to withdraw from the study, you are still entitled to the $5 e-gift card (contact mriemer@wlu.ca if you decide to withdraw from the study). Please note: Any compensation received related to the participation in this research study is taxable. It is the participant's responsibility to report the amount received for income tax purposes and Wilfrid Laurier University will not issue a tax receipt for the amount received. **RISKS** There are minimal anticipated risks related to your participation in this study. You may experience fleeting moments of discomfort because some questions ask you to reflect on your thoughts and behaviour. These feelings are normal and should be temporary. The goal of this study is NOT to evaluate or judge participants on an

individual basis, but rather to understand the prospective zero-carbon building tenants' notions of sustainability and how this changes over time. Also, the researchers will NOT share any personal information about you or your experiences with the organization with which you are involved. If you experience any lasting negative feelings as a result of participating in this study, please contact the researchers. **BENEFITS** By participating in this study, you will be helping us advance our understanding of how the culture of sustainability develops over time; and you will be supporting the organization with which you are affiliated in advancing their sustainability practices. You will also contribute to academic literature on sustainable high-performance buildings, such as the zero-carbon building. **CONFIDENTIALITY** Only the research team and other authorized researchers will have access to the data from this study. All reasonable measures will be taken to ensure that your data are kept confidential. Your survey will be assigned a unique numerical identifier, which you will create with instructions. Your survey responses will be stored separate from your personal information (i.e., contact information to receive the gift card and final report, and for follow-up to subsequent phases of the research). Please note that while in transmission on the internet, confidentiality of data cannot be guaranteed. The researchers acknowledge that the host of the online survey (Qualtrics) may automatically collect participant data without their knowledge (i.e., IP addresses). Although this information may be provided or made accessible, the researchers will not use or save this information without participants' consent. Further, electronic data will only be stored on a secure university network drive. The data that do not contain identifying information will be retained indefinitely for future analyses and may be made available to other authorized researchers. **CONTACT** This project has been reviewed and approved by the Wilfrid Laurier University Research Ethics Board (REB #5720), which is supported by the Research Support Fund. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. Jayne Kalmar, Chair, Research Ethics Board, 519-884-0710 x3131, or REBChair@wlu.ca **If you have questions at any time about the study, the procedures, your compensation, or you experience adverse effects as a result of participating in this study, you may contact Dr. Manuel Riemer at mriemer@wlu.caor (519) 884-0710, ext. 2982.** **FEEDBACK AND PUBLICATION** This survey is part of a larger study. By September 30, 2021, a final report that will summarize the findings will be produced and shared with the key contact from your organization. Also, the results of the research may be disseminated in academic journals such as the American Journal of Community Psychology or presented at a scholarly conference. The findings may be made available through Open Access resources.

CONSENT **CONSENT** I have read and understand the above information. I agree to participate in the study. Please print or save a copy of this form for your files.

- ○ Yes, I agree to participate (Click here to be directed to the survey) (1)
- ○ No, I do not want to participate (Click here to exit) (2)

Skip To: End of Survey If CONSENT I have read and understand the above information. I agree to participate in the study. Pl... = No, I do not want to participate (Click here to exit)

End of Block: Informed Consent

Start of Block: Survey Instructions

SURV_INST Thank you for participating in this survey!
This survey asks series of questions related to your personal commuting and consumption habits. The purpose is to establish a baseline prior to moving into zero-carbon building so that we can see if choices change over time. These questions are not meant to judge or evaluate you personally. **Our goal is to calculate the environmental footprint of the future citizens of the zero-carbon building collectively.** Thus, please answer the following questions honestly and to the best of your knowledge rather than trying to guess what we would like to hear. **You can skip any question you do not feel comfortable answering.**

End of Block: Survey Instructions

Start of Block: Anonymized Identifier

TITLE_ID
Anonymized Identifier

This set of questions is a standard process for creating a unique survey identifier for you that does not reveal your actual identity. This process ensures that all your answers are fully anonymous – the researchers will not be able to link your responses to you.

Please pay careful attention to these questions. If you choose to participate in subsequent phases of this project or if you participated in the previous online survey, this unique survey identifier will be used to connect your responses from multiple surveys.

ID1 1. The last letter of your last name? If married, use the last letter of your maiden name.
(e.g., Olivia Paxton-BeesleY)

ID2 2. The first letter of the city you were born in? (e.g., Toronto)

ID3 3. What is the first letter of the month in which you were born? (e.g. October)

ID4 4. The last digit of the year you were born? (e.g., 1994)

End of Block: Anonymized Identifier

Start of Block: Waste

Q193 First, we have a few questions about waste disposal and recycling. For each of the following, please provide separate responses for work and home.

WASTE1A Approximately what percentage of your **waste paper/cardboard goes to recycling** at work and home? *(Move the slider to the appropriate percentage)*

	Percentage (%) 0 10 20 30 40 50 60 70 80 90 100
Paper/cardboard recycling at WORK ()	
Paper/cardboard recycling at HOME ()	

WASTE1B_PLASTIC Approximately what percentage of your **plastic and glass containers** go to recycling at work and home. *(Move the slider to the appropriate percentage)*

Percentage (%)

0 10 20 30 40 50 60 70 80 90 100

Plastic and glass recycling at WORK ()	
Plastic and glass recycling at HOME ()	

WASTE1C_FOOD Approximately what percentage of your **food scraps and organic waste** (e.g. banana peels) goes to compost/green bins at work and home. *(Move the slider to the appropriate percentage)*

	Percentage (%)
	0 10 20 30 40 50 60 70 80 90 100
Composting at WORK ()	
Composting at HOME ()	

End of Block: Waste

Start of Block: Current Commuting

COMMUTE2 Next, we would like to ask some questions about your commute.

Do you typically use the same types of transportation throughout the year to commute to work?

- Yes (1)
- No (2)

Display This Question:

If Next, we would like to ask some questions about your commute. Do you typically use the same type... = Yes

COMMUTE2A_YR Please think about how you commuted to work **over the last year**. Using the bars below, please indicate – on a percentage basis – the form(s) of transportation you used. **The total must sum to 100%.** If you used one type of transportation all the time, please put

100% beside that option. If you used more than one type of transportation, please estimate the approximate percentage for each type. For example: Car (60%) + Bike (35%) + Walk (5%) = 100%

_____ Car (gas/diesel) (1)
_____ SUV/van/truck (gas/diesel) (2)
_____ Electric/Hybrid Vehicle (3)
_____ Bus/LRT (4)
_____ Walk (5)
_____ Bike (6)
_____ Carpool (7)
_____ Other (8)

Display This Question:

If Next, we would like to ask some questions about your commute. Do you typically use the same type... = Yes

COMMUTE2B_YR Next, please estimate your current one way commute to work in kilometers.

If needed, please use Google Maps for the estimate: https://maps.google.ca/

_____ km (1)

Display This Question:

If Next, we would like to ask some questions about your commute. Do you typically use the same type... = No

*

COMMUTE2C_SSN Please think about how you commuted to work **during the warmer season** (i.e., May to October). Using the bars below, please indicate – on a percentage basis – the form(s) of transportation you used. **The total must sum to 100%.** If you used one type of transportation all the time, please put 100% beside that option. If you used more than one type of transportation, please estimate the approximate percentage for each type. For example: Car (60%) + Bike (35%) + Walk (5%) = 100%

_____ Car (gas/diesel) (1)
_____ SUV/van/truck (gas/diesel) (2)
_____ Electric/Hybrid Vehicle (3)
_____ Bus/LRT (4)
_____ Walk (5)
_____ Bike (6)
_____ Carpool (7)
_____ Other: (8)

Display This Question:

If Next, we would like to ask some questions about your commute. Do you typically use the same type... = No

COMMUTE2E_SSN Please think about how you commuted to work **during the colder season** (i.e., November to April). Using the bars below, please indicate – on a percentage basis – the form(s) of transportation you used. **The total must sum to 100%.** If you used one type of transportation all the time, please put 100% beside that option. If you used more than one type of transportation, please estimate the approximate percentage for each type. For example: Car (60%) + Bike (35%) + Walk (5%) = 100%

_____ Car (gas/diesel) (1)
_____ SUV/van/truck (gas/diesel) (2)
_____ Electric/Hybrid Vehicle (3)
_____ Bus/LRT (4)
_____ Walk (5)
_____ Bike (6)
_____ Carpool (7)
_____ Other: (8)

Display This Question:

If Next, we would like to ask some questions about your commute. Do you typically use the same type... = No

COMMUTE2D_SSN Next, please estimate your current one way commute to work in kilometers.

If needed, please use Google Maps for the estimate: https://maps.google.ca/

_____ km (1)

Display This Question:

If Next, we would like to ask some questions about your commute. Do you typically use the same type... = Yes

Or Next, we would like to ask some questions about your commute. Do you typically use the same type... = No

COMMUTE2F We are interested in your comments about commuting options. What are the biggest factors that influence your current commuting choices? (e.g. commuting distance, weather, poor transit options, etc.)

End of Block: Current Commuting

Start of Block: Future Commuting

Q207 Next, we would like to ask about factors influencing your **future commuting** choices.

FTRCOMMUTE **Factors influencing future commuting choices:**

	Yes (1)	No (2)	Not Applicable (3)
Are you interested in changing the way you commute to work? (FTRCOMMUTE_1)	○	○	○
Would you be more likely to take public transit if your workplace was next to a transit stop? (FTRCOMMUTE_2)	○	○	○
Would you be more likely to purchase an electric vehicle (EV) if there were charging stations at your workplace? (FTRCOMMUTE_3)	○	○	○
Would you be more likely to bicycle to work if showers were available at your workplace? (FTRCOMMUTE_4)	○	○	○
Would you be more likely to bicycle to work if there were a better bike route to your workplace? (FTRCOMMUTE_5)	○	○	○

FTRCOMMUTE_COMMENTS Please provide additional information for any of the above:

End of Block: Future Commuting

Display This Question:

If Would you be interested to calculate your score right now and share it with us? It only takes 5 m... = Yes

CFSCORE_4B1 To go to the Project Neutral online calculator using the following link: http://www.projectneutral.org/login. Then, return to this web page and enter your score here:
_____ tCO2 (1)

End of Block: Carbon Footprint

Start of Block: Food

Q218 The type of **food** we eat also has different impacts on the environment. For example, cattle account for nearly 10% of global greenhouse gas emissions, primarily methane from their digestive system. Thus, if you don't mind, we would like to ask you a couple of food-related questions.

FOOD5A_BEEF In a typical week, approximately how many times do you eat beef?

- ○ Times per week: (1) _____
- ○ Prefer not to say (2)

FOOD5B_SOURCE How often do you buy locally (Ontario) produced food?

- ○ A lot of the food I buy is locally sourced (1)
- ○ Some of the food I buy is locally sourced (2)
- ○ Almost no food I buy is locally sourced (3)
- ○ I do not pay attention to the source of the food I buy (4)
- ○ Prefer not to say (5)

End of Block: Food

B. Copy of Pre-occupancy Attitudinal Survey

Pre-occupancy Attitudinal Survey

Start of Block: Informed Consent

CONSENT_FORM **Pre-occupancy Assessment: Investigating human factors in green office buildings (REB #5720)** *Principal Investigator:* Dr. Manuel Riemer, Associate Professor, Department of Psychology, Wilfrid Laurier University *Research Team:* Dr. Simon Coulombe (Laurier), Dr. Joel Marcus (York), Dr. Paul Parker (UW), Dr. Sean Geobey (UW), Bianca Dryer (Laurier), Andriana Vinnitchok (Laurier), Kai Reimer-Watts (Laurier), Brittany Spadafore (Laurier), Stephanie Whitney (UW) **Informed Consent Statement – Pre-occupancy Online Survey** As a future citizen of the zero-carbon building, you are invited to participate in a psychology research study. The purpose of this study is to capture the experiences of those moving into this iconic building and the effect it has on their well-being, productivity, and environmental engagement. This Pre-occupancy survey is part of a larger three-year research project about sustainability in the zero-carbon building. **INFORMATION** You are invited to fill out a brief online survey (approximately 10 minutes) that will ask questions about your experience of your current work space, your perceived well-being and productivity, your interest in environmental sustainability, and some basic demographic questions. All future zero-carbon building citizens (i.e., 340 prospective participants), who are 18+ years of age, are invited to participate in this study. **The survey will remain open for two weeks.** **PARTICIPATION** Your participation in this study is voluntary. You may decline to participate without penalty. If you choose to participate, you may omit to answer any questions or withdraw from the study at any time without any penalty or loss of benefits to which you are otherwise entitled. Your decision to participate in this study will not impact your job or relationship with the organization with which you are involved/employed. If you withdraw from the study, every attempt will be made to remove your data from the study, and have it destroyed. Please note that your data cannot be withdrawn after data collection is complete because the data will be stored without identifiers. **COMPENSATION** To thank you for your participation in this study, you are eligible to receive a $5 Starbucks e-gift card. If you would like to receive the e-gift card, please provide us with your email on the form after the survey (to ensure confidentiality, your email will be collected separately and not linked your responses to this survey). The gift card will be sent to you electronically within four weeks after the survey closing date. If you choose to withdraw from the study, you are still entitled to the $5 e-gift card (contact mriemer@wlu.ca if you decide to withdraw from the study). Please note: Any compensation received related to the participation in this research study is taxable. It is the participant's responsibility to report the amount received for income tax purposes and Wilfrid Laurier University will not issue a tax receipt for the amount received. **RISKS** There are minimal anticipated risks related to your participation in this study. You may experience fleeting moments of discomfort because some questions ask you to reflect on your thoughts and behaviour. These feelings are normal and should be temporary. The goal of this study is NOT to evaluate or judge participants on an individual basis, but rather to understand the prospective

Zero-carbon building tenants' notions of sustainability and how this changes over time. Also, the researchers will NOT share any personal information about you or your experiences with the organization with which you are involved. If you experience any lasting negative feelings as a result of participating in this study, please contact the researchers. **BENEFITS** By participating in this study, you will be helping us advance our understanding of how the culture of sustainability develops over time; and you will be supporting the organization with which you are affiliated in advancing their sustainability practices. You will also contribute to academic literature on sustainable high-performance buildings, such as the zero-carbon building. **CONFIDENTIALITY** Only the research team (listed at the top of this consent form) will have access to the data from this study. All reasonable measures will be taken to ensure that your data are kept confidential. Your survey will be assigned a unique numerical identifier, which you will create with instructions. Your survey responses will be stored separate from your personal information (i.e., contact information to receive the gift card and final report, and for follow-up to subsequent phases of the research). Please note that while in transmission on the internet, confidentiality of data cannot be guaranteed. The researchers acknowledge that the host of the online survey (Qualtrics) may automatically collect participant data without their knowledge (i.e., IP addresses). Although this information may be provided or made accessible, the researchers will not use or save this information without participants' consent. Further, electronic data will only be stored on a secure university network drive. The data that do not contain identifying information will be retained indefinitely for future analyses and may be made available to other authorized researchers. **CONTACT** This project has been reviewed and approved by the Wilfrid Laurier University Research Ethics Board (REB #5720), which is supported by the Research Support Fund. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. Robert Basso, Chair, Research Ethics Board, (519) 884-0710 ext. 4994 or rbasso@wlu.ca. If you have questions at any time about the study, the procedures, your compensation, or you experience adverse effects as a result of participating in this study, you may contact Dr. Manuel Riemer at mriemer@wlu.ca or (519) 884-0710, ext. 2982. FEEDBACK AND PUBLICATION This survey is part of a larger study. By September 30, 2021, a final report that will summarize the findings will be produced and shared with the key contact from your organization. Also, the results of the research may be disseminated in academic journals such as the American Journal of Community Psychology or presented at a scholarly conference. The findings may be made available through Open Access resources. **If you are interested in receiving a copy of the final report, please contact Dr. Manuel Riemer at mriemer@wlu.ca.**

CONSENT **CONSENT** I have read and understand the above information. I agree to participate in the study. Please print or save a copy of this form for your files.

- ○ Yes, I agree to participate. (1)
- ○ No, I do not want to participate. (2)

Skip To: End of Survey If CONSENT I have read and understand the above information. I agree to participate in the study. Pl... = 2

End of Block: Informed Consent

Start of Block: Survey Instructions

SURV_INST **Thank you for participating in this survey. Please complete the questionnaire honestly and to the best of your knowledge.**

End of Block: Survey Instructions

Start of Block: Anonymized Identifier

TITLE_ID

Anonymized Identifier

This set of questions is a standard process for creating a unique survey identifier for you that does not reveal your actual identity. This process ensures that all your answers are fully anonymous - the researchers and/or your employer will not be able to link your responses to you.

Please pay careful attention to these questions. If you choose to participate in subsequent phases of this project, this unique survey identifier will be used to connect your responses from multiple surveys.

ID1 1. The last letter of your last name? If married, use the last letter of your maiden name. (e.g., Olivia Paxton-BeesleY)

ID2 2. The first letter of the city you were born in? (e.g., Toronto)

ID3 3. What is the first letter of the month in which you were born? (e.g. October)

ID4 4. The last digit of the year you were born? (e.g., 1994)

End of Block: Anonymized Identifier

Start of Block: Section 2A – Environmental beh and attitudes

TITLE_SEC2
Environmental behaviours and attitudes

ENGBEH **Please rate the extent to which you engage in the following behaviours at work.**

	Never 0 (0)	1 (1)	Sometimes 2 (2)	3 (3)	Always 4 (4)
I conserve the amount of materials I use at work. (ENGBEH_1)	○	○	○	○	○
I promote environmentally friendly behaviours amongst my coworkers. (ENGBEH_2)	○	○	○	○	○
At work, I reduce the amount of energy I use. (ENGBEH_4)	○	○	○	○	○
I encourage my organization to reduce its environmental impact. (ENGBEH_6)	○	○	○	○	○

ENGEMO **Please rate the extent to which the following items reflect how you <u>feel about environmental sustainability</u>.**

	Not at all how I feel 0 (0)	1 (1)	2 (2)	3 (3)	Very much how I feel 4 (4)
I feel guilty when I don't act in environmentally friendly ways. (ENGEMO_1)	○	○	○	○	○
I worry about my environmental impact. (ENGEMO_2)	○	○	○	○	○
I feel good when I do something positive for the environment. (ENGEMO_3)	○	○	○	○	○
I feel satisfied when I act in environmentally friendly ways. (ENGEMO_4)	○	○	○	○	○

ENGCOG **Please rate the extent to which the following items reflect how you <u>think about environmental issues</u>:**

	Not at all how I think 0 (0)	1 (1)	2 (2)	3 (3)	Very much like I think 4 (4)
I know how to act in environmentally friendly ways. (ENGCOG_2)	○	○	○	○	○
I regularly think about environmental issues. (ENGCOG_3)	○	○	○	○	○
I consider environmental impact when I make decisions. (ENGCOG_4)	○	○	○	○	○
I think about how I can reduce my environmental impact. (ENGCOG_5)	○	○	○	○	○

End of Block: Section 2A – Environmental beh and attitudes

TABLES

Table 6.

Pre-occupancy Tenant 2 Parking Lot Composition, August 2018

Date and time		Commute types								Total N
		bikes	motorcycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		
				sedan	SUV/van/truck	sedan	SUV/van/truck	sedan	SUV/van/truck	
2018-08-21	10:30 am	0	0	119	78	2	0	2	0	201
2018-08-22	10:57 am	0	0	129	74	2	0	2	0	207
2018-08-23	10:27 am	9	0	118	76	4	0	2	0	209
2018-08-23	2:11 pm	9	0	121	66	4	0	2	0	202
2018-08-24	10:55 am	7	2	107	55	3	0	1	0	175
2018-08-24	2:43 pm	8	3	113	55	3	0	1	0	183
Total		33	5	707	404	18	0	10	0	1177
Average		5.5	0.83	117.8	67.3	3.0	0.0	1.7	0.0	196.2

Table 7.

Pre-occupancy Tenant 3 (A) Parking Lot Composition, August 2018

Date and time		Commute types								Total N
		bikes	motorcycles	gas/diesel vehicles		hybrid-Evs		Pure-Evs		
				sedan	SUV/ van/truck	sedan	SUV/ van/truck	sedan	SUV/ van/truck	
2018-08-21	10:45 am	0	0	156	102	3	0	0	1	262
2018-08-22	11:05 am	0	0	163	113	3	0	0	1	280
2018-08-23	10:35 am	0	0	140	100	3	0	0	1	244
2018-08-23	2:19 pm	0	0	147	92	3	0	0	1	243
2018-08-24	11:02 am	2	1	136	91	1	0	0	0	231
2018-08-24	2:48 pm	2	0	134	77	2	0	0	0	215
Total		4	1	876	575	15	0	0	4	1475
Average		0.7	0.17	146.0	95.8	2.5	0.0	0.0	0.7	245.8

Table 8.

Pre-occupancy Tenant 3 (B) Parking Lot Composition, August 2018

Date and time		Commute types								Total
		bikes	motorcycles	gas/diesel vehicles		hybrid-Evs		Pure-Evs		
				sedan	SUV/van/truck	sedan	SUV/van/truck	sedan	SUV/van/truck	
2018-08-21	11:03 am	0	0	9	11	0	0	2	0	22
2018-08-22	11:15 am	1	0	12	15	0	0	1	0	29
2018-08-23	10:22 am	0	0	11	9	0	0	1	0	21
2018-08-23	2:08 pm	0	0	14	14	1	0	2	0	31
2018-08-24	10:52 am	6	0	12	11	0	0	2	0	31
2018-08-24	2:38 pm	5	0	13	14	0	0	2	0	34
Total		12	0	71	74	1	0	10	0	168
Average		2.0	0.0	11.8	12.3	0.2	0.0	1.7	0.0	28.0

Table 9.

Pre-occupancy Tenant 3 (C) Parking Lot Composition, August 2018

Date and time		Commute types								Total N
		bikes	motorcycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		
				sedan	SUV/van/truck	sedan	SUV/van/truck	sedan	SUV/van/truck	
2018-08-21	11:15 am	4	0	34	53	2	0	0	0	93
2018-08-22	10:45 am	6	0	27	46	2	0	0	0	81
2018-08-23	10:10 am	11	0	27	39	3	0	1	0	81
2018-08-23	2:29 pm	14	0	25	46	3	0	0	0	88
2018-08-24	10:43 am	10	0	18	33	2	0	0	0	63
2018-08-24	2:34 pm	13	0	18	30	1	0	0	0	62
Total		58	0	149	247	13	0	1	0	468
Average		9.7	0.0	24.8	41.2	2.2	0.0	0.2	0.0	78.0

Table 10.

Pre-occupancy Tenant 3 (D) Parking Lot Composition, August 2018

Date and time		Commute types								Total
		bikes	motorcycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		
				sedan	SUV/ van/truck	sedan	SUV/ van/truck	sedan	SUV/ van/truck	
2018-08-21	11:30 am	0	0	13	11	1	0	1	0	25
2018-08-22	10:30 am	1	0	15	11	0	0	0	1	28
2018-08-23	10:47 am	0	0	13	13	3	0	0	0	29
2018-08-23	2:39 pm	0	0	9	12	2	0	0	0	23
2018-08-24	10:14 am	2	0	6	7	1	0	0	0	10
2018-08-24	2:08 pm	0	0	6	7	0	0	0	0	13
Total		3	0	56	61	7	0	0	1	128
Average		0.5	0.0	11.2	10.2	1.2	0.0	0.0	0.2	21.3

Table 11.

Pre-occupancy Tenant 4 Parking Lot Composition, August 2018

Date and time		Commute types								Total N
		bikes	motorcycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		
				sedan	SUV/ van/ truck	sedan	SUV/ van/ truck	sedan	SUV/van /truck	
2018-08-21	11:45 am	0	0	34	22	0	0	1	0	57
2018-08-22	10:15 am	0	0	27	22	0	0	1	0	50
2018-08-23	10:57 am	0	0	29	15	0	0	0	0	44
2018-08-23	2:49 pm	0	0	36	13	1	0	0	0	50
2018-08-24	10:22 am	0	0	28	25	0	0	1	0	54
2018-08-24	2:18 pm	0	0	27	22	1	0	1	0	51
Total		0	0	181	119	2	0	4	0	306
Average		0.0	0.0	30.2	19.8	0.3	0.0	0.7	0.0	51.0

Table 12.

Post-occupancy Parking Lot Composition from December 2018

Date and time		Commute types								Total
		bikes	motorcycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		
				sedan	SUV/ van/truck	sedan	SUV/ van/ truck	sedan	SUV/van/ truck	
2018-12-04	10:05 am	1	0	85	66	3	0	3	0	158
2018-12-04	3:30 pm	1	0	89	70	2	0	3	0	165
2018-12-05	10:00 am	1	0	89	50	2	0	4	0	146
2018-12-05	3:30 pm	1	0	81	59	4	0	3	2	150
2018-12-06	10:00 am	0	0	82	57	2	0	1	0	142
2018-12-06	3:30 pm	0	0	81	52	2	0	2	0	137
Total		4	0	507	354	15	0	16	2	898
Average		0.7	0.0	84.5	59.0	2.5	0.0	2.7	0.3	149.7

Table 13.

Post-occupancy Parking Lot Composition from January 2019

Date and time		Commute types								Total
		bikes	motorcycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		
				sedan	SUV/van/truck	sedan	SUV/van/truck	sedan	SUV/van/truck	
2019-1-21	10:00 am	2	0	92	57	2	0	5	0	158
2019-1-21	3:30 pm	1	0	96	61	2	0	6	0	166
2019-1-22	10:00 am	1	0	82	59	3	0	2	0	147
2019-1-22	3:30 pm	1	0	89	62	2	0	3	1	158
2019-1-24	10:00 am	0	0	73	56	1	0	4	1	135
2019-1-24	3:30 pm	0	0	79	45	3	0	4	1	132
Total		5	0	511	340	13	0	24	3	896
Average		0.8	0.0	85.2	56.7	2.2	0.0	4.0	0.5	149.3

Table 14.

Post-occupancy Parking Lot Composition from August 2019

Date and time		Commute types								Total N
		bikes	motor cycles	gas/diesel vehicles		hybrid-EVs		Pure-EVs		
				sedan	SUV/ van/truck	sedan	SUV/ van/truck	sedan	SUV/ van/truck	
2019-8-19	10:00 AM	10	1	73	38	2	0	5	0	129
2019-8-19	3:30 PM	8	0	79	40	3	0	4	0	134
2019-8-20	10:00 AM	7	0	84	47	4	0	3	0	145
2019-8-20	3:30 PM	9	1	82	45	3	0	4	0	144
Total		34	2	318	170	12	0	16	0	552
Average		8.5	0.3	78.7	41.7	3.0	0.0	4.0	0.0	138.0