LIGHTS OUT!

THE EFFECT OF GREEN BUILDING CERTIFICATION AND PRO-ENVIRONMENTAL PROMPTS ON THE LIGHTING BEHAVIORS OF DORMITORY OCCUPANTS

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ABSTRACT

In recent years a variety of methods have been utilized to minimize our global reliance on fossil fuels in an effort to reduce the amount of greenhouse gases (GHGs), including CO_2, released into the environment. Administrative controls to minimize the release of gases, including intergovernmental agreements, federal and regional legislation, and Voluntary Emission Reductions (VERs) programs, have been a major focus among political and organizational leaders, while engineering controls to reduce the initial usage of fossil fuels in daily activities have been more of a focus at the consumer level. In the U.S. among the building industry, both administrative and engineering controls have been utilized through several reduction mechanisms. The aim of this research was to determine the impact that the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design Green Building Rating System's (LEED) had on occupants' fossil fuel consumption, specifically related to artificial lighting usage measured in carbon footprints, in two student dormitories. The research also investigated whether LEED certification influenced an individual's participation in efficiency and curtailment behaviors to reduce lighting energy consumption and to test potential improvements to the program.

This study compared the lighting usage of ten participants living in either a LEED certified dormitory or similarly designed and built non-LEED certified dormitory, situated on a university campus. The additional potential for lighting consumption reduction was tested by exposing participants to a lighting conservation prompt, which was a sign. Lighting usage was measured for each participant over a two-week period, and data was extrapolated to find the Estimated Annual Lighting Carbon Footprint (EALCF) for each participant. Additional data was

collected in an attempt to understand other variables that may have influenced the outcome of the study.

Results showed that LEED certification reduced a participant's EALCF, however, signage only impacted the EALCF in situational conditions. Results indicated building certification, the male gender and the fewer number of luminaires available to the participant resulted in a reduction of available luminaire wattage. Additionally the source of the luminaire also impacted the available wattage and the total kilowatts used by each participant. The university-supplied luminaires were lower wattage than the personally supplied luminaires and were more utilized in both buildings. Luminaire usage was also positively and negatively impacted by a combination of variables including LEED certification, number of luminaires and prompt signage. Results indicated individuals with only university supplied lighting within their rooms had much lower EALCFs than those that had university and personally supplied lighting. This study also found no effect on EALCF based on previous and current pro-environmental beliefs and behaviors.

In conclusion, the LEED certification did have an impact on overall lighting usage for the participants in this study. Prompting signage was only found to have an effect when combined with other variables. Additional variables were recommended for investigation in future research including the impact of the possible engineering controls on the type of lighting installed and the impact of creating administrative controls limiting the type of lighting allowed within LEED certified buildings to further reduce energy consumption. This data could be used to create more robust studies to understand the full impact of the LEED program and uncover additional ways to increase occupant participation in the program.

BIOGRAPHICAL SKETCH

Kelly Chiappa Wilson was born June 14, 1978 in Richmond, Virginia. In 1996, she graduated from Atlee High School in Mechanicsville, Virginia with honors in art. In 1996, she was selected as a Reynolds Metals Scholar with a full academic scholarship to the Virginia Commonwealth University, located in Richmond Virginia. In 2000, she graduated Cum Laude and received a Bachelor of Fine Arts in Interior Design from their School of Arts. She worked within the design industry for 2 years before moving with her husband to Ithaca, New York. In 2005, she was selected to receive a full scholarship through the Cornell University Employee Degree Program, where she enrolled in the Masters program at the Department of Design and Environmental Analysis (DEA) within the School of Human Ecology. In 2008, she received a full teaching assistantship scholarship for the spring and fall semesters. She completed an internship in physical ergonomics at Corning Dow and is currently employed as an Associate Ergonomist at Humanscale Corporation in San Diego, California.

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CHAPTER 1: LITERATURE REVIEW

1.1 Introduction

In recent years placing the word "green" before any product or service has been associated with promoting a reduction in negative biospheric impacts when using that product or service. As industries and corporations align to practice and market "green" initiatives and endeavors, consumers are becoming more educated about the impact purchasing and usage habits can play within the biosphere (Estes, 2009). Consequently, questions have begun to arise on the effectiveness of governmental and privately-run programs created to mitigate the negative environmental impacts of our constantly increasing human population. Specifically, if these initiatives actually work to reduce the negative environmental impacts of the modern lifestyle; and the impact of consumer purchasing and usage behaviors on these initiatives and their mitigation goals. If there is a combination effect, does that change how we develop initiatives to increase consumer compliance and become more effective at reducing negative biospheric impacts in today's society? To answer these types of questions we must first understand and respect how we, as a society, reached this level of global climate change, and how basic human behavioral tendencies, relating to environmental concern, shape the decisions of the average consumer. Within this thesis, I will investigate the effects of participation in a well-known green initiative on a consumer's behavior and its overall ecological impact. I will investigate the impact environmental concern plays on personal tendency to comply with requests to acting a more environmentally friendly manner. I will draw conclusions on the use of this information in creating more effective environmental initiatives to work with human behavior tendencies while cultivating the desire to react in a more environmentally conscious manner.

1.2 Global Climate Change

Earth is the only known planet within our solar system currently sustaining life, as we know it, through the presence of water, sun, oxygen, carbon dioxide and a stable climate (Ward & Brownlee, 2000). The greenhouse effect is part of the stabilization process for the earth's near-surface temperature and atmospheric conditions (Le Treut, Somerville, Cubasch, Ding, Mauritzen, Mokssit et al., 2007). During the process both naturally occurring and anthropogenic[1] greenhouse gases (GHGs) including water vapor, carbon dioxide (CO_2), methane or nitrous oxide, absorb and emit infrared radiation, from the sun, to help warm the earth's surface (Herivel & Williams, 1975). Consequently, when excess GHGs exist in the environment the greenhouse effect is easily accelerated resulting in unstable atmospheric conditions (Le Treut et al., 2007).

An excess of any one of the GHGs associated with the greenhouse effect can cause this atmospheric instability. However, the most common GHG associated with an accelerated greenhouse effect is CO_2 (Le Treut et al., 2007). As CO_2 moves between the atmosphere, land, and water, several natural regulation processes control the levels of CO_2 in the atmosphere, and these processes are known collectively as the carbon cycle[2]. When the GHG levels are balanced, the carbon cycle is capable of regulating the amount of CO_2 released and absorbed into the environment (Keeling, 1961; 1998). Currently, scientists estimate a balanced system results in a

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[1] Caused by human activity.

[2] One example of a CO_2 regulation process is photosynthesis, where autotrophs convert CO_2 to organic material, or food, by reducing the GHG to carbohydrates thus removing the CO_2 from the atmosphere or the body of water where the autotroph resides. (Vermaas, 1998)

maximum annual absorption rate of ~6 billion metric tons for both natural and anthropogenic CO_2 (Energy Information Administration, 2008).

1.2.1 Climate Change Theory and Controversy

Climate change is defined as an unbalanced or accelerated greenhouse gas effect that produces significant changes in the near-surface and oceanic temperatures (Le Treut et al., 2007). As a global society over 10 billion metric tons of anthropogenic and natural CO_2 is released into the atmosphere annually, (Department of Energy, 2009) causing an imbalance in the greenhouse effect's emission and absorption rates, and resulting in a continual build-up of excess of GHGs in the atmosphere (Department of Energy, 2009). With 3.2 billion metric tons of GHGs associated with anthropogenic activity and an anticipated increase of 1.9% over the next 10 years, scientists are calling for action. One of the main consequences of excess greenhouse gases in the environment is the disruption to global temperature regulation processes (Hare & Meinshausen, 2006; Wigley, 1995). As these processes, such as cloud dispersion and glacier formation, become disrupted, the ability repair them becomes even more complicated. Because both excess GHGs and/or extreme temperatures affect temperature regulation processes, the normal temperature cycle can easily remain unbalanced without the addition of excess GHGs. Some scientists argue, during periods of extreme temperature variations, this self-sustaining abnormal temperature cycle can only be disrupted through a dramatic drop in GHGs released, even below normally acceptable ranges (Forster, Ramaswamy, Artaxo, Berntsen, Betts, Fahey, et al., 2007; Raper, 1996; Wigley, 1995). This self-sustaining temperature cycle is commonly referred to as the "commitment to climate change", because the consequences of today's actions are seen well into the future (Klein & Maciver, 1999). Some scientists believe this aim to change makes it more imperative to address climate change immediately.

According to scientists, the climate change the earth may be currently experiencing (IPCC, 2007), has been traced back to the Industrial Revolution (Hansen, Sato, Lacis, Ruedy, Tegen, & Matthews, 1998). Because most industrial machinery requires the combustion of fossil fuels to operate, the amount of CO_2 and methane in the atmosphere has increased by 36% and 148% respectively since the mid-1700s (Energy Information Administration, 2008). Within the last 20 years, the burning of fossil fuels is the source of three quarters of all anthropogenic CO_2 in the atmosphere (Energy Information Administration, 2008). With the use of fossil fuels remaining strong, at current GHG production rates, global climate projections indicate the earth could see a near-surface temperature increase of 1.1°C to 6.4°C by the end of the 21st century if GHG emissions don't decrease immediately. (IPCC, 2007)

Since not all scientists agree with these projections, (Durkin, 2007; Folland, Karl, Christy, Clarke, Gruza, Jouzel, et al., 2001) the National Research Council (NRC) (2006) in Washington, DC has been using historical documents, borehole temperatures, (Deming, 1995) tree rings and ice cores to create an estimated model of the earth's climate history for the past 2,000 years. This model has been used in a number of studies to support or disprove the existence and threat of climate change (Mann, Bradley, & Hughes, 1998; Seidel & Lanzante, 2004). While supporters of the climate change theory argue this model provides overwhelming evidence supporting the existence of climate change, (Folland, et al., 2001; Pollack, Huang, & Shen, 1998) opponents argue 2,000 years is an insufficient timeframe to fully explain the current climatic conditions relative to the earth's existence (Durkin, 2007; Seidel & Lanzante, 2004).

Using the 2,000 year model, both proponents and opponents to the climate change theory cite two historic time frames in support of their cause: the Medieval Warm Period (11th-14th centuries) (Fitzhugh & Ward, 2000; Lamb, 1965) and the Little Ice Age (16th-19th centuries)

(Matthes, 1939). During each of these times periods, temperatures were either above or below average yearly temperatures, when compared to other time periods (Mann, Bradley, & Hughes, 1998; Jones, Briffa, Barnett, & Tett, 1998). Opponents to the climate change theory cite the borehole temperatures from these time periods as evidence that the earth's temperatures can experience phases of natural change and claim the current rise in the earth's surface temperature is due to a natural warming period (Denton & Karlen, 1973; Harris & Chapman, 1997), and not the result of human activity (Deming, 1995). However, proponents to the existence of climate change say the reported time frames and regions in which these changes occurred were too sporadic to say the events were global (Bradley & Jones, 1993; Crowley & Lowery, 2000; Koch & Clague, 2011; Skinner & Majorowicz, 1999). They argue the sporadic nature of these events made it impossible to form a widespread un-natural self-sustaining temperature regulation disruption, proving the current and steady rise in global temperature is globally disrupted to an alarming degree (Folland, et al., 2001; Koch & Clague, 2011). However, most scientists assent with the recorded global meteorological data from 1906 to 2005, which reveals a global surface temperature increase of .74°C ± .18 (Trenberth, et al., 2007). The Intergovernmental Panel on Climate Change (IPCC) believes this increase in temperature did not happen isochronally, and the majority of the temperature increase was experienced from 1956 to 2005 (.64°C ± .13) (IPCC, Summary for Policymakers, 2007, p. 10). The IPCC predicates:

> The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is extremely unlikely that global climate change of the past 50 years can be explained without external forcing, and very likely that it is not due to known natural causes alone (IPCC, Summary for Policymakers, 2007).

Despite opposition to these startling numbers, organizations and governments around the world have begun to enact a variety of programs to slow and stop excess GHGs from entering the atmosphere.

1.2.2 International Climate Change Policy

International concern began after scientific data captured from the 1960's and 1970's revealed concentrations of CO_2 in the atmosphere were increasing at an alarming rate (Weigel & Weigel, 1978). This concern caused climatologists and other environmental organizations to press for an organized action to address climate change (Martinez, 2005). Years after international concern began, in 1988; the World Meteorological Organization (WMO) and the United Nations Environmental Programme (UNEP) were able to form the Intergovernmental Panel on Climate Change (IPCC) to address these issues on a global scale (IPCC, 2011).

The mission of IPCC was to present clear scientific data to the world on the "current state of climate change and its potential environmental and socio-economic consequences" (IPCC, 2011). The IPCC is open to all members of the WMO and United Nations (UN), making it an intergovernmental agency. Because governments and scientists are working together the IPPC reports they have a "unique opportunity to provide rigorous and balanced scientific information to [key] decision makers" (IPCC, 2011). According to the IPPC, their data, while policy-relevant, is never politically motivated and provides an un-bias report on the current state of the global environment based on research done throughout the world (IPCC, 2011).

One of the first tasks the IPPC was charged with accomplishing was: a comprehensive review with recommendations for the state of science with regards to climate change; an understanding of the social and economic impact of climate change; recommendations on how to proceed on forming an international convention to respond to climate change issues (IPCC, 2011). The first IPCC report, in 1990, stated climate change within the political environment and the need to tackle the challenges and consequences as unified nations (Houghton, Jenkins, & Ephraums, 1990). The response to this first report led to the creation of the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC, 2011).

1.2.3 United Nations Framework Convention on Climate Change

The UNFCCC was adopted at the United Nations headquarters in New York City, New York in May 1992 and by March of 1994 was entered into force; nearly 35 years after the wide-spread concern for environmental conditions began. The mission of the UNFCCC is "to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system" (UNFCCC(e) 2011). Additionally, the UNFCCC is charged with setting the strategy for intergovernmental efforts when dealing with the challenges posed by climate change. According to the UNFCCC website, under the convention, governments: (UNFCCC(b), 2011):

- Gather and share information on greenhouse gas emissions, national policies and best practices.
- Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries.
- Cooperate in preparing for adaptation to the impacts of climate change.

1.2.4 Kyoto Protocol

In 1992, the UNFCCC took the first steps towards creating an international agreement to globally reduce GHGs (UNFCCC(c), 2011). The agreement, later called the Kyoto Protocol Treaty, was negotiated in 1997 at the UNFCCC conference in Kyoto, Japan, and finally adopted in 1998 (UNFCCC(c), 2011). By June 2010, 184 industrialized nations had signed the agreement, that starting January 1, 2008 they would reduce their GHGs emissions by 5.2% (based on their 1990s CO2 levels) by the year 2012 (United Nations, 1998). This legally binding contract mandates the signed nations to reduce their GHG emissions by utilizing "flexible mechanisms" to reach the collective global GHG reduction of goal of 11% (United Nations, 1998).

The emissions goals for the industrialized nations of the Kyoto Protocol are given "assigned amounts", or allowable GHG emissions levels for their nation (United Nations, 1998). To meet the assigned amount, nations must take considerable measures to reduce their emission level, however, the protocol does allow for some flexibility through three market-based reduction mechanisms: Emissions Trading, Clean Development Mechanism (CDM), and Joint Implementation (JI) (UNFCCC(g), 2011; United Nations, 1998).

Emission trading is also known as "the carbon market" or "cap and trade". A central governing agency that monitors the "assigned amounts" oversees the cap and trade allowed in the Kyoto protocol. If a nation doesn't use all of their assigned amounts, known as emission credits, they can trade their credits on a trading exchange to other nations that have exceeded their own assigned amounts. This is seen as a way to penalize those who pollute and reward those who do not (Montgomery, 1972). Ideally, to avoid monetary penalties from GHG caps set forth in the Kyoto Protocol, nations participating in an emissions trading program aim to decrease their overall emissions.

The CDM allows developing countries to participate in emission-reduction projects to earn "certified emission reduction" (CER) credits. Each credit awarded is equivalent to one ton of CO_2, and can be traded or sold to industrialized nations trying to meet their reduction requirements under the Kyoto Protocol (UNFCCC, 2011). One of the early criticisms to the Kyoto protocol was the limited incentive for developing countries to control and curb their emissions (Kato, Hayashi, & Tanaka, 2003). The UCFCCC implemented this mechanism in response to the concern by trying to stimulate sustainable development and emission reductions within these developing countries, while helping industrialized nations meet their limitation targets. Each project is publically registered and tested to insure the end result will produce measurable and verifiable emission reductions based solely on the project's objectives (UNFCCC, 2011).

Joint Implementation (JI) allows a country to earn an emission reduction unit (ERU) by developing and implementing emission reduction projects in other Kyoto Protocol participating countries. Each project can earn one ERU, which is equivalent to one ton of CO2, and can be used towards meeting their Kyoto Protocol goal. JI projects must go through the same rigorous process as the CDM projects (UNFCCC(d), 2011). This particular mechanism is particularly useful to countries with global corporations and provides incentive to continue sustainable efforts abroad.

The UNFCCC also tracks the targets for the industrialized countries through two types of registry systems. The first is governmental national registries. These registries act as regulations enforcement, are held within each industrialized nation. They serve as a tracking system for the government to ensure all involved are holding and trading credits properly (UNFCCC(c), 2011). The second registry tracks the projects by issuing credits once a project has been deemed a carbon reduction success using the two registries, emissions are tradable by delivering the units or credits from the seller to the buyer thus creating the infrastructure to cap and trade as it relates to the Kyoto Protocol participating countries (UNFCCC(c), 2011; Finus, 2008). Reporting and compliance with the processes and procedures put in place by the Kyoto Protocol are considered critical by some to maintain the integrity and effectiveness of the Protocol (Brechin, 2003; Finus, 2008; Michaelowa, 2003). In December of 2005, a set of monitoring and compliance procedures were put into effect to enforce the rules and address any compliance issues raised during calculation of emissions data and accounting procedures. While countries were required to keep track of their own data, a committee was created to make sure the annual data was accurate and honest throughout the protocol's existence. The progress and reports filed by each country annually are then submitted for public visibility on the UFCCC's website (UNFCCC(c), 2011). Accessibility and transparency in the reporting system aims to create a more honest and competitive emissions control environment (Schmidt, 2010).

While some individuals believe the Kyoto Protocol effectively addresses many of the aspects of GHGs emission reduction, others believe it falls short in a number of ways (Kato et al., 2003). Despite the controversy surrounding the Kyoto Protocol, of those who acknowledge the existence of climate change, many agree some type of intergovernmental emissions protocol should be put in place to mitigate the excess GHGs in the atmosphere.

1.3 Climate Change Initiatives in the United States

1.3.1 National Legislative Policies

Separate of international efforts, local governmental and private agencies in the U.S., have created policies and programs to encourage businesses and residences to take steps to reduce their environmental impact. In the United States one of the latest federal efforts to contain and reduce GHG emissions included several Acts previously under consideration by the 111th Congress including the American Power Act (APA) introduced May 12, 2010 by Senators

Kerry and Lieberman (Kerry, 2012). Previous energy acts introduced to Congress included the Carbon Limits and Energy for American's Renewal Act (CLEARA), the American Clean Energy and Security Act (ACESA) which passed to the House of Representatives June 23, 2009 (Civic Impulse, LLC, 2012; Waxman, 2009), and the Energy Independence and Security Act of 2007 which was enacted after being signed by the President of the United States on December 17, 2007 (Civic Impulse, LLC., 2012). All 4 Acts introduced to Congress aim to reduce GHGs emissions in the U.S. by 2050. The measures by which they are reduced differ for each plan.

The APA, in particular, proposed an emissions cap system for both GHGs and hydrofluorocarbon (HFC) usage[3]. If it had been ratified, it is estimated the APA cap would have covered up to 87% of the U.S. GHG emissions currently being expelled into the atmosphere, after 2013 (Kerry, 2012). Similar to the Kyoto Protocol, there are proponents and opponents to any legislation mandating if and how GHGs should be regulated. Proponents argue that as one of the largest nations in the world the U.S. should be leading the charge in passing legislation to control emissions and reduce the U.S. dependence on carbon-based energy (Brooks, 2010; Weiss, 2010). Opponents to the legislation vary in their reasoning, as previously mentioned, some don't believe in climate change, others believe the costs associated with cap and trade models out-weigh the benefits (Hodges, 2012; Revkin, 2010), and more cost-effective methods could be developed to successfully manage GHG emission reduction (Manzi, 2010). Others believe domestic cap and trade poses feasibility issues and monetary consequences with regards to business and consumer compliance. Some legislation claims to consider consumer welfare by

[3] HFCs have been used since 1996 in the U.S. to replace the use of chlorofluorocarbon (CFC), in items such as refrigeration systems and aerosols. While HFC was once believed to be a safe substitute for CFCs, it has been proven otherwise. For these reasons, most new emission capping Acts specifically address the GHG HFC.

creating a CO_2 cap tax penalty scheme based on level of cap exceedance and household income. Legislators claim this distribution scheme will reduce energy usage among all households without affecting the overall income level of households (Kerry, 2012; Waxman, 2009). Opponents believe this could create unequal collection and distribution of cap exceedance penalty taxes that could prove to be ineffective at funding carbon mitigation projects aimed at helping consumers reduce their energy usage, or worse leave the consumer economy (Rausch, 2010).

1.3.2 Regional Legislative Policies

Within the U.S. several regional climate change initiatives have been created, including the Western Climate Initiative (WCI), the Northeast and Mid-Atlantic Regional Greenhouse Gas Initiative (RGGI), and the Midwest GHG Reduction Accord (MGGRA) (CORE, 2009; Cummins, 2012; RGGI, Inc, 2012). Each one of these initiatives aims to bring communities together to identify, evaluate and implement policies focused on addressing climate change on a regional level. The focus of these groups is the reduction of GHG emissions, encourage green technologies, and building a clean energy economy by reducing dependence on fossil fuels (Cummins, 2012; RGGI, Inc, 2012). While not one regional initiative covers all of the U.S., between the three groups over one-half of the U.S. population and three-quarters of the Canadian population lives in areas that are members or observers of one of these initiatives (Environmental Protection, 2010).

Recently, these three groups have begun to collaborate between each other to share ideas and experiences with regional cap and trade development. They have also given input into the federal legislation being presented before the Senate and Congress (Environmental Protection, 2010). In a collaborative white paper written by members of the WCI, RGGI and the MGGRA heavy importance is placed on using offsets within a cap and trade system (Three-Regions Offset Working Group, 2010).

1.3.3 Cap and Trade Programs

To understand the debate and impact on consumers' green related habits, it is important to understand the system being pushed by political leaders worldwide. Within a cap and trade system, a "GHG offset" refers to a GHG emissions reduction project aimed at reducing or removing specific types of GHGs not covered under a regulating cap and trade program (U.S. Department of Energy, 2012). GHG emitting consumers are able to trade one ton of regulated CO_2 expelled, with one ton of CO_2-equivalent (CO_2e) non-regulated GHG reduced or removed from the atmosphere. According to the three groups (Three-Regions Offset Working Group, 2010, pp. 6-7):

> Conceptually, an offset is used to allow a regulated emissions source to emit an additional ton of greenhouse gas in exchange for a ton of greenhouse gas emissions reduction or removal achieved outside of the capped sector(s) by an offset project activity. The regulated emissions source is allowed to emit more in exchange for achievement of emissions reduction elsewhere.

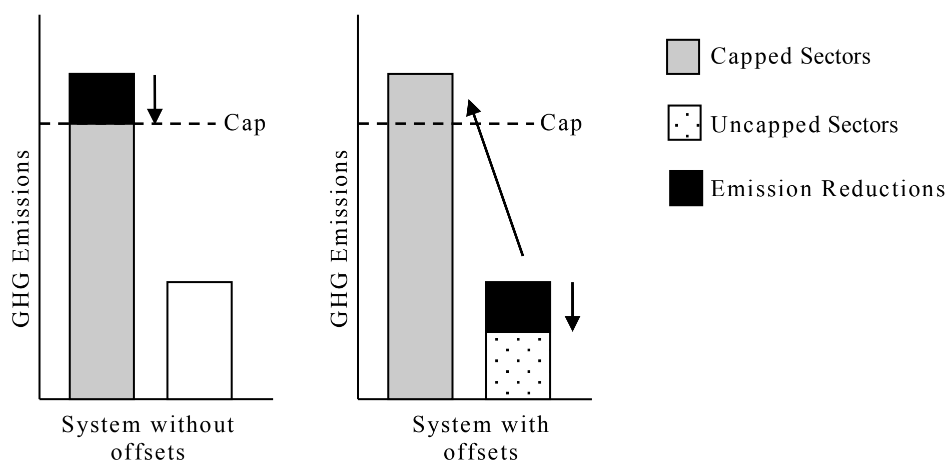


Figure 1.1: The Role of Offsets in Cap-and-Trade Programs (Three-Regions Offset Working Group, 2010, p. 7)

The three groups argue this is a more cost-effective way to ensure compliance with the cap and trade program, because it allows a flexibility mechanism (Three-Regions Offset Working Group, 2010). They argue it allows individuals to use more cost-effective methods to reduce their GHG emissions and comply with traditional emissions caps, while avoiding the costly tax penalties associated with exceeding the cap. In most cap and trade systems, a process is outlined to ensure each GHG offset project must be (Three-Regions Offset Working Group, 2010, pp. 10-15):

- Real - The project must represent at least one ton of CO_2e reduction or removal that can be identified as an emissions reduction activity. There must be methodologies in place for accurately accounting for all CO_2e emissions and reductions related to the project.
- Additional - The project must be the result of the offset program and provide a true emissions reduction based on requirements stated within the offset program. In basic terms the offset project would not have existed without the existence of the offset program.
- Verifiable - The reductions or removal of the CO_2e emissions must be verifiable and to receive credit as an offset program the emission reduction must be currently in place and verified it is in fact removing or reducing CO_2e emissions.
- Permanent - The CO_2e reductions and removals must be permanently removed from the atmosphere without risk of reversal.
- Enforceable - The offset project must have "sufficient regulatory authority and enforcement mechanisms to compel compliance with its program requirements".

Each project will be subject to a formal review by a regulatory agency to make sure it complies with all elements listed above.

According to the three groups, an important element of a successful offset program is a 'standardized approach' or a single set of program requirements for each project type, and not evaluate each project on a case-by-case basis (Three-Regions Offset Working Group, 2010). The perceived benefits to this program approach is increased program transparency, a more objective review process, reduced project transaction costs, reduced financial risk for project developers, reduced market uncertainty, and a more streamlined project regulatory review process. In the 'standardized approach' each of the five elements of an offset project would be addressed depending on the project category and not the individual project (Three-Regions Offset Working Group, 2010). This would reduce the time needed to develop individualized criteria for each project; leave less room for variability in the interpretation of the requirements for a qualifying CO_2e emissions reduction project; and would ensure the same level of enforcement for each offset project (Three-Regions Offset Working Group, 2010)

Opponents to the inclusion of offsets within the cap and trade programs cite perceived flaws in the system. One of which allows a for-profit company to develop a CO_2e emissions reducing project that meets all the criteria list above and is certified, and then turn around and sell their CO_2e credits to another company for profit (Eilperin & Mufson, 2010). This allows the purchasing company to purchase CO_2e credits to offset their own CO_2 cap exceedance, in addition to trading/purchasing allowance credits from other cap and trade regulated corporations. They argue these programs promote companies to continue to expel CO_2 emissions and then find back-up programs to pay their way out of bad environmental practices, rather than making a conservative effort up-front to reduce CO_2 emissions (Broder, 2010; Koenig, 2011; Salmon, 2008).

1.3.4 Voluntary Emissions Reduction Programs

While in the United States the Kyoto Protocol has not been formally adopted by the federal government, cap and trade programs are still being debated. Few regulations are in place to force business and consumers to limit their CO_2 emissions. However, there is a social trend in the U.S. towards participation in VERs programs. Because of the predicted implementation and impact of the cap and trade system (Chestnut, 2012), many VERs programs are developed and modeled after them with the pretense of quick compliance with future regulations (CORE, 2012). However these VERs programs are not without controversy. While the idea of VERs programs are similar to the offsets offered within the legislative cap and trade programs, individuals or companies have the freedom to decide which programs they believe will be the most effective at helping to offset the carbon emissions they or their organizations produce during daily activities. Organizations that offer these programs, like the Nature Conservatory, say their offset programs help reduce the build-up of GHGs in the atmosphere by funding projects designed to rebuild the environment and fund new "green" or environmentally-sustainable technologies (Conservatory, 2011).

Some organizations such as The Corner House and FERN claim these VERs programs are part of dangerous schemes aimed at detracting the public from supporting legislation that would force stricter CO_2 emissions regulations (Gilbertson & Reyes, 2009; Kill, Ozinga, Pavett, & Wainwright, 2010). Others claim that historically regulating agencies fall short in proving the equivalence between CO_2 expended and offsets purchased. They also argue there are "unsolvable measuring and accounting problems and that the technicalities and jargon of carbon offsetting presents an obstacle" to ensuring individuals feel confident their money is going to fund projects that will truly offset their daily activities (Barnes, 2010; The House of Commons Environmental Audit Committee, 2007). The largest drawback to VERs programs verses mandatory regulations lies on the reliance of individual and organizations to show concern and awareness to the amount of CO_2 emissions resulting from their daily activities, without concern these groups will never take the step to consider VERs initiatives (Kotchen, 2009). Most of these VERs programs rely on consumer and organizational awareness of their energy usage and the related CO_2 emissions resulting from their daily activities to be most effective.

1.4 Environmental Concern and Behavior

While the environmental impact of the industries is generally the focus of research and governmental legislation, the current conditions of the environment are overwhelming linked to consumer choices (Schipper, Bartlett, Hawk, & Vine, 1989). In response to this, scientists have developed an inclusive model for looking at the impact individual behavior has on the environment. The Consumer Lifestyle Approach (CLA) model refers to the overall environmental impact of product and consumption choices, including the pre- and post-consumer related requirements of each product (Bin & Dowlatabadi, 2005). The premise is without an individual's decision to purchase, use and dispose of a product, the industry would be nonexistent that creates or supports the use of that product. Every purchase or activity has a direct and indirect impact on the environment, and many researchers claim the industry cannot be blamed for current environmental conditions. Bin and Dowlatabadi (2005) also assert regulations minimally reduce current CO_2 levels and there is a need to first change product purchasing and usage habits before a substantial reduction will result. According to Bin and Dowlatabadi (2005), the direct and indirect influences can be defined as:

> If a consumer's activity leads to energy consumption and CO_2 emissions while the product or service is in or resulting from use, these are called *direct influences*, where energy consumption and CO_2 emissions occur in the preparation (production and delivery) of a product or service and before its use are called *indirect influences*. (p. 199)

Within the CLA model, individual behaviors can fall into one of the two types of environmental influences. Examples of direct influences usually include home energy usage and personal travel, while indirect includes housing operation, transportation operation, food and beverage consumption, etc. (Table 1.1)

Table 1.1: Consumer Consumption Activities Categorization (Bin & Dowlatabadi, 2005, p. 200)

Consumer activities categorization			Sources
Direct influences	• Home Energy	• Space heating • Air conditioning • Refrigeration • Other appliances and lighting	Residential Energy Consumption Survey (Energy Information Agency, 1999), RECS
	• Personal travel	• Long distance by automobile and trucks • Long distance by air • Long distance by others • Short distance by automobiles and trucks • Short distance by others	American Travel Survey (Bureau of Transportation Statistics, 1997), or ATS; Transportation Energy Data Book (Oak Ridge National Laboratory, 1999), or TEDB
Indirect influences	• Housing operations • Transportation operation • Food and beverage • Apparel and services • Healthcare • Entertainment • Personal Insurance • Others	• Shelter, utilities, etc. • Vehicle purchase (net), gasoline and motor oil, other vehicle expenses, etc. • Food at home, food away from home • Men and boys, women and girls, etc. • Fees and admissions, magazines, etc. • Personal insurance and pensions • Education, tobacco, etc.	Consumer Expenditure Survey (Bureau of Labor Statistics, 2001), CES

Note: This table illustrates the types of activities included in the CLA model

When an individual's behavior is placed into the CLA model, indirect influences of that behavior have a much larger impact on GHG emissions than direct influences. When combined, both the direct (29%) and indirect (57%) impacts of an individual's behavior accounted for 85%

of the U.S. energy consumption. With the overwhelming impact indirect influences have on GHG emissions, some argue pro-environmental concern is crucial, and emissions reduction will only happen if individuals begin to adopt pro-environmental behaviors (Bin & Dowlatabadi, 2005).

1.4.1 Environmental Beliefs and Values

During the 1970s early rise of the ecological and environmental crisis in the U.S., studies aimed at hypothesizing the motives behind individual tendencies towards pro-environmental behavior began to emerge. Researchers became fascinated by the distinct differences individuals placed on the term "environmental ethics" (Eckersley, 1992; Stern & Dietz, 1994). Some defined the term as stressing the means in which the environment should be a resource used solely for the needs of human existence, (Mohai & Bryant, 1992) while others viewed the term as calling to claim to the rights the biosphere has above and beyond human needs (Starik, 1995). While this debate still exists within research, it has facilitated the discussion and empirical research needed to begin to understand the motivation behind individuals and their decisions participate in pro-environmental behavior.

Some theorists believe action is driven by intention, they also believe intention or beliefs are driven by basic values (Parsons & Shils, 1962). Based on research conducted to understand these basic values that govern beliefs, three main values have emerged as the underlying motivators causing humans to show concern for or against pro-environmental issues: egoistic, altruistic, biospheric (Schultz, 2001; Schwartz, 1977; Stern & Dietz, 1994; Stern, Dietz, & Kalof, 1993). Egoistic values are formed when a person considers themselves above all other living beings. Altruistic values influence beliefs based on a moral obligation to consider all living beings when making decisions and have been classified as falling under the "golden rule" (Do unto others as you would have them do unto you.) (Heberlein, 1977; Schwartz & Howard, 1981). Biospheric values effect beliefs by placing the needs of the environment over the needs of humans (Schultz, 2001). Stern and Dietz (1994) concluded the importance of values is in the ability to transfer information to that individual. Values govern beliefs and if the information being given doesn't align with the values of the individual then they will be less likely to accept the information as true and act upon the belief (Schultz, 2001; Stern & Dietz, 1994). Thus having implications for how organizations promote pro-environmental beliefs and behaviors.

Once the concern for the environment has been established, no matter the value system governing that concern, the individual must then choose to act on that concern for the pro-environmental behavior to occur. Researchers have been attempting to ascertain the motivators for individuals to act on concern for the environment built by their beliefs (Spada, 1990; Weigel, 1983). While a number of theories exist, one stands out among researchers, Ajzen and Fishbein's theory of planned behavior (TPB) (Ajzen , 1991; Ajzen & Fishbein, 1980; Bamburg, 2003; Harland, Staats, & Wilke, 1999). TPB states that three key elements govern a person's intention to perform an action based on beliefs: the perceived consequences of the behavior (behavioral belief[4]); the social implications of the behavior (normative belief[5]); the availability of resources to perform the behavior (control belief[6]) (Bagozzi, Youjae, & Baumgartner, 1990; Schultz & Oskamp, 1996; Ajzen I. , 1991). For example, the action to turn-off a light when leaving a room is governed by: the consequences of turning off the light; how the lack of light

[4] Behavior beliefs affect the perceived personal feeling towards the behavior.

[5] Normative beliefs are perceived social response (social norms) to the behavior.

[6] Control beliefs are issues affecting the perceived ease of performing the behavior.

will be perceived among others; how easy it is to turn off the light. In a space that is only occupied by that individual this may be a very easy choice depending on the control belief. If others occupy the space, the ability to act on the concern for not turning off the light becomes more complicated.

In a study conducted by Sebastian Bamberg (2003), participants were given information regarding "green" electricity products in a seminar and polled on their behavioral, normative, control beliefs surrounding the topic. Participants were given the opportunity to request more information on the topic and were tracked on a basis of implied interest (tearing off a post-card to request more information) and those who performed the pro-environmental behavior to request the information (actually mailing the postcard). Bamberg found the pro-environmental behavior was influenced by a positive evaluation of the personal and social beliefs associated with the action. He also found the negative control beliefs for performing the action were overcome if pro-environmental values existed. Bamberg concluded, pro-environmental behavior is predicated by positive responses to beliefs surrounding the perceived consequences and obstacles of performing the behavior.

1.4.2 Influencing Pro-environmental Behavior

While a vast array of published literature attempts to uncover and explain the motivations behind the belief systems of individuals to predict behavior, other studies are aimed at uncovering ways to influence values and beliefs of those who act adversely to the environment to gain a desired pro-environmental behavior. The most common interventions tested can be divided into two categories: antecedent and consequence. Both strategies work to increase or decrease the probability of an intended behavior. Antecedent interventions are "stimulus events occurring before the target behavior", while consequence behavior involves "stimulus events occurring after the target behavior" (Ester & Winett, 1981,1982; Geller, Berry, Ludwig, Evans, Gilmore & Clarke, 1990).

1.4.2.1 Consequence Strategies

Consequence interventions include: feedback (continuous, interval, and comparative) and rewards. Both of these interventions have been shown to have positive influence on pro-environmental behavior and have been studied extensively. Feedback aims to inform individuals participating in pro-environmental behavior of the impacts their actions can have on the environment (Seligman & Darley, 1977). A number of studies have found no matter the interval or type of feedback provided, individuals receiving feedback build a sense of obligation or understanding of environmental impact of their actions and thus reduce their negative or unwanted behavior (van Houwelingen & Van Raaij, 1989; Winett, Neale, & Grier, 1979; Hayes & Cone, 1981; Brandon & Lewis, 1999). The reasoning behind this success within feedback interventions is the result of three stages of progression. Consumers must first learn of the consequences of their actions; they must then make an effort to reform their habits; before full compliance they must internalize the behavior and feel the full benefits of their change in behavior (van Raaij & Verhallen, 1983). Feedback allows the consumer to be constantly reminded of the consequences and benefits of the new target behavior, allowing for easier internalization of why they are behaving in a particular manner.

Providing an incentive to reach a goal has also been shown in a number of studies to influence pro-environmental behavior, however some argue it can be short lived, due to the extrinsic nature of a reward (McClelland, 1980; Winett, Kagel, Battalio, & Winkler, 1978; Slavin, Wodanski, & Blackburn, 1981). While most studies investigating rewards use monetary incentives to encourage participation in pro-environmental behaviors, other rewards have been studied. For example, Energy Conservation Challenges in dormitories aim to reduce energy and water consumption, use tangible rewards other than money, including: free events, items and plaques located within the winning dormitory. In a number of these studies, students have admitted to taking drastic measures to win the contest, including not showering for days at a time; using flashlights to move around the room, or spending the majority of their time in another building. Admittedly by students, these are hard to maintain after the contest and can even defeat the idea of energy or water conservation (Petersen, Shunturov, Janda, Platt & Weinberger, 2007).

1.4.2.2 Antecedent Strategies

Antecedent interventions involving pro-environmental behavior can include: goal setting, information and prompting. Antecedent interventions results are not as consistent as consequence interventions and can depend greatly on the specific intervention, personal norms, and social norms of the participant (Abrahamese, Steg, Viek & Rothengatter, 2005; Becker, 1978; Staats, Wit & Midden, 1996; van Houwelingen & Van Raaij, 1989; Winett & Kidd, 1982-1983). However they are a highly desired interventions because they are typically low in cost to implement and can reach a large audience.

Goal setting involves setting a specific conservation goal for a person or group of individuals to obtain, and the goals can be personally or externally set. Goal setting can be executed through commitment interventions that require an individual to provide "oral or written pledge or promise to change behavior" (Abrahamese, Steg, Viek, & Rothengatter, 2005). Goals can also be set and executed using a modeling technique. Modeling tailors a conservation strategy to match the beliefs and behaviors of the individuals aiming to meet a specific conservation goal within a specified time (Bandura, 1977).

When generalizing these interventions, the governmental and VERs programs, such as Kyoto Protocol, Cap and Trade policies, Architecture 2030 and the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) fall within this category of goal setting. Each program relies on different strategies for determining the appropriate goals individuals and societies should meet. The USGBC LEED program (outlined in section 1.5.2) is the best example of a modeling intervention because it provides several specific goals a building can obtain and then provides exact guidelines in which the owner, designer, or builder can follow to meet them. Within a research environment, goal setting, both commitment and modeling have shown to be highly effective if the goals are relevant and achievable (Becker, 1978; McCalley & Midden, 2002). However, this type of pro-environmental intervention relies heavily on pre-existing pro-environmental values and belief of an individual, and requires the individual to choose to participate in the intervention (McCalley & Midden, 2002; Thogersen, 2003). Some argue that creating a mandatory requirement (including a penalty for non-compliance) would force individuals to participate in a goal setting intervention, but as seen from research, mandatory regulations or goals, do not always lead to acceptance. A good example this can be seen in governmental policies that impose mandatory recycling and increased penalties for excess trash collection. While overall compliance tends to increase after the policy and penalty is enacted, the full compliance among residences is still limited and heavily dependent on available resources and convenience of compliance (Cohn, 1992; Hanley, 1988; Reschovsky & Stone, 1994).

Less resolute forms of antecedent interventions can be seen in informational and prompting techniques. However, research to-date has revealed minimal consistent results in developing a method for encouraging pro-environmental behaviors using information or prompting techniques. Researchers cite a main concern for these techniques. Depending on the values or beliefs of the individual being investigated, the most effective method for the specific wording of the message and delivery can vary. For example, messages aimed at individuals already exhibiting some of the desired behavior will see little benefit from the information or prompting (Geller, 1990).

Information interventions can be divided into to several groups including: mass-media communications; in-person seminars, and tailored information (specific information provided to a person or group of individuals of common interest). Mass media interventions can include video media, pamphlets, and brochures. The effectiveness of mass media in changing behaviors has shown to limit success (Hopper, 1991; Hutton & McNeill, 1981; Luyen, 2002). For example, field studies looking at consumer energy consumption behavior following the distribution of brochures and pamphlets specifically addressing these issues have yield non-significant results (Cone & Hayes, 1980; Geller, Winett, & Everett, 1982). A study conducted by Hutton & McNeill (1981) went one step further by providing means to participate in energy conservation behavior. Hutton & McNeill's study looked at the Low Cost/No Cost energy conservation initiative. A booklet on energy conservation created by the United States federal government and a shower control device were sent to 4.5 million households. The results from a phone survey following the mailing revealed no significant difference in implementing energy conservation tips between households who had received the information by mail and those who had not. According to Winett and Kagel (1984) these findings are based on finding a resulting behavior from a mass transfer of knowledge, yet many studies fail to gather data on if participants paid attention to the information given to them. Ester and Winett (1981-1982) assert these research studies aimed at mass information lack effective means of understanding the importance of the message and delivery methods when increasing or decreasing the chance of influencing behavior. They also state the importance of this method of behavior change solely because it can influence legislative policies mainly based on the low cost involved in information transfer.

In-person seminars tend to reveal similar results as mass-media studies (Marcell, Agyeman, & Rappaport, 2004). Geller (1981) conducted a similar study to Hutton & McNeill's by providing information on energy-conservation measures and a low flow water control device for showerheads. Instead of just sending the information to household, Geller held workshops on the information within the booklet along with visual instructions on how to install the low flow device in the showerhead. The study did find the workshop led to an increase in: knowledge about environmental conditions; environmental concern; and intention to practice more pro-environmental behaviors. However, post seminar in-home visits revealed no difference in the adaptation of energy conservation measures than those who had not attended the seminar. Studies looking at continued involvement in environmental seminars (i.e. more than one class), reveal mixed results in impacting an individual's pro-environmental behavior (Tung, Huang, & Kawata, 2002). Currently a limited amount of studies investigate the topic, however results indicate in a cumulative learning environment, a number of influences including transfer of information, consistency of message and behavior from influential figures that can impact a person's ability to understand and internalize the environmental information (Higgs & McMillan, 2006).

Prompting can be a more effective way to encourage pro-environmental behaviors than just providing information (Winett & Kagel, 1984). Prompts include cues, messages, or devices used prior to a particular behavior to influence its occurrence or frequency. These can include the alarms in a car to remind the passengers to buckle-up, writing on the side of a bin that says "Please recycle", or a sign that tells occupants to "turn off the lights". Extensive research has determined prompts are more effective at achieving pro-environmental behaviors when certain criteria are considered in its development (Winett & Kagel, 1984, p. 657). The prompt should:

- Highly specific;
- Stated in nondemanding or nonthreatening language;
- Salient;
- Convenient;
- Proximal to the requested behavior;
- Repeated.

Ambrahamese et al. (2005) caution that current studies have a number of flaws and rarely all 6 elements are placed in a prompt that is being investigated for its effectiveness at increasing pro-environmental behaviors.

1.4.2.3 Combined Strategies

Various studies investigate the effects of both antecedent and consequence strategies, and it is difficult to separate each strategy to understand the impact on results. Consequently these studies should be examined separately to see the overall effectiveness of combining strategies. As previously mentioned, the Energy Conservation Challenges taking place in dormitories across the U.S., tend to utilize both of these strategies (Marcell et al., 2004). These competitions use an antecedent strategy of goal setting by challenging dormitory residents in differing buildings to conserve the most energy and water within a specified amount of time. Consequence strategies include a reward for the dormitory that saves the most energy and water, and in most of the challenges individuals receive feedback on the amount of energy and water being used. In some cases up to 30-55% consumption reduction can be seen resulting from the combined energy conservation efforts (Petersen et al., 2007).

1.4.3 Categorizing Pro-environmental Behavior

Similar to the CLA model, sociologists place pro-environmental behaviors into one of two categories: efficiency behaviors and curtailment behaviors (Stern & Gardner, 1981). Efficiency behaviors are pro-environmental behaviors that happen only once and do not require a continual commitment to repetitive pro-environmental practices. For example in USGBC LEED building (see section 1.5.2 for additional details) the stakeholders and occupants influence/participate in both types of behaviors. However stakeholders are typically participating in efficient behaviors, such as installing Light Emitting Diodes (LED) lighting to reduce energy usage while in operation, while occupants are generally responsible for curtailment behaviors, switching off the LED lights when not in use. However either group can participant in either type of behavior. For example, occupants can supply their own lighting in a building if they feel the current lighting is not to their standards. Builders can install occupancy light sensors that control the use of lighting when the occupant is not in the space. Categorization of these behaviors becomes important when planning or evaluating an intervention aimed at encouraging pro-environmental behavior. Based on the information presented previously, it can be deduced that compliance to the environmental intervention is increased when the both types of behaviors are exhibited by consumers/occupants.

1.4.4 Carbon Footprinting

Of the individuals who have decided to participate in either an efficiency or curtailment behavior, a number of them are using lifestyle calculators, known as carbon footprint calculators, to help them determine the best method for increasing the impact of their pro-environmental behavior. According to the Carbon Trust, a United Kingdom not-for-profit organization, (Carbon Trust, 2012) carbon footprinting is a method of quantifying GHG emissions produced by an individual, organization, event or product utilizing the CLA model. Measured in tones of carbon dioxide equivalent (tCO_2e) it measures all six of the gases mentioned under the Kyoto Protocol including carbon dioxide, methane, nitrous oxide, hydrofluocarbons, perfluorocarbons, and sulfur hexafluoride. Based on information in Table 1.1, most calculators include questions about home energy usage, transportation usage, food and product choices, even product disposal methods. Using calculations agreed on by the organization supplying the calculator, each response to the questions is given a tCO_2e usage amount based on how it is answered. The tCO_2e amount for each question is added together to give the individual or business an estimated amount of GHG emissions produced per year in tonnes. Individuals can reduce or increase their annual GHG emission just by changing their behavior, including investing in offset programs or just reduce their emissions through making more informed decisions (Carbon Trust, 2012). Many organizations are using these calculators to report their progress when promoting and engaging in either efficiency or curtailment behaviors.

1.5 Building Industry and Green Initiatives

As a direct result of consumer supply and demand, construction and operation costs of buildings have one of the largest impacts on CO_2 emissions. In the building industry, a number of efficiency and curtailment strategies have been considered to reduce this impact and reduce subsequent emissions. One of those ways is to reduce the dependence on fossil fuels to build and operate buildings. In the U.S., 76% of the electricity created is used for the construction and operation of both commercial and residential buildings. One of the most common ways to produce electricity is through the combustion of fossil fuels, which represents 80% of all fuel sources for all energy produced (U.S. Energy Information Administration, 2011), and in the U.S. coal accounts for 50% of these fuels (American Coalition for Clean Coal Electricity, 2012). When electricity is produced through the burning of coal the resulting thermal radiation is used to heat large quantities of water. The process forces extremely hot and highly pressured steam through an electricity-creating turbine generator (Hendriks, 1994).

The production of electricity results in large amounts of by-products associated with coal combustion. After traditional coal combustion, these by-products (particles, gases and water vapor) are forced through a gas flue and subsequently released into the atmosphere. Efforts have been made to reduce the environmental impact of these elements by removing some of the elements before they are released into the air. However, while the majority of coal power plants use air scrubbers within the flue stacks to extract particles from flue gases, GHGs are still able to pass through scrubbers into the atmosphere (Hendriks, 1994). Many scientists believe it is possible to keep these harmful gases out of the atmosphere while still being able to harness the power of coal. Since the widespread use of such technologies is still years away, both proponents and critics agree one of the immediate way to minimize the impact of buildings on the environment is to reduce implementation of consumption by employing electricity conservation strategies.

1.5.1 Architecture 2030

One of the ways to reduce energy usage in buildings is to promote and encourage conservation awareness among building owners and occupants. In the architecture and design community this idea has taken form in the Architecture 2030 challenge. Architecture 2030 takes cues from the Kyoto Protocol by creating GHG reduction goals, which encourage architecture, design, and construction professionals to take the appropriate steps towards a carbon-neutral[7] society. Professionals can voluntarily adopt the following targets for their current and future projects (Architecture 2030, 2012):

- All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.
- At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.
- The fossil fuel reduction standard for all new buildings and major renovations shall be increased to 60% in 2010; 70% in 2015; 80% in 2020; 90% in 2025; and carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate).

The Architecture 2030 challenge suggests meeting these targets through sustainable building design, and the creation or purchase of renewable power. The group suggests utilizing the aid of a green building assessment tool to ensure new and renovated buildings meet the following criteria (Architecture 2030, 2012):

- lower energy usage;
- maximize water efficiency;
- reduce CO_2 emissions;

[7] Carbon-neutral is "making or resulting in no net release of carbon dioxide into the atmosphere, especially as a result of carbon offsetting". (New Oxford Dictionary, 2012)

- improve indoor environmental quality;
- and promote stewardship of resources and sensitivity to their impacts.

1.5.2 USGBC and LEED

In the U.S., the most recognizable green building assessment tool among designers and engineers is the Leadership in Energy and Environment Design (LEED) Green Building Rating System created by the United States Green Building Council (USGBC). The USGBC is (U.S. Green Building Council, 2011):

> A nonprofit organization committed to a prosperous and sustainable future through cost-efficient and energy-savings green buildings. USGBC works towards its mission of market transformation through its LEED green building certification program, robust educational offerings, a nationwide network of chapters and affiliates, the annual Greenbuild International Conference & Expo, professional credentials and advocacy in support of public policy that encourages and enables green buildings and communities.

Launched in 2000, the LEED Certification System is a set of guidelines created to guide builders and owners through the process of designing, constructing and operating a sustainable building (Katz, 2012; U.S. Green Building Council, 2012). The rating system evaluates environmental performance from a whole building perspective over a building's life cycle, providing a definitive standard for what constitutes a 'green building'. The USGBC also claims LEED certification publicly promotes sustainability by awarding excellence in building performance within seven areas of commercial green building design:

- Sustainable Sites - Encourages decision makers to choose building sites that promote the use of land development practices that preserve or restore local resources and limit the negative impact on the local ecosystem.
- Water Efficiency - Encourages the reduction of large amounts of water that people use in buildings which generally does not return to the natural water system.
- Energy and Atmosphere - Encourages the reduction of fossil fuel dependence by minimizing usage and by utilizing less harmful types of energy.
- Materials and Resources - Encourages the reduction, utilization of locally produced and use of renewable building materials to divert up to 80% of construction related waste from landfills.
- Indoor Environmental Quality - Encourages the reduction of indoor air and light pollutants to result in healthier, happier and more productive occupants.
- Innovation Design - Encourages new green design principles by awarding excellence in innovation and sustainable designs with credit towards building certification.
- Regional Priority - Encourages support of local environmental concerns that have been selected by local entities through the design, construction and maintenance of the building.

Within each category the USGBC outlines perquisites that must be met and other guidelines that can be chosen from to receive credit towards the building's aspiring certification level (U.S. Green Building Council, 2009).

The USGBC offers 9 product lines within the LEED Rating System including: New Construction; Existing Buildings: Operations and Maintenance; Commercial Interiors; Core & Shell; Schools; Retail; Healthcare; Homes; and Neighborhood Development (U.S. Green Building Council(e), 2012). In each product line, specific building types are addressed within the seven categories of green design to ensure all types of buildings and the unique issues associated with them are considered during the construction process. Because the guidelines are open to scrutiny, the USGBC occasionally revises them as designers and technology advance in their ability to create and maintain more sustainable environments (U.S. Green Building Council, 2009).

The USGBC has outlined a certification process to make it easier for projects to conform to the LEED rating System. At the beginning of each building project, the design team determines which product line is most appropriate for their project depending on the type of building they are constructing or renovating (Kubba, 2010). The project is registered with the USGBC and a fee is paid, allowing the design team to access essential tools and information needed to properly document and certify the project (U.S. Green Building Council, 2009). In most cases the owner and/or architect has already decided which level of certification they will pursue for the building. Currently there are 4 levels of certification: Certified, Silver, Gold and Platinum. If the Platinum certification, the most challenging and generally the most initially expensive to meet the requirements, if obtained then the USGBC returns the registration and certification fee after it is awarded (U.S. Green Building Council, 2009).

After initial registration, a project team leader is chosen and subsequently made responsible for collecting information and performing calculations needed to satisfy the perquisites and credits within each category within the LEED rating system (U.S. Green

Building Council, 2009). To receive the LEED Certification the project must satisfy all of the prerequisites and a minimum number of additional credits. This depends on the level of certification the project is trying to obtain and the product line chosen based on the building type. For example in the New Construction certification process, the rating levels include: Certified, 26 – 32 credits; Silver, 33 – 38 credits; Gold, 39 – 51 credits; and Platinum 52 – 69 credits. During the construction process the USGBC reviews the project twice to insure LEED rating system compliance, once after the design phase and again after the construction phase. When the USGBC determines a project has met 1 of the 4 levels of LEED certification, they send a formal letter of certification and mountable plaque for the building (U.S. Green Building Council, 2009). Participating in the certification process and the awarding of any level of LEED certification is used in most organizations as a way to promote their pro-environmental stewardship (Kubba, 2010).

However, critics of the LEED rating system argue the current certification requirements fall short in providing consistent energy conservation results in LEED certified buildings (Kamenetz, 2007). While researchers have shown LEED buildings on average utilize 10-39% less energy than traditional buildings (Baylon & Storm, 2008; Fowler & Rauch, 2008; Fowler, Rauch, Henderson & Kora, 2010; Newsham, Mancini & Birt, 2009), these numbers are not nearly those required to meet the Architecture 2030 Challenge. Critics also claim this provides evidence that LEED certification levels (certified, silver, gold, and platinum) do not correlate with energy conservations results in LEED buildings (Newsham et al., 2009; Diamond, Opitz, Hicks, Vonneida, & Herrera, 2006) and that while higher certification levels can improve resale on buildings it does not resulting in corresponding energy savings (Fuerst & McAllister, 2010). Surprisingly, some studies show 28-35% of LEED buildings use more energy than their non-

LEED certified counterparts, (Newsham et al., 2009) and in some cases occupied LEED buildings consumed more energy than was expected by designers and engineers during the planning phase of the project. Researchers tended to conclude the designers, in these instances, did not account for occupant behavior and their willingness to adapt to new technology (Torcellini et al., 2004).

While LEED has been proven to improve building efficiency it takes a more traditional approach, and mainly targets architects, designers, and owners, not occupants. Some researchers now argue building technology alone will not result in significant differences in energy consumption and that individual occupant behavior must be considered to have the greatest impact on conservation (Newsham et al., 2009). According to the National Institute of Building Sciences, when considering life-cycle costs of a building (those costs incurred during the life-span of the building) only 2% represents the initial cost of the building, 6% is the cost of operation of equipment, and 92% is related to the occupants costs (Osso, Walsh, Gotfried, & Simon, 1996). Studies have also shown behavior accounts for 45%-55% of all energy usage and while consumption can vary daily by 15%, depending on the choices people make regarding energy conservation behavior, (Schipper et al., 1989) a 25% reduction alone can occur from changing how individuals use readily available conservation technology (Junnila, 2007; Osso, Walsh, Gotfried, & Simon, 1996). While LEED focuses on the promoting energy-conservation behaviors, questions surround the motivation of occupants to participate in and not sabotage pro-environmental intentions set by others, and whether or not this consideration be included in the overall understanding of a building's potential energy savings.

1.5.3 Lighting Conservation

One of the easiest areas for an occupant to reduce energy consumption is through smart lighting choices and usage. During 2010 in the U.S., 13% of the natural resources used for energy are designated for lighting (U.S. Energy Information Administration, 2012). While this number has decreased down from 17% in 2006, further reductions are possible through efficiency and curtailment behaviors. The addition of alternative energy sources have helped to reduce the negative impacts of excess lighting usage, but more importantly with the advent of newer technology including LEDs and occupancy sensors, users are able to have a greater impact on the environment while utilizing these devices. This idea has lead the U.S. government to enact the Energy Independence and Security Act of 2007 which, among other goals, will phase out most incandescent light bulbs by the year 2014 (110th Congress, 2007). However, the best and most efficient devices are only effective if used properly.

Lighting usage studies have revealed switching behavior among individuals appears to be random, but is instead controlled consciously and consistently. The reasoning, however, behind variations in switching patterns between individuals can vary greatly depending on the space and the lighting technology (Hunt, 1979; Love, 1998; Pigg, Eilers, & Reed, 1996; Reinhart & Voss, 2003). A number of elements influence a person's need to use lighting including: time of day; age; eye-sight; fatigue; and cultural background (Rea, 2000). In a study by Reinhart and Voss (2003), comparisons were made between a various lighting studies to investigate switching behaviors of individuals in search of commonalities. (See Table 1.2)

Table 1.2: Comparison of switching behaviors across lighting studies (Reinhart & Voss, 2003)

Trends in Manual Control of Artificial Lighting	References
• People usually pertain to either of the following behavioral classes; • People who switch the lights for the duration of the working day and keep it on even in times of temporary absence and; • People who use electric lighting only when indoor illumination levels due to daylight are low.	Love 1998, Reinhart and Voss 2003
• All lights in a room are switched on and off simultaneously	Hunt 1979
• Switching mainly takes place when entering or vacating a space	Hunt 1979, Love 1998, Pigg 1996
• The switch-on probability on arrival for artificial lighting exhibits a strong correlation with minimum daylight illuminances in the area.	Hunt 1979, Love 1998
• The length of absence from an office strongly relates with the manual switch-off probability of the artificial lighting system	Pigg 1996, Reinhart and Voss 2003
• The presence of an occupancy sensor influences the behavioral patterns of some individuals. • On the average, people in private offices with occupancy control are only half as likely to turn off their lights upon a temporary departure as people without sensors.	Pigg 1996

Comparisons across studies revealed opportunities for occupants to reduce lighting use by switching off lighting when not needed. In several instances, individuals were observed leaving lightings on when the room was unoccupied, turning on a light when the light level was previously sufficient or not switching off a light when the lighting became brighter than was required to complete a task (Hunt, 1979; Love, 1998; Pigg et al., 1996; Reinhart & Voss, 2003). Energy simulation software predicts the use of curtailment behaviors by individuals could reduce energy expended on lighting upwards to 40%, (Bourgeois, Reinhart, & Macdonald 2006). Reducing lighting usage through curtailment behaviors and maximizing the use of energy efficient lighting can help achieve the greatest savings of lighting energy and reduce the amount of CO_2 being released into the atmosphere.

1.6 Hypotheses

All the above-mentioned literature indicates a number of ways to decrease reliance on fossil fuels and reduce CO_2 emissions being released into the environment. Current regulative initiatives are forming standards and protocols aimed towards focusing nations at meeting energy conservation goals. However, research states these tactics may not be as effective as governments and corporations had hoped. There are opportunities to investigate ways to promote organizational environmental stewardship and consumer pro-environmental behaviors, but understanding the role of each player is a critical first step towards compliance. Taking a step back and investigating one of the more popular approaches among organizations today, in promoting environmental commitment might yield interesting results in improving current systems, specifically the desire to build "green".

While recent emphasis has been placed on sustainable building design, construction, and operational energy consumption, it is also important to understand consumption behaviors of the building's occupants. Stricter requirements in LEED guidelines on energy consumption are a step in the right direction, but more research needs to be completed to fully understand the human factor in sustainable design. Participating in efficiency behaviors when the building is planned is only one method that can be utilized when constructing a LEED building. Considering the values and beliefs of the occupants in the space could increase the adoption rate of new technologies. While understanding the effectiveness of curtailment-focused energy conserving designs could increase curtailment behaviors among occupants. Consequently, the specific questions to be addressed when building "green" are whether existing LEED certified buildings promote sustainable energy consumption habits among its occupants, and what improvements can be made to the current guidelines to improve occupant involvement in energy conservation. This research aims to answer these questions through testing the following hypotheses:

- Occupants in a US Green Building Council LEED Certified student dormitory have lower estimated annual lighting carbon footprints than those in a similarly designed and built non-certified building.
- Occupants continually exposed to lighting energy conservation prompting signage have lower estimated annual lighting carbon footprints, based on the profile for the duration of the study period, than those not exposed to the signage.
- Of those occupants exposed to lighting conservation prompting signage, the occupants in a US Green Building Council LEED Certified student dormitory will have lower estimated annual lighting carbon footprints, based on the profile for the duration of the study period, than those in a similarly designed and built non-certified building.

In addition, the research results may have implications for additional design guidelines that would encourage environmentally sustainable habits among building users in a green building.

CHAPTER 2: METHODOLOGY

2.1 Research Sites

Two Cornell University undergraduate student dormitories were chosen for the study - the Alice H. Cook House, a USGBC LEED Certified building (see Appendix A for a copy of the LEED points awarded), and the Hans Bethe House, a building comparable in design specifications, construction, and operational methods but not LEED certified. Both buildings are located on the West Campus of Cornell University in Ithaca, New York, and were designed by Kieren Timberlake Associates, LLP and built by Welliever McGuire Construction Company. Both are relatively similar in site orientation, size, and design. The buildings were built with similar sustainable design and construction practices; however USGBC LEED certification was only applied for and awarded to the Alice H. Cook House. Both dormitories rely on university-supplied energy for both heating and electricity created through the use of coal-fired generators. The coal-fired generators and a waste heat steam generator supply heating; however the coal-firing generators solely supply electricity. Each dormitory provides furnished resident rooms for sophomores, juniors and seniors, and includes mostly suites and a small number of rooms not attached to suites. The non-suites rooms have access to a shared public bathroom, whereas the suites contain, on average, 4-7 resident rooms, a shared bathroom and a common area.

Completed and LEED Certified in 2004, the Alice Cook House (LEED building) contains six stories: two stories specifically for mechanical spaces (Ground and the 5th floor), one story includes common areas (1st floor), and three stories are designated residence floors (2nd, 3rd and 4th floors). (See Appendix B for complete floor plans.) This LEED building houses 115 students, 2 Graduate Resident Fellows and an occasional visitor. Additionally, there are two separate apartments for the House Professor and the House Dean.

Completed in 2007, Hans Bethe House (non-LEED building) has 7 stories: two stories specifically for mechanical spaces (Ground and the 6th floor), two stories contain common areas (1st and 2nd floors), and five stories designated resident housing (1st, 2nd, 3rd, 4th, and 5th floors). (See Appendix C for complete floor plans.) This non-LEED building houses 314 students, 6 Graduate Resident Fellows, and an apartment for the House Professor. Table 2.1 shows the amenities, size and distribution of space for each dormitory.

Table 2.1: Area Comparison of Dormitories

Location	Alice Cook House	Hans Beth House
Building Gross Area	78,438	142,901
Building Net Area	65,735	119,377
House Professor Apartment	2,121	2,529
House Dean Apartment	1,417	N/A
Dining Hall	~8,300	~7,700
Common Room	1,873	1,464
Administrative Offices	815	1,030
Seminar Room	516	611
Conference Room	269	334
Library	764	766
Lounge	139	195
Computer Lab	221	111
Music Room	83	104
Bike Storage	124	110
Laundry Facilities	185	287

Note: Data is representative of the net area, in square feet, per listed location, except building gross area.

Table 2.2 and Table 2.3 show the quantities and average square feet of the areas on the floors included in the study (floors 2, 3, and 4 only).

Table 2.2: Quantities comparison of dormitories (Floors 2-4)

Areas of Interest	Alice Cook House	Hans Beth House
Students per floor	27-44	59-84
Non-suite Singles Bedrooms per floor	7	11-21
Non-suite Double Bedrooms per floor	1-2	3-4
Suites per floor	4-6	8-19
Bathrooms per suite	1-2	1-2
Single Bedrooms per suite	3-5	3-4
Double Bedrooms per suite	1-2	1

Note: Data is representative of quantities of specified spaces on floors 2, 3, 4 only.

Table 2.3: Area comparison of dormitories (floors 2-4)

Areas of Interest	Alice Cook House	Hans Beth House
Avg. gross area per floor	12,337	23,298
Avg. net area per floor	10,143	19,041
Non-suite Single Bedroom	~111	~104
Non-suite Double Bedroom	~198	~213
Suite Common Room	~308	~278
Suite Bath	~85	~92
Suite Single Bedroom	~110	~103
Suite Double Bedroom	~217	~189

Note: Data is representative of the net area, in square feet, per listed location, except floor gross area.

2.1.1 Participant Resident Room Description

To control for daylight effects in both dormitories, only single-occupancy rooms on floors 2, 3 and 4 with North or South facing windows were selected for participation in the study. The participant resident rooms included in the study ranged in size from 100 to 110 square feet, and each contained a small closet (~8 sq. ft.). Materials used in each room included: white drywall walls, white acoustical tile ceilings ranging from 10 to 12 feet high, solid wooden doors, and wall-to-wall carpeting. Wooden furnishings provided by the university included one extra long twin bed, a desk with a detachable hutch, and a three-drawer dresser.

The lighting in all rooms included a university supplied ambient-light luminaire[8] (operated by a wall switch next to the room's entry), a university supplied task-light luminaire (controlled at the source) and some rooms had additional luminaires supplied by the student (controlled at the source). The type of ambient-light luminaire used was dormitory dependent. The rooms in the LEED building had a small round wall luminaire that held one 26-watt (F26TBX/SPX30/A/4P) lamp. The rooms in the non-LEED building had an up-light luminaire kit attached to a fan that held one 40-watt (T-5 Circline Lamp) lamp. Both buildings provided the same task light that held a 13-watt (F13BX/SPX35/835) lamp. Additionally, each room received daylight through two operational windows, and operational double cellular blackout shades were provided at each window for day lighting control and visual privacy. (See the Appendix D for examples of single rooms and luminaires in each building.)

2.2 Participants

Ten participants, five males and five females voluntarily participated in the study. All participants were enrolled in the university during the spring 2008 semester and were recruited through a personal invitation before and after the semester began (See Appendix E for a copy of the invitation). Upon completion of the data collection and surveys each participant was give a compensation of $10. The Cornell University Human Participants Institutional Review Board deemed the study exempt from Federal Regulation for the Protection of Human Subjects on March 5, 2007. (See Appendix F for copy of exemption.)

[8] Luminaire is defined here by lighting fixture containing a lamp.

Participants varied between 19 and 24 years old with a mean age of 21.1, and current education levels included sophomores (n=3), juniors (n=5), and seniors (n=2). Participants resided on 3 different floors within both buildings (2nd floor, n=2; 3rd floor, n=4; 4thfloor,n=4), 6 of the participants were in the LEED building and 4 in the non-LEED building. Location of participant rooms varied on each floor but included an equal distribution of north and south facing windows. Nine participants resided in the dormitory of their choice, and 1 participant resided in the non-LEED building, but listed the LEED building as their first choice on their dormitory selection application. Of the participants who chose the Alice Cook House as a residence, none listed the LEED Certification as a contributing factor toward their choice, and none were aware of the LEED certification before the experiment began.

2.3 Design

The study was a quasi-experimental design involving two levels of independent variables and one dependent variable as depicted in Figure 2.1. The first independent variable level was LEED Certification and its existence (LEED) or absence (non-LEED) within a building. The second level of independent variable was embedded in the first independent variable and tested

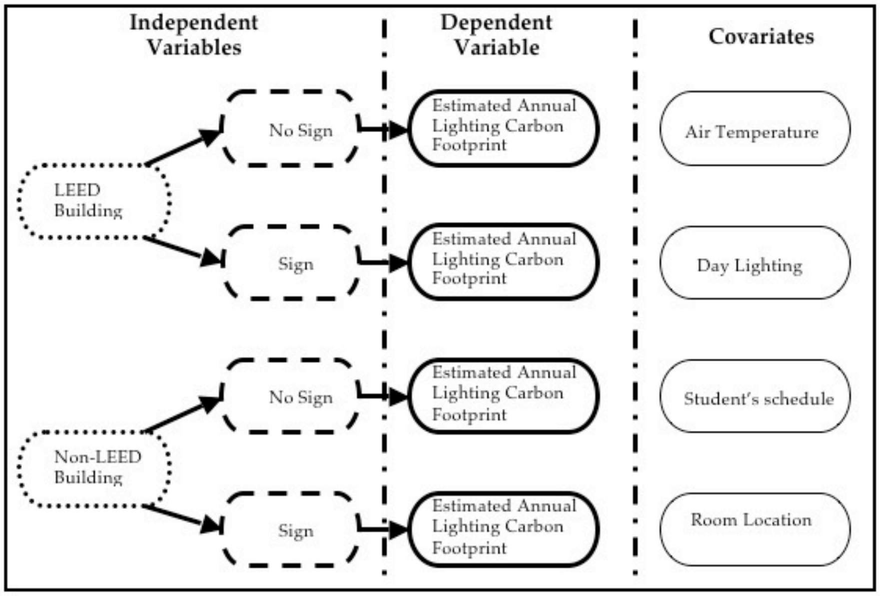


Figure 2.1: Experimental design

the absence (no sign) or presence (sign) of a lighting conservation sign. The dependent variable was the estimated annual lighting carbon footprint (EALCF) produced by each participant for the duration of a school year. Additionally, the investigators controlled for covariates such as room location, temperature, day lighting and student's schedules during the study. A mediator - participant's daily artificial lighting usage in kilowatt hours (DkWh) – was used in the calculation of the EALCF. A simplified representation of the EACF calculation can be seen in Figure 2.2.2. (The entire formula can be seen in Section 2.7) Additional predictor variables considered were each student's environmental involvement, 2007 transportation carbon footprint, and gender.

Figure 2.2.2: Use of Mediator in EALCF Calculation

2.4 Apparatus

2.4.1 Signage

The overall design of the lighting conservation signs was the same for both buildings except the wording of the phrases varied by building, because building-specific information was included on the signs. For example on the LEED sign, the investigator included a way for participants to obtain information about the USGBC LEED certification process. The original intended placement of the sign, as a double light switch cover (4.75” wide x 4.5” high), served as the template for the signs’ original shape and size. However, the sign need to be increased in size to ensure readability, making it too large to serve as a light switch cover. Since the presence of the sign, not the design of the sign, was being tested, a simple readable sign was deemed the most important element. Additionally, the sans serif and color of the font were chosen for the easier legibility. The main font size was designed to meet the recommendations made by Evans and Ginsburg (1985) for a viewing distance of 8’ with 20/40 vision. The muted background color was chosen to help the legibility of the text and the color was chosen because, in the United States, sustainability is usually associated with the color green. The symbol chosen to accompany the text was a fluorescent light bulb, because it is often promoted as the easiest way to increase lighting energy efficiency.

The final signs were created using graphics software (Adobe Illustrator CS2 version 12.0.1 for Mac). The overall size of both signs was 6.2” wide x 5.5” high with rounded corners. The background color was green (color #: C6E898 - R-198 G-232 B-152) with a .5” wide white line enclosure (color #: FFFFFF - R-255 G-255 B-255). The light bulb graphic was retrieved from www.istockphoto.com, (image #: 455319 - image name: cartoon light bulb bonus pack) and placed to the right side of the sign. The colors within the light bulb were altered to be a brighter yellow (color #: F6E35F - R-246 G-227 B-95) and shades of gray on the top (color #: b2b2b2 - R-178 G-178 B-178) and bottom (color #: 8d8c8a R-141 G-140 B-138) of the socket.

Both the primary and secondary text for both signs was black (color #: 000000 - R-0 G-0 B-0) with font Ariel. The primary text was justified left with a font size of 35.98 points and the secondary text was center justified with a font size of 15.75 points. For easier readability by the participants the words chosen for the primary text were constructed as a simple active sentence (Broadbent, 1977). Additionally to aid legibility the entire text was a mixture of upper and lower case letters (Poulton, 1967). The primary text for the LEED sign was "Turn off the Lights! You're in a LEED Certified Green building", and the secondary text included "LEED buildings improve the quality of life for everyone. For more information on LEED visit www.usgbc.com". The primary text for the non-LEED sign was "Turn off the Lights! You're in a Green building", and the secondary text included "Green buildings improve the quality of life for everyone". Once the design was finalized, each sign was printed in color on matte cardstock using a laser printer and laminated before posted. (See Appendix G for reprints of the signs.)

2.4.2 Indoor Data Loggers

Interior data loggers (HOBO model #: H08-004-02 from the ONSET Computer Corporation) capable of tracking temperature, relative humidity and/or light intensity within its immediate environment were used. However, for this experiment only the light intensity feature was activated. According to the HOBO manual (2003) the "light intensity sensor approximates the sensitivity to the human eye…the nominal range is 2 to 600 footcandles (21.5 to 6458.3 lux); maximum value can vary from 300 to 900 footcandles (3229.1 to 9687.5 lux). The sensor's angular response is roughly cosine dependent, with 0° being directly above the sensor." In accordance to the angular response, one HOBO was assigned to each luminaire and the light sensor was placed in direct contact with each lamp's shade or diffuser to capture the highest light intensity readings as possible. (See Appendix H for an example of HOBO placement).

Prior to data collection, the HOBOs were individually programmed to record light intensity every 5 minutes during data collection, starting at 8 am on the first day and ending at 5 pm on the last day. The data was then stored on the HOBO until the investigator downloaded it using HOBOware, the same software used to program the HOBOs. The data was then exported from HOBOware into a .csv file that was later imported into Microsoft Excel 2004 for Mac, version 11.5. The investigator reviewed each file and dichotomized the status of the lights (on/off) using the thresholds customized for each luminaire. Once the lumen thresholds for each luminaire were determined, the investigator was able to calculate the participant's daily lighting usage in minutes per luminaire (LD*m*).

2.4.3 Kilowatt meter

An electricity usage monitor (kWh meter) (model #: P4400 Kill A Watt manufactured by P3 International), was used to collect several types of measurements from corded luminaires including: watts, kilowatt hours, and elapsed time. (See Appendix I for an example of the meter) Only corded luminaires were measured using the kWh meter because it tracked usage by having the luminaire directly plugged into the kWh meter, and then the kWh meter plugged into an electrical socket. The kWh meter allowed for a maximum voltage of 125VAC, maximum current of 15A, and maximum power of 1875VA.

Data was cumulatively stored and displayed on a Liquid Crystal Display (LCD) display located on the front of the kWh meter. During the study the displays were covered so participants could not view their kWh total, because the effect of a feedback display on kWh usage was not within the parameters of the study. Since the kWh meters didn't have a memory or backup power source, data only remained on the kWh meter while it was plugged into the electrical socket and once removed from the socket the stored data was cleared. Consequently, data tracked by the kWh meter had to be recorded manually by the investigator at every data collection point. The cumulative data stored could not be separated by day, resulting in only 1 data point for each tested condition per corded luminaire. The main purpose of the data collected using the kWh meters was to ascertain the wattage of luminaires and verify the results calculated from the HOBO data for the corded luminaires.

2.5 Survey Instruments

During the last meeting the participants were asked to complete an online survey created by the investigator. (See Appendix K for a non-html version of the survey) The survey was created and administered by the investigator through Checkbox version 4.4, designed by Prezza Technologies, Incorporated. The main purpose of the survey was to ascertain each participant's environmental impact and involvement. The survey included 22 multiple-choice questions and 11 open-ended questions. Participants were asked specific questions about their schedules during the data collection process, including: personal, work and school. They were also asked about their lighting usage, recycling habits, involvement in environmental programs, and dormitory selection preferences. Lastly they were asked about their transportation usage for 2007, including: car, bus, train and plane usage. The survey took under 20 minutes to complete and answers were compiled using the export function in Checkbox. The results were used in conjunction with the daily kWh usage ascertained over the 2-week data collection period to calculate covariates and predictor variables.

2.6 Procedure

2.6.1 Schedule and Installation

The data collection phase began during Cornell University's 2008 spring semester, starting January 26 and ending March 2. Testing for each participant occurred between 13 and 15 consecutive days within the data collection phase. The first 5 participants (2 in the non-LEED building and 3 in the LEED building) were tested between January 26 and February 10. After a 5-day break the remaining 5 participants (2 in the non-LEED building and 3 in the LEED building) were tested between February 16, and March 2. During these 2-week data collection periods, each week tested a different sign condition. The first week of data collection tested the effect of no sign in the participant's room, and the second week tested the effect of a sign in the participant's room. There was 6 to 8 day variability per condition per participant due to the investigator's limited access to the participants' room.

Each participant's lighting usage was monitored and metered during the entire data collection period using HOBOs and kWh meters. The HOBOs were adhered to all luminaires in the room (corded and hardwired) to track switching behaviors, specifically how long each luminaire was pulling electricity. The kWh meters were used to track the amount of electricity each corded light was pulling during the duration of the study under each condition. Additionally, data from the kWh meters were used to verify some of the raw HOBO data conversions made by the investigator, when calculating daily lighting usage. After verifying the total number of minutes the lighting was in use per day by each participant, this data and the wattage of each light were used in the final calculation of each participant's estimated annual lighting carbon footprint.

2.6.2 *On-site Data Collection*

Upon entering the participant's room for the first time, a verbal explanation of the procedure was given and a consent form explaining the partial purpose of the experiment, basic procedure, risks/benefits, compensation, and investigator contact information was presented to the participants. (See Appendix J for copy of consent form.) It is important to note participants were not told the full purpose of the experiment to reduce the chance for evaluation apprehension. The participants were told the purpose of the study was to research lighting usage habits of college students in different types of resident halls. Sustainability testing was not mentioned until the investigator returned on the final day of data collection. Once the consent form was signed the investigator recorded the location of the furniture, windows and lights within the room. If the participant was located within the LEED building they told they lived in a LEED building and were then presented with two brochures explaining the U.S. Green Building Council and the purpose of LEED certification. The investigator then unplugged all the corded luminaires currently plugged into the electrical sockets in their room. The investigator plugged each corded luminaire into a separate kWh meter and then plugged the kWh meter in to the electrical socket. This kWh meter did not affect their luminaires, and participants were encouraged to use the lighting in the same manner as before the installation of equipment. The kWh meter's digital output display was also covered with black electrical tape and participants were instructed to not remove the tape. They were advised to leave the meter in place during the duration of the experiment, because removal from the socket would result in lost data. Participants were also advised not to plug or unplug any items into the kWh meter during the testing weeks, as this would result in inaccurate data. The HOBOs were attached using electrical tape to all lights including the ambient light luminaire. (See section 2.4.2 for installation details.)

Participants were also instructed to leave the HOBOs in place for the duration of the experiment. The entire process took approximately 15 to 30 minutes to complete. Before exiting the room the investigator and participant set-up a follow-up meeting for the next weekend based on the participant's availability.

When the investigator returned at the start of week 2 for the second meeting, data on the kWh meters was manually recorded and a sign was posted in the room, above the light switch, for the remaining days of data collection. This meeting did not exceed 15 minutes. Before leaving the room the investigator and participant set-up the final meeting for the following weekend based again on the participant's availability.

On the last day of data collection, the investigator returned to record the final data and remove equipment from the room. Once the kWh data was recorded the kWh meters were removed from the sockets and the corded luminaires were plugged back into the electrical sockets. The HOBOs were also removed from all luminaires. During this time the participant was informed of the full purpose of the experiment. The investigator asked the participant to complete an online survey regarding their lighting usage behaviors from the previous 2 weeks, transportation usage for 2007, and some personal information. Subjects were then compensated $10 at the completion of the survey. The final meeting did not exceed 30 minutes.

2.7 Data Analysis

All data were analyzed using a multivariate statistical package, SSPS version 15 for Mac. To transform each luminaire's daily usage in minutes (LDm) into EALCF, LDm was divided by 60 to ascertain its daily lighting usage in hours (LDh).

1. $\frac{LDm}{60} = LDh$

Next the each luminaire's daily kWhs expended (LDkWh) was calculated by multiplying LDh by the luminaire's wattage (LW).

2. $LDh(LW) = LDkWh_{(1+2+\cdots+n)}$

Then the total daily kWhs expend per participant (DkWh) was calculated by adding all the LDkWh results for that participant together.

3. $LDkWh_1 + LDkWhL_2 + \cdots + LDkWh_n = DkWh$

The DkWh was then multiplied by amount of carbon emission produced per kWh (1.7 lb) to determine the daily carbon emissions in pounds produced by each participant from their lighting usage (DLCF).

4. $1.7DkWh = DLCF$

DLCF was then multiplied by the number of days the dormitory was open for student living in the school year 2007-2008 (273 days) to determine the EALCF.

5. $DLCF(273) = EALCF$

Additional calculations were performed to determine significance of variables within the second step of the EALCF equation producing the Linear Mixed Model Analysis results. To perform this analysis the total the total luminaire wattage per participant (TLW) and the total artificial lighting usage in hours by participant per day (TLD*h)* was calculated. The TLW was determined by adding all the LW within the participant's room:

$$LW_1 + LW_2 + \cdots + LW_n = TLW$$

The TLDh per participant was calculated by added the LDh of each luminaire with the room:

$$LDh_1 + LDh_2 + \cdots + LDh_n = TLDh$$

Following the calculations to determine the EALCF, additional calculations were performed to find the significance within the data. EALCF data was analyzed using a Linear Mixed Model analysis (variables included: green building certification, signage, gender, and number of luminaires), LW was examined through an analysis of variance, and TLDh was investigated using a regression equation comparing the sign verses no sign condition.

Each participant's personal norm towards pro-environmental behavior was determined by measuring his or her participation in easily accessible pro-environmental activities. Participants were questioned about their recycling and composting habits when living on-campus and off-campus, and their level of involvement in environmental programs or organizations all year. All responses were combined to formulate a final pro-environmental behavior score.

(Recycling Score + Composting Score + Environmental Program Participation)/3

CHAPTER 3: RESULTS

3.1 Estimated Annual Lighting Carbon Footprint

3.1.1 Disruption Effect

When the Estimated Annual Lighting Carbon Footprint (EALCF) data was first analyzed an anomaly was discovered in the Day 1 data for both weeks of data collection. On the days the experimenter had contact with the subjects, installed and adjusted equipment and/or signage, lighting consumption was found to be abnormally greater than the days that followed. (Figure 3.1) The investigator believes this disruption had a behavior altering effect on the subjects substantially skewing the data for most subjects, otherwise known as a disruption effect. (Bracht & Glass, 1968) Consequently the investigators made the decision to remove all of day one data of both signage conditions to minimize the disruption effect. All the calculations for this study included data from the days following day one of each signage condition.

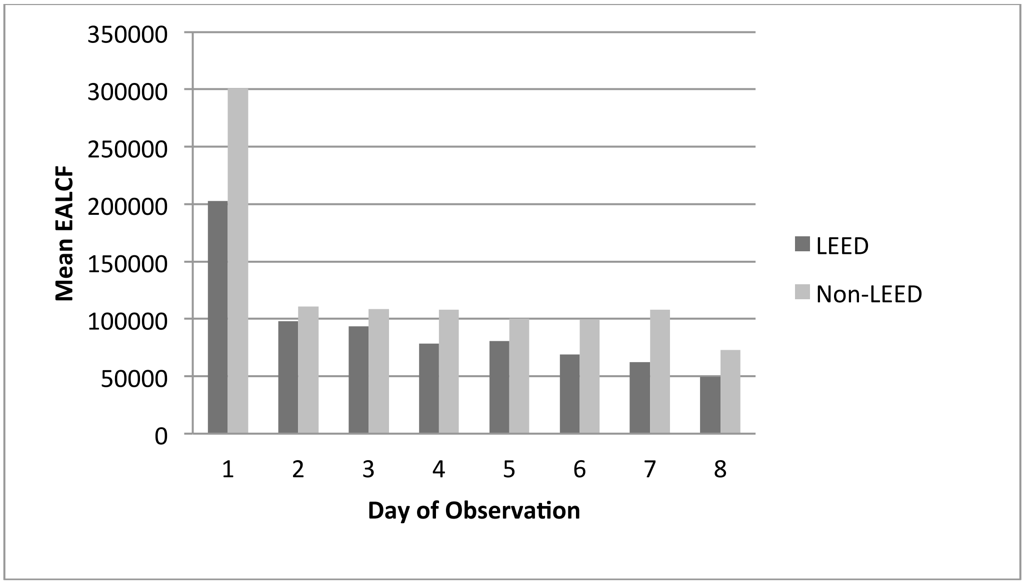


Figure 3.1: Mean EALCF by day of observation

3.1.2 Main Effects

The linear mixed model (LMM) revealed a main effect of green building certification ($F_{(1,\ 3.04)} = 19.57$ $p < .05$), and the average EALCF was lower for participants who lived in the LEED Building (n= 87, mean= 6298.38, SD = 4793.13) than those in the non-LEED building (n = 53, mean = 13102.13, SD = 8773.07) (Figure 3.2). There were no main effects for gender, $F_{(1,\ 3.59)} = 2.39$ $p > .05$, signage $F_{(1,\ 121.35)} = 2.14$ $p > .05$, and number of luminaires, $F_{(1,\ 3.17)} = 6.56$ $p > .05$. During data analysis 2-, 3- and 4-way interactions were tested, however only 2 different 3-way interaction effects were significant.

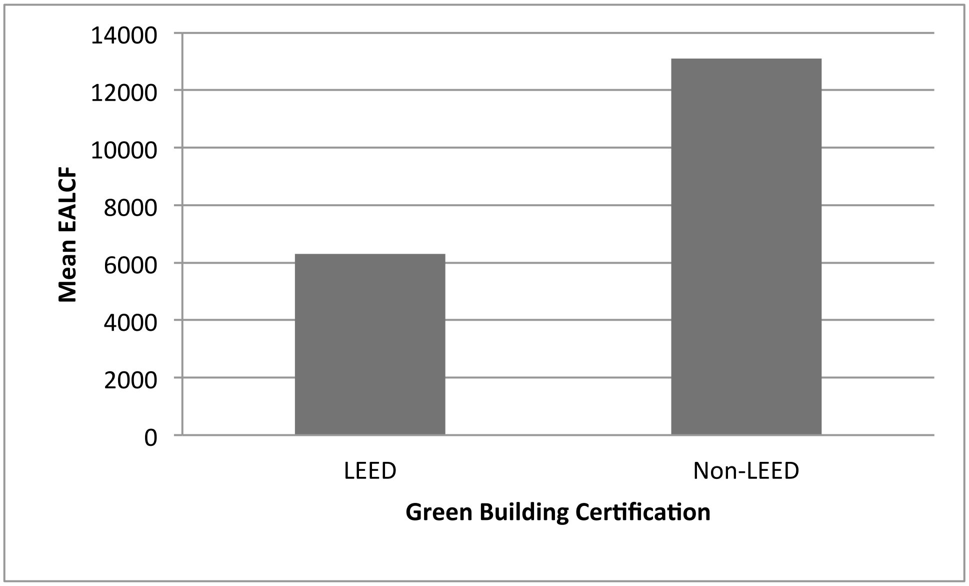


Figure 3.2: Mean Estimated Annual Lighting Carbon Footprint by Green Building Certification

3.1.3 Interactions

There was an interaction between green building certification, signage and number of luminaires, $F_{(1,\ 121.12)} = 10.93$, $p < .05$ (Figure 3.3). Pairwise comparisons were subsequently performed to determine the level of contribution each independent factor had on the interaction's significance. By isolating and cross-comparing each factor, the investigator was able to determine which variables' values were significant and had contributed to the interaction's level of significance. The factors values found significant within the interaction were:

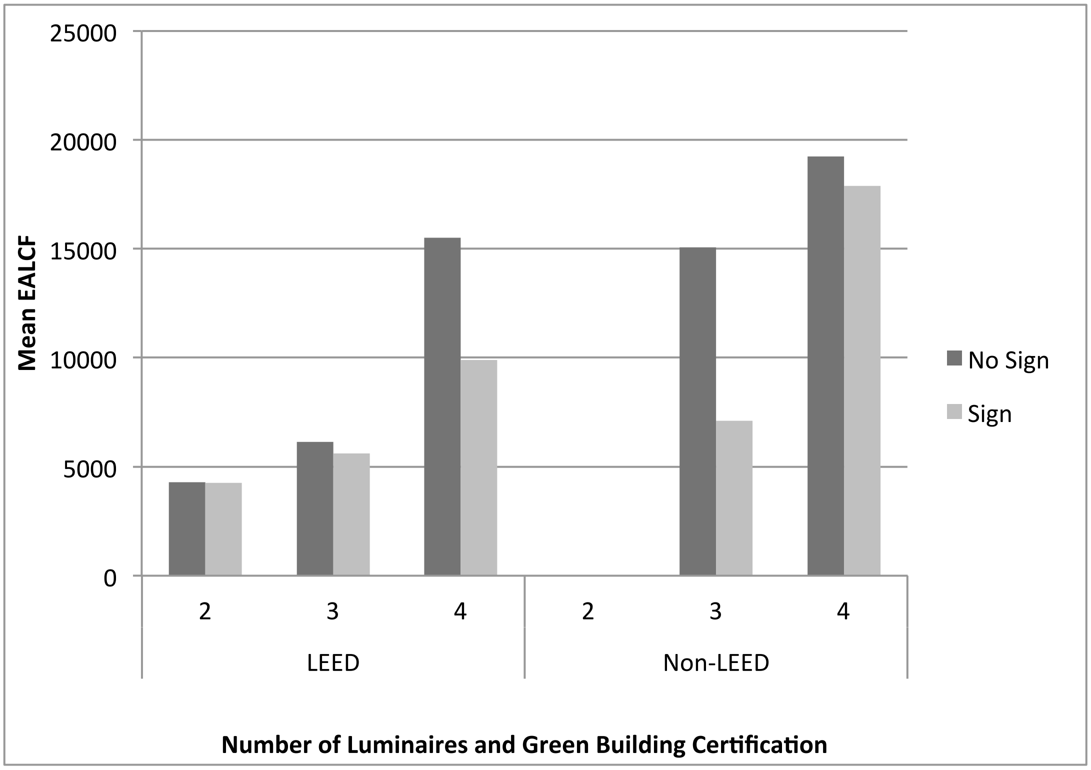


Figure 3.3: Mean Estimated Annual Lighting Carbon Footprint by Signage, Luminaires, and Green Building Certification

Within the signage factor:

- Participants with 3 luminaires, in the non-LEED building, had lower EALCFs during the sign condition (n = 19, mean = 7116.42, SD = 3795.62) than the no sign condition (n = 19, M = 15068.30, SD = 7621.24), $F_{(1, 121.46)} = 26.70$, $p < .05$. (Figure 3.3)

Within the luminaires factor:

- LEED building participants, during the sign condition, had lower EALCFs with 2 luminaires (n = 23, mean = 4285.83, SD = 1712.38) than those with 4 luminaires (n = 8, mean = 15489.39, SD = 7192.84), $F_{(1, 9.53)} = 4.44$, $p < .05$. (Figure 4.6)

- Non-LEED building participants, during the sign condition, had lower EALCFs with 3 luminaires (n = 20, mean = 7116.42, SD = 3795.62) than those with 4 luminaires (n = 7, mean = 17875.34, SD = 11130.69), $F_{(1, 12.155)} = 17.65$, $p < .05$. (Figure 3.3)

Within the green building certification factor:

- Participants with 3 luminaires within the no sign condition had lower EALCFs in the LEED building (n = 14, mean = 6151.69, SD = 3130.60) building than those in the non-LEED building (n = 19, mean = 15068.30, SD = 7621.24), $F_{(1, 11.65)} = 23.78$, $p < .05$. (Figure 3.3)
- Participants with 4 luminaires within the sign condition had lower EALCFs in the LEED building (n = 7, mean = 9906.32, SD = 6347.00) than those in the non-LEED building (n = 7, mean = 17875.34, SD = 11130.69), $F_{(1, 11.00)} = 11.45$, $p < .05$. (Figure 3.3)

There was also a significant interaction between green building certification, signage and gender, $F_{(1, 121.43)} = 9.38$, $p < .05$. The pairwise comparison of this interaction's factors' values found significance:

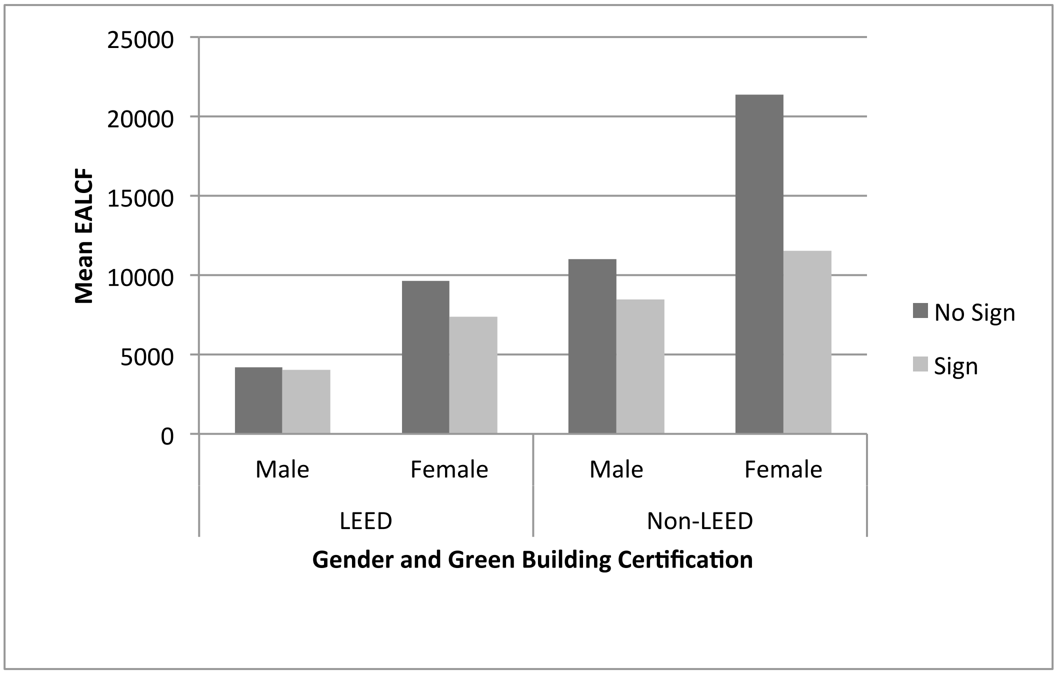


Figure 3.4: Mean Estimated Annual Lighting Carbon Footprint by Signage, Gender, and Green Building Certification

Within the signage factor:

- Among female participants living in the non-LEED building, EALCF was lower during the sign condition (n = 13, mean = 11544.88, SD = 1084.34) than the no sign condition (n = 13, mean = 21372.59, SD = 9225.65), $F_{(1, 15.851)} = 15.85$, $p < .05$. (Figure 3.4)

Within the gender factor:

- During the sign condition in the non-LEED building, male participants (n = 13, mean = 8481.23, SD = 3696.08) had lower EALCFs than female participants (n = 13, mean = 11544.88, SD = 10684.34), $F_{(1, 13.20)} = 5.68$, $p < .05$. (Figure 3.4)

- During the no sign condition in the non-LEED building, male participants (n = 13, mean = 11009.85, SD = 3094.83) had a lower EALCFs than female participants (n = 13, mean = 21372.59, SD = 9225.65), $F_{(1, 13.20)} = 6.92$, $p < .05$. (Figure 3.4)

Within the green building certification factor:

- Among female participants during the no sign condition, LEED building participants (n = 22, mean = 9658.55, SD = 6550.58) had lower EALCFs than non-LEED building participants (n = 13, mean = 21372.59, SD = 9225.65), $F_{(1, 11.18)} = 21.64$, $p < .05$. (Figure 3.4)
- Among male participants within the sign condition, LEED building participants (n = 21, mean = 4054.77, SD = 1956.28) had lower EALCFs than non-LEED building participants (n = 13, mean = 8481.23, SD = 3696.09), $F_{(1,11.63)} = 22.138$, $p < .05$. (Figure 3.4)

3.2 Lighting Wattage and Usage

3.2.1 Luminaire Wattage

Each luminaire was examined for the expected wattage produced when in full operation and the average total wattage for all luminaires within the participant's room (TLW) was 114.97 watts (n = 138, SD = 91.73). A two sample t-test was computed on the luminaire wattage by supplier, and found the average wattage of university supplied luminaires (n = 138, mean = 46.65, SD = 7.29) was significantly less than the average wattage of participant purchased luminaires (n = 138, mean = 68.31, SD = 89.40), $t_{(1, 137)} = -2.83$, $p < .05$. (Figure 3.5)

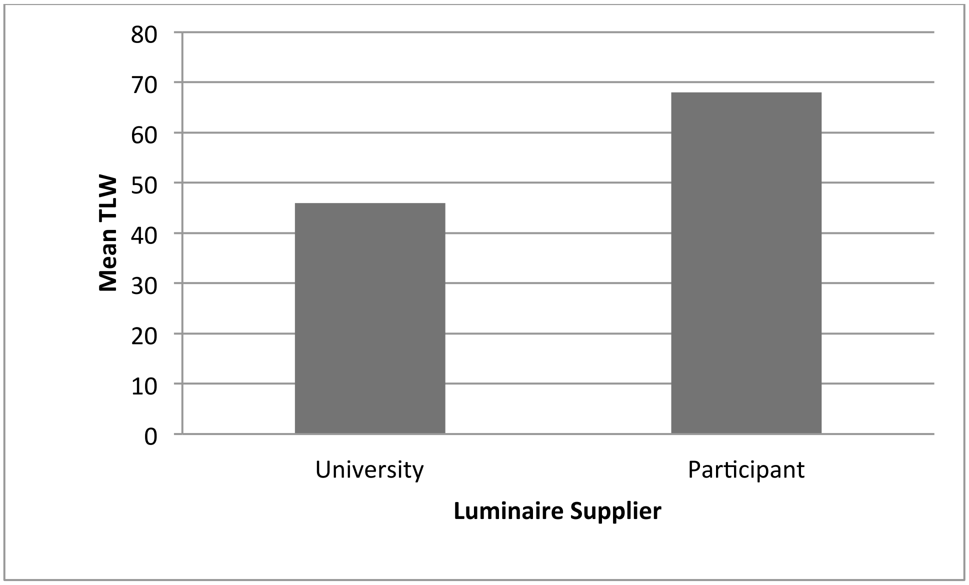


Figure 3.5: Mean Total Luminaire Wattage by Supplier

An analysis of variance (ANOVA) was conducted to investigate the impacts of independent variables on the TLW and EALCF results. Three significant main effects and two interactions were uncovered ($R^2_{adj} = .99$). There was a significant main effect of green building certification, $F_{(1, 1)} = 16.22$, $p < .05$. LEED building participants (n = 6, mean = 88.17, SD = 88.32) had a lower TLW than non-LEED building participants (n = 4, mean = 154.5.39, SD = 102.39) (Figure 3.6). There was a main effect of gender, $F_{(1, 1)} = 187.17$, $p < .05$, and male participants (n = 5, mean = 60.00, SD = 18.25) had lower TLW than females (n = 5, mean = 169.40, SD = 111.54) (Figure 3.6). There was a main effect of the number of luminaires, $F_{(1, 2)} = 785.80$, $p < .05$, as the number of luminaires increased so did the TLW (2 luminaires [n = 3 mean = 41.71, SD = 0] 3 luminaires [n = 5 mean = 93.20, SD = 44.98] 4 luminaires [n = 2 mean = 279.80, SD = 18.34]) (Figure 3.6).

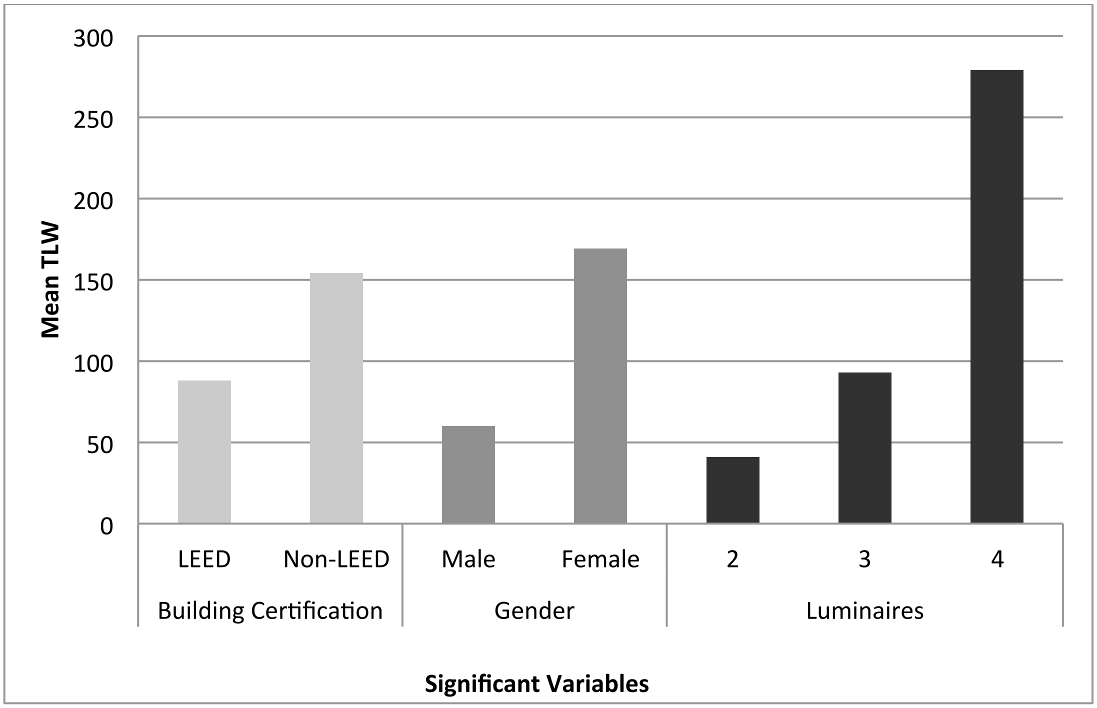


Figure 3.6: Mean Total Lighting Wattage among Participants by Green Building Certification, Gender, and Number of Luminaires

There was interaction between gender and green building certification, $F_{(1, 1)}$, $p < .05$. Male participants in the LEED building (n = 3, mean = 49.00, SD = 13.86) had the lowest TLW and female participants in the non-LEED building have the highest TLW (n = 2, mean = 232.50, SD = 84.14) (Figure 3.7)

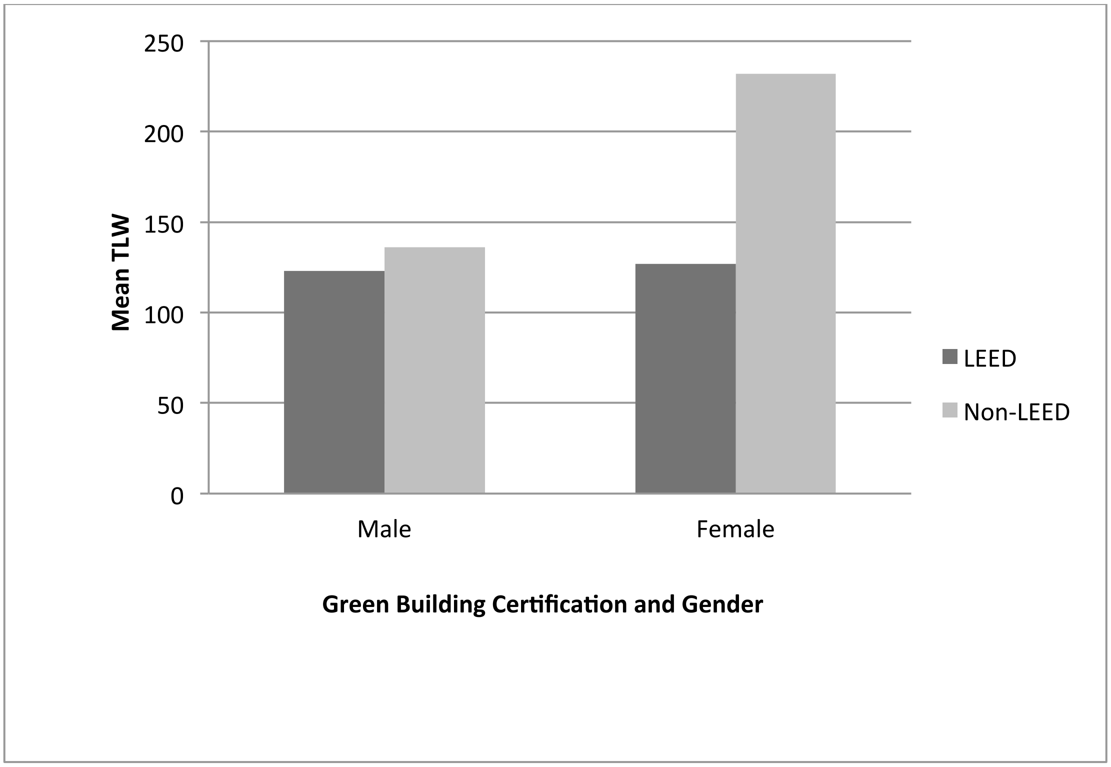


Figure 3.7: Total Lighting Wattage by Gender and Green Building Certification

There was an interaction between green building certification and number of luminaires, $F_{(1, 1)}$, $p < .05$. Participants with 2 luminaires in the LEED building participants had the lowest TLW (n = 3, mean = 41.71, SD = 0). Participants with 3 luminaires in the LEED building (n = 2, mean = 70.00, SD = 7.07) had lower TLW averages than non-LEED participants (n = 3, mean = 124.75, SD = 55.90). Participants with 4 luminaires in the non-LEED building (n = 1, mean = 243.75) had lower TLWs than LEED participants (n = 1, mean = 263.85) (Figure 3.8).

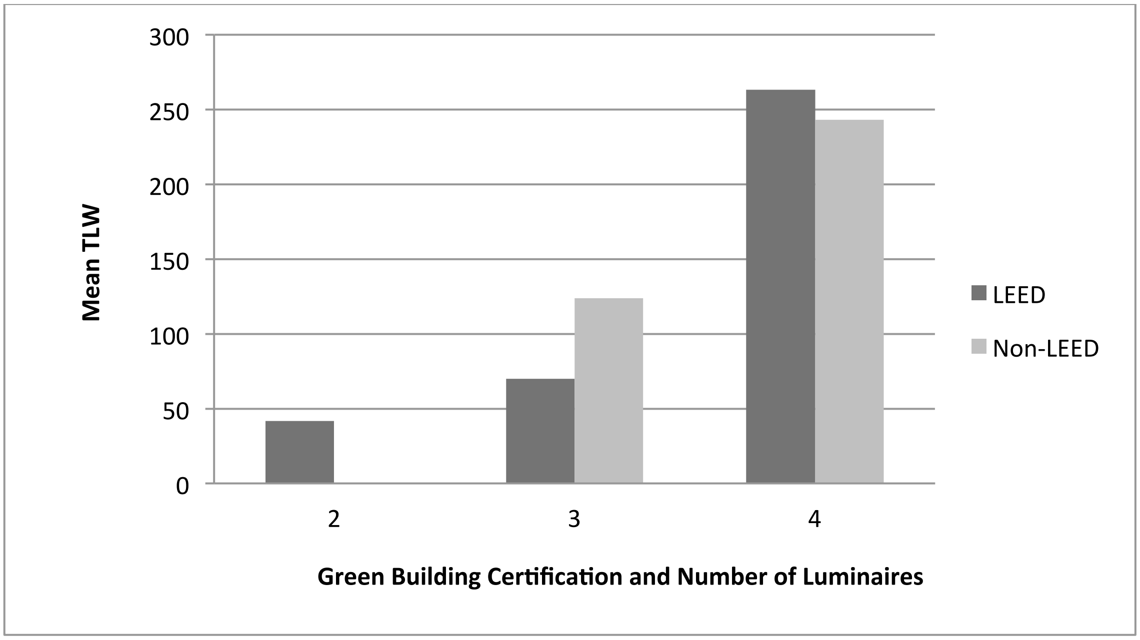


Figure 3.8: Total Luminaire Wattage by Green Building Certification and Number of Luminaires

3.2.2 Total Luminaires Usage

The data retrieved from the HOBO indoor data loggers revealed the average daily use of luminaires (TLD*h)* during the study was 8.89 hours (n=138, SD = 5.28). A paired two sample t-test found theTLD*h* of university supplied luminaires (n = 138, mean = 7.19, SD = 4.54) was significantly greater than the TLD*h* of non-university supplied luminaires (n = 138, mean = 1.8, SD = 2.98), t (1, 137) = 11.12, $p < .05$. (Figure 3.9)

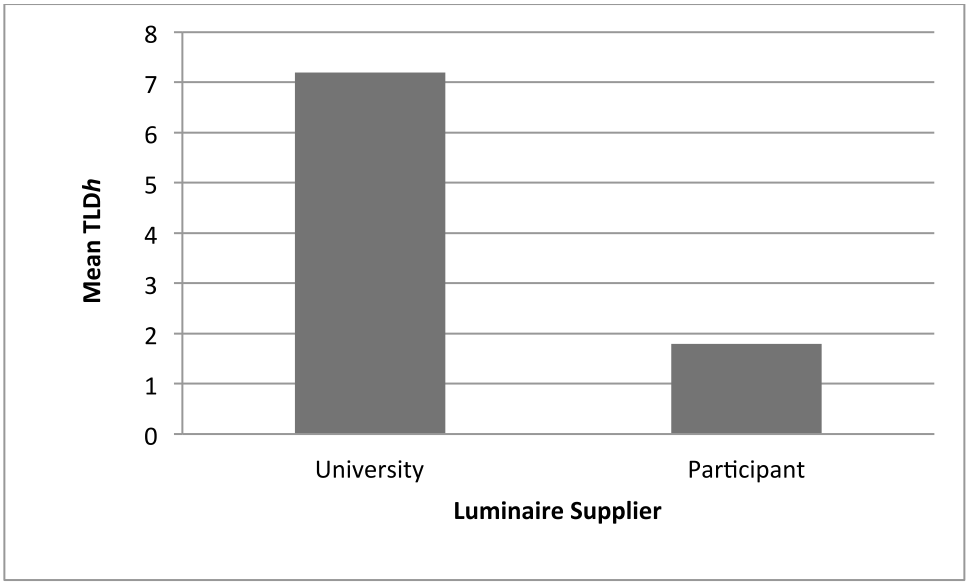


Figure 3.9: Daily Total Luminaire Usage in Hours by Luminaire Supplier

A regression equation was used to look at the effects of specific variables on the TLD*h* comparing the no sign and sign conditions. The linear model (LM), below revealed a R^2_{adj} = .194 during the sign condition and R^2_{adj} = .302 during the no sign condition:

TLDh (sign or no sign) = y + Green Building Certification +Gender+# of Luminaires + (Green Building Certification x # of Luminaires) +(Gender x Green Building Certification)

Within the equation the only main variable found to be significant was green building certification, $F_{(1, 2)} = 6.95$, $p < .05$. LEED building participants during the signage condition had the lowest observed TLD*h* (n = 41, mean = 7.12) and non-LEED participants during the no sign condition had the highest observed TLDh (n = 25, mean = 13.40). (Figure 3.10) The two interaction effects green building certification x number of luminaires, $F_{(1, 2)} = 6.33$, $p < .05$ (Figure 3.11) and gender x green building certification $F_{(1, 2)} = 7.82$, $p < .05$ (Figure 3.12) were also found to be significant.

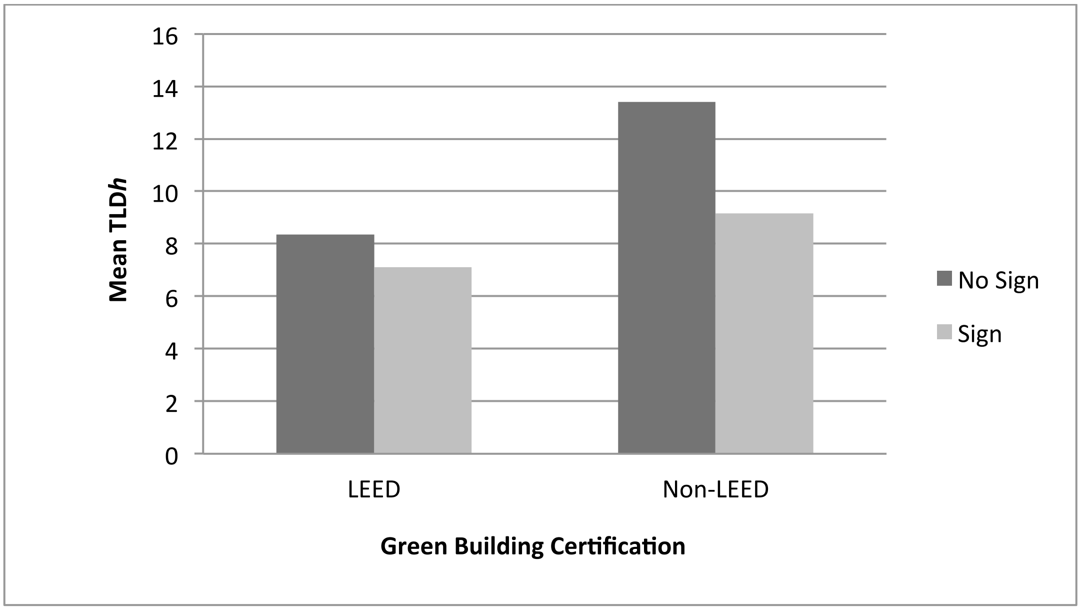


Figure 3.10: Daily Total Luminaire Usage in Hours by Signage, Green Building Certification and Number of Luminaires

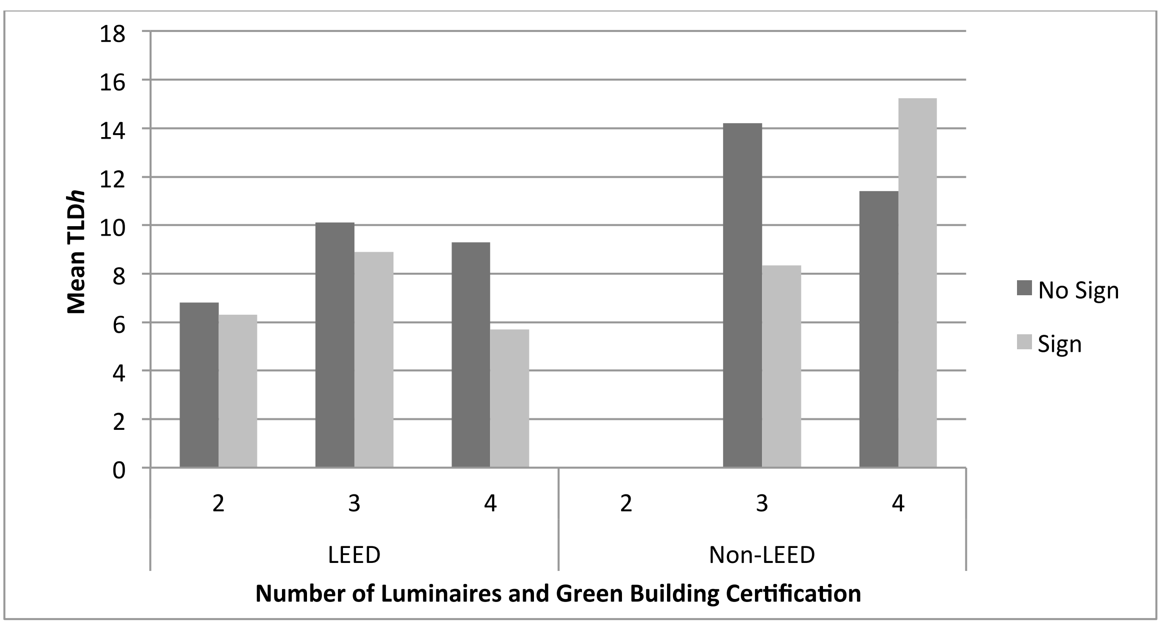


Figure 3.11: Daily Total Luminaire Usage in Hours by Signage, Green Building Certification and Number of Luminaires Interaction

When examining at the green building certification and the number of luminaires interaction, trends in the TLD*h* were noted.

Within the signage conditions:

- During the no signage condition the LEED building participants with 2 luminaires had the lowest observed TLD*h* (n = 20, mean = 6.82) and non-LEED participants with 3 luminaires had the highest observed TLD*h* (n = 18, mean = 14.19). (Figure 3.11)
- The highest and lowest TLD*h* means observed within the sign condition were also the overall highest and lowest TLD*h* of both signage conditions. LEED building participants with 4 luminaires had the lowest observed TLD*h* (n = 7, mean = 5.75) and non-LEED participants with 4 luminaires had the highest observed TLDh (n = 7, mean = 15.24). (Figure 3.11)

Within the green building certification and luminaires conditions:

- Among LEED building participants, those with 4 luminaires during the sign condition had the lowest TLD*h* (n = 7, mean = 3.46) while those with 3 luminaires during the no sign condition had the highest TLD*h* (n = 14, mean = 7.04). (Figure 3.11)
- Among non-LEED building participants, those with 4 luminaires during the sign condition had the highest TLD*h* (n = 7, mean = 10.44) while those with 3 luminaires during the signage condition had the lowest TLD*h* (n = 19, mean = 4.38). (Figure 3.11)

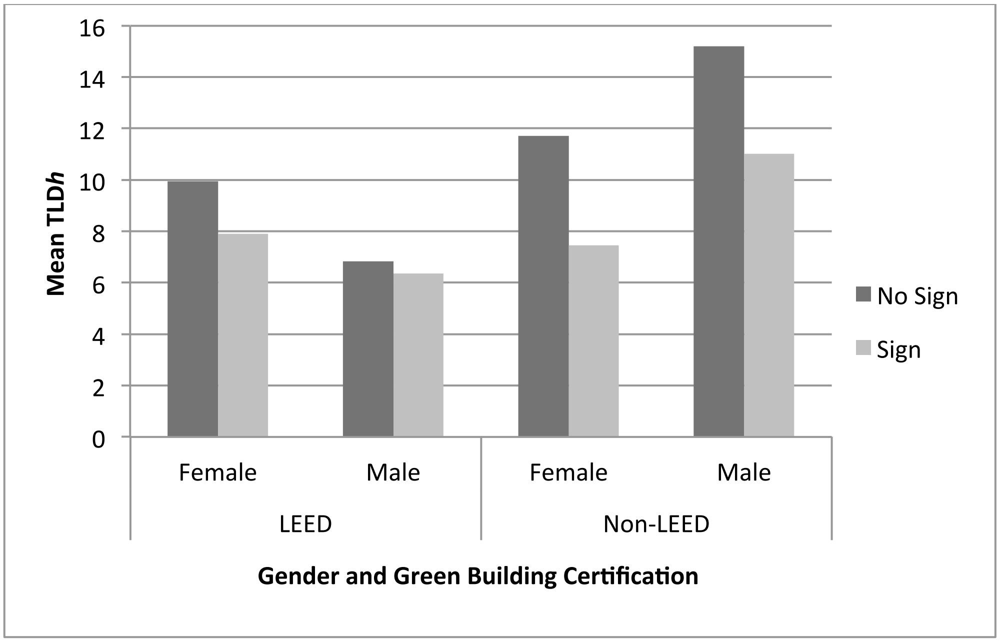


Figure 3.12: Daily Total Luminaire Usage in Hours by Signage, Green Building Certification and Gender Interaction

Within the green building certification and gender interaction, trends were noted in the TLD*h* results. Within the signage conditions:

- The highest and lowest TLD*h* means during the no signage condition included male participants in the LEED with the lowest observed TLD*h* (n = 21, mean = 6.82) and in the non-LEED building they had the highest observed TLD*h* (n = 12, mean = 15.21). (Figure 3.12)
- Within the sign condition, male participants in the LEED building had the lowest observed TLD*h* (n = 21, mean = 6.36) and the highest observed TLD*h* in the non-LEED building (n = 12, mean = 11.01). (Figure 3.12)

Within the green building certification and gender conditions:

- Among LEED building participants, males during the sign condition had the lowest TLD*h* (n = 21, mean = 6.36) while females during the no sign condition had the highest TLD*h* (n = 20, mean = 9.49). (Figure 3.12)
- Among non-LEED building participants, females during the signage condition had the lowest TLD*h* (n = 13, mean = 7.49) while males during the no sign condition had the highest TLD*h* (n = 12, mean = 15.21). (Figure 3.12)

3.2.3 University supplied Luminaires Usage

A regression equation was used to look at only the TLD*h* used by the university supplied luminaires (USTLD*h*)*,* these included the ambient luminaire (dormitory dependent) and the task light (the same for all participants), comparing the no sign and sign conditions. The linear model (LM), below revealed a R^2_{adj} = .159 during the sign condition and R^2_{adj} = .334 during the no sign condition:

USTLDh (sign or no sign) = y + Building Certification +Gender +

(Gender x Building Certification)

Within the equation both of the main variables were found to be significant, building certification, $F_{(1, 2)} = 4.37$, $p < .05$ and gender $F_{(1, 2)} = 9.77$, $p < .05$. (Figure 3.13) LEED building participants during the signage condition had the lowest observed USTLD*h* (n = 41, mean = 5.99) and non-LEED participants during the no sign condition had the highest observed USTLDh (n = 25, mean = 9.99). (Figure 3.13) On average the participants in the LEED buildings had a lower lower USTLD*h* than participants in the non-LEED building during both the signage conditions. Female participants during the signage condition had the lowest observed USTLD*h* (n = 33, mean = 5.13) and male participants during the no sign condition had the highest observed USTLD*h* (n = 33, mean = 10.51) On average female participants had lower USTLD*h* than male participants for both signage conditions. (Figure 3.13)

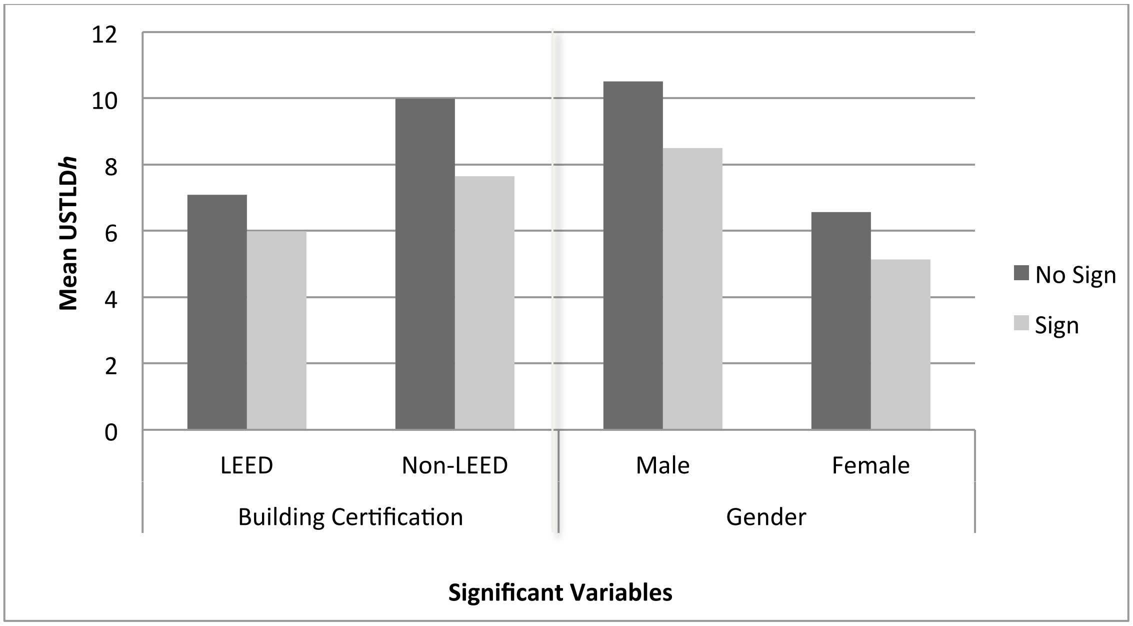


Figure 3.13: Daily Total Luminaire Usage of University Supplied Luminaires in Hours for Green Building Certification and Gender

Within the green building certification and gender interaction, trends were noted in the USTLD*h* results. Within the signage conditions:

- During the no signage condition, female participants in the non-LEED had the lowest observed USTLD*h* (n = 13, mean = 5.77) and male participants in the non-LEED building had the highest observed USTLD*h* (n = 12, mean = 14.20). (Figure 3.14)
- Within the sign condition, female participants in the non-LEED building had the lowest observed USTLD*h* (n = 13, mean = 4.65) and male participants had the highest observed USTLD*h* in the non-LEED building (n = 12, mean = 10.64). (Figure 3.14)

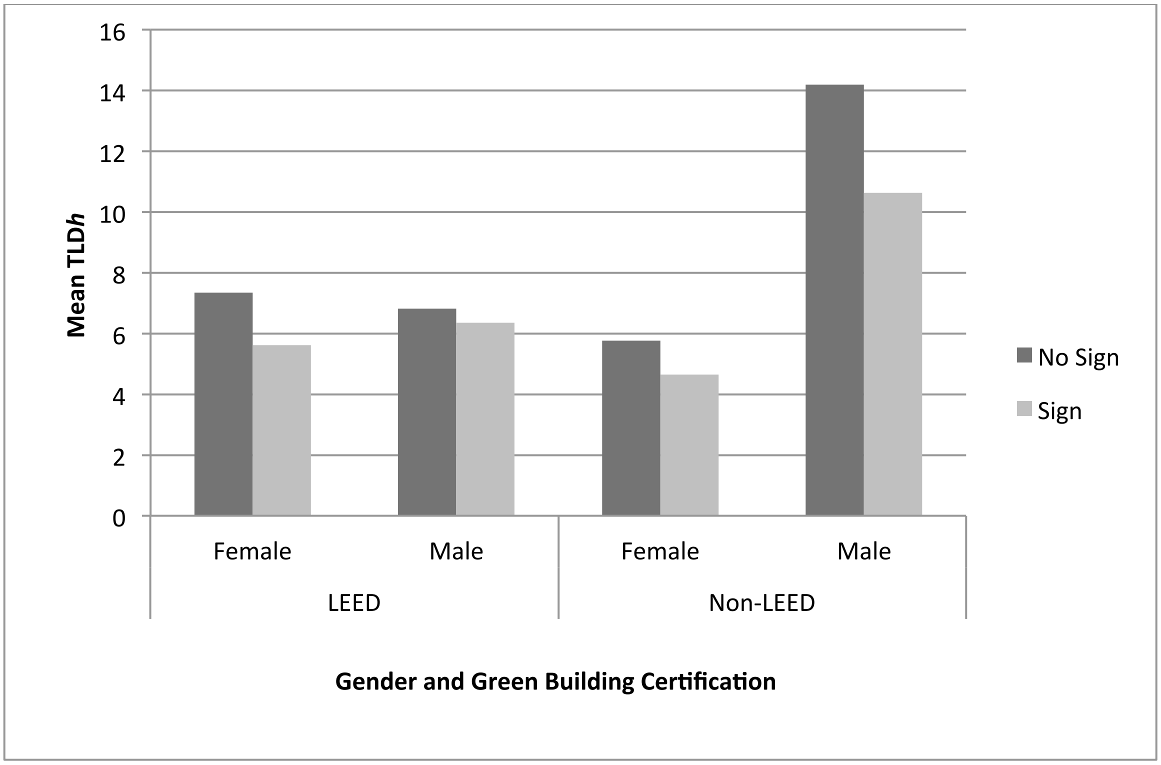


Figure 3.14: Daily Total Luminaire Usage of University Supplied Luminaires in Hours by Green Building Certification and Gender Interaction

Within the green building certification and gender conditions:

- Among LEED building participants, females during the sign condition had the lowest USTLD*h* (n = 20, mean = 5.62) while females during the no sign condition had the highest USTLD*h* (n = 20, mean = 7.35). (Figure 3.14)
- Among non-LEED building participants, females during the signage condition had the lowest USTLD*h* (n = 13, mean = 4.65) while males during the no sign condition had the highest USTLD*h* (n = 12, mean = 14.20). (Figure 3.14)

3.3 Self-reported luminaire Preference and Usage

Participants were asked specific questions about their luminaire usage and preference. All participants responded they either always (LEED = 3, non-LEED = 6) or usually (LEED = 3, non-LEED = 1) turned off the lights when they left the room. Another question asked participants if they utilized non-university supplied luminaires. Results indicated 50% of the LEED building participants and 100% of the non-LEED participants utilized additional lighting sources. Neither gender nor building type had a significant effect on the number of luminaires in the participant's room.

Additionally, a significant difference in EALCF (independent T-test: $t_{(1,136)} = -5.72$, $p < .05$) and the TDL*h* (independent T-test: $t_{(1,136)} = -3.88$, $p<.05$) was exhibited depending on the combination of luminaires available to the participants. (Figure 3.15 and Figure 3.16) Participants who only had university-supplied luminaires (n=43) (EALCF (mean = 3911.20, SD = 1.55); TDL*h* (mean = 6.42, SD = 3.23)) in their room had, on average, a significantly lower EALCF and TDL*h* than those who had had university-supplied and personal luminaires (n=95) (EALCF (mean = 8287.47, SD = 2.243); TDL*h* (mean = 10.00, SD = 5.65)).

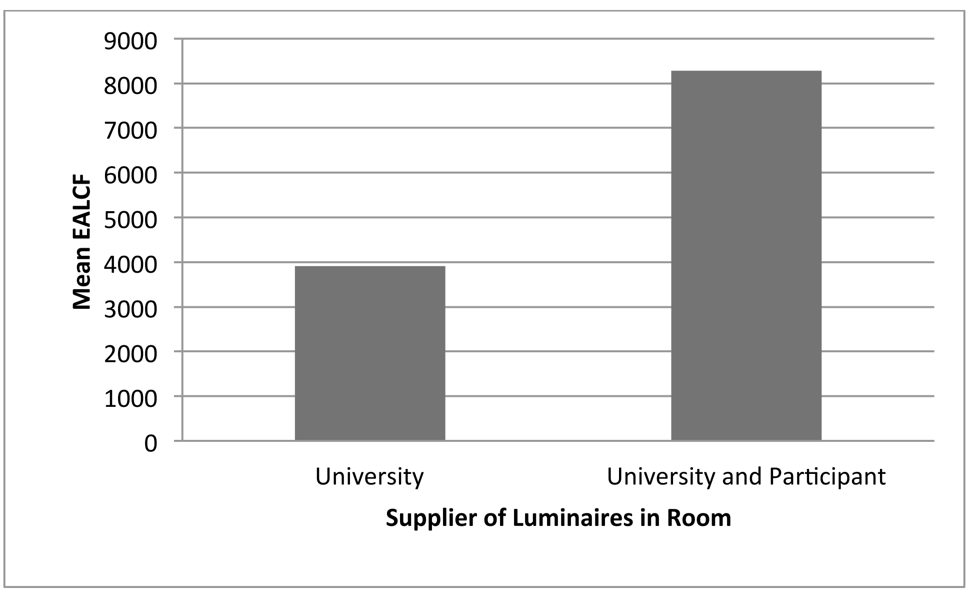


Figure 3.15: Mean Estimated Annual Lighting Carbon Footprint by Availability to Luminaire Types

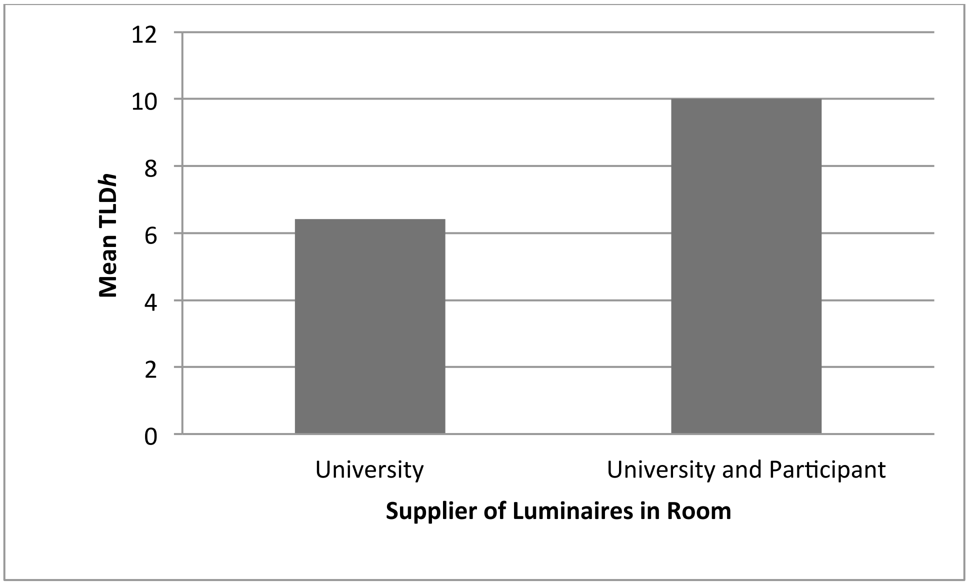


Figure 3.16: Mean Total Daily Lighting Usage in Hours by Availability to Luminaire Types

Reasons listed by participants for adding personal luminaires to their room included:

- The university lights are not bright enough;
- The university lighting levels are not adjustable enough;
- The university lights are harsh lighting types, eg. fluorescent lights;
- The university did not provide a bedside light for reading and studying.

3.4 Pro-environmental behavior

Each participant's personal norm towards pro-environmental behavior was determined by measuring his or her participation in easily accessible pro-environmental activities. Results revealed no significant differences with regard to gender, green building certification and number of luminaires within the pro-environmental scores. This could be the result of the highly skewed results within each variable of the pro-environmental behavior score.

3.4.1 Recycling and Composting Behaviors

Survey results for each participant's paper and container (plastic and glass) recycling habits during the entire year were analyzed. The reported recycling habits were skewed towards frequent recycling for both types of recyclable material. When the recycling frequency for paper and containers were calculated together, the majority of participants reported always recycling (60%), followed by usually recycling (37.5%), and occasionally (2.5%) (No participants reported seldom or never recycling.). (Figure 3.17) Independent sample t-tests revealed no significant differences in the mean scores for paper or container recycling based on gender or the green building certification in which the participant resided in while on-campus.

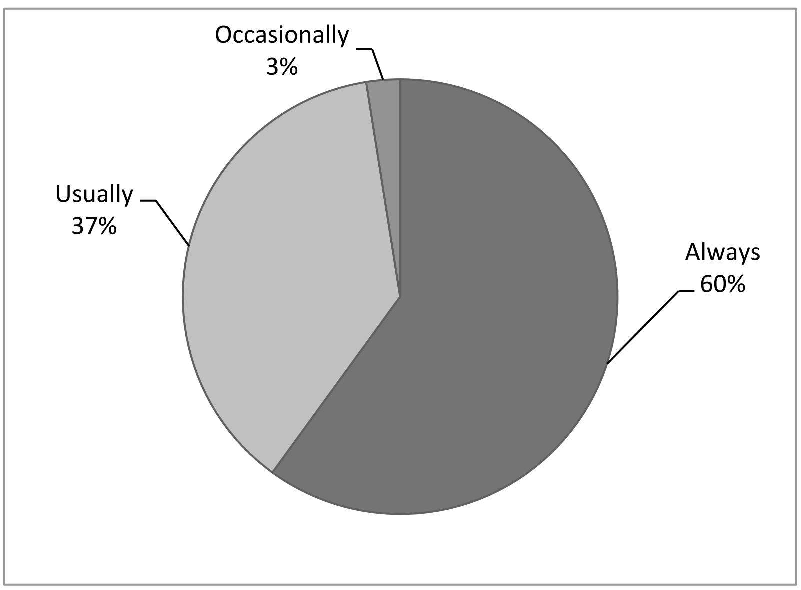


Figure 3.17: Recycling frequency of paper and containers among all participants

Composting was also skewed in frequency, but unlike recycling habits, composting was highly skewed towards a lower frequency of composting for both participants in the LEED and non-LEED building. The frequency of composting for the majority of participants was never (40%), followed by seldom (25%), usually (15%), always (15%), and occasionally (5%). (Figure

3.18) This skewed frequency resulted in independent samples t-tests showing no significant differences in mean scores based on the subject's gender or dormitory green building status.

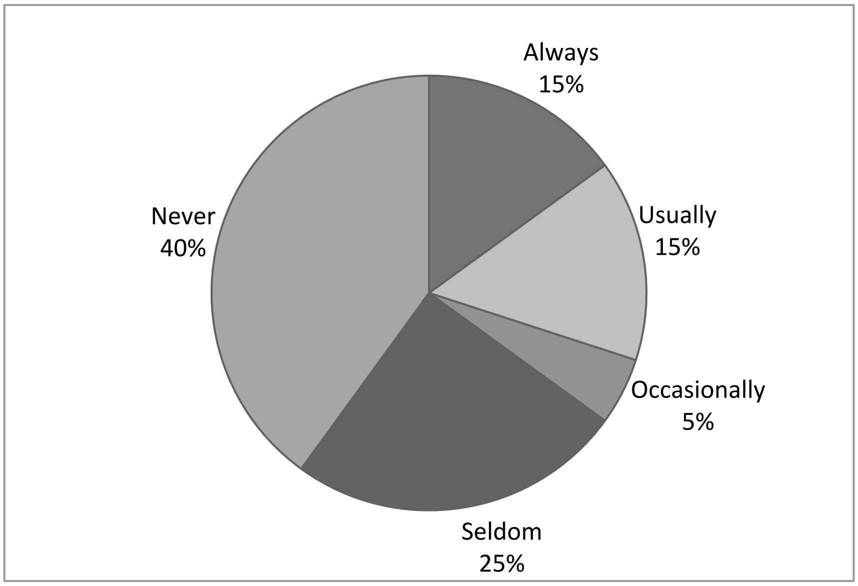


Figure 3.18: Frequency of composting among participants

When overall recycling and composting scores were compared, composting (n=10, mean = 2.30, SD = 1.09) was significantly less (independent t-test: $T_{(1,18)} = 6.05$, $p < 0.05$) utilized than recycling of both paper and containers (n=10, mean = 4.53, SD = 0.42). [Always = {5}, Usually = {4}, Occasionally = {3}, Seldom = {2}, Never = {1}] (Figure 3.19).

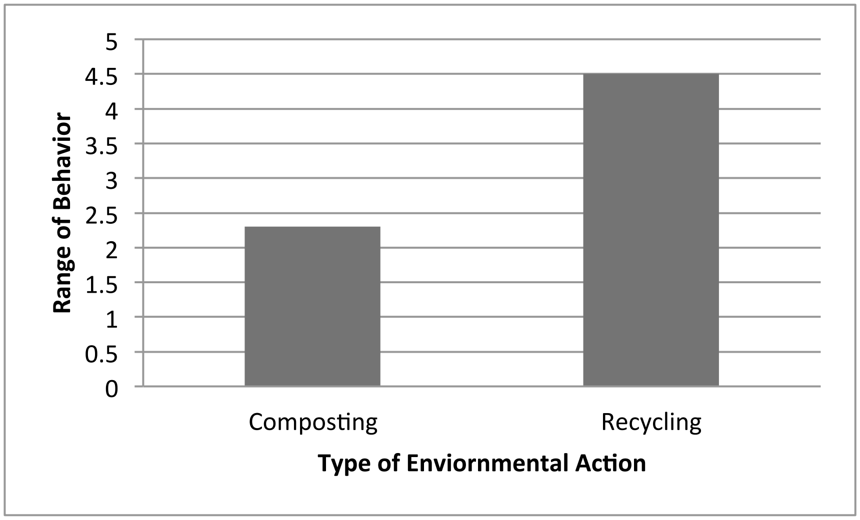


Figure 3.19: Mean recycling and composting frequency among participants

3.4.2 Environmental Program Involvement

Fifty-one percent of participants reported some level of environmental program involvement including, classroom involvement (20%), participation in an environmental organization (11%), attendance of a seminar (10%), and involvement in government environmental policy-making efforts (10%). (Figure3.20)

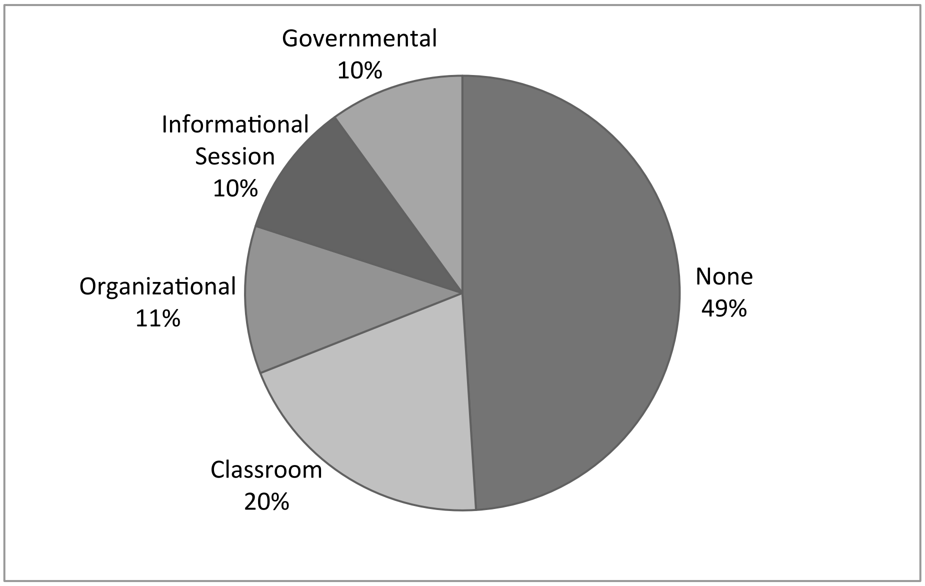


Figure 3.20: Percentage of environmental program involvement among participants

3.5 Reported Driving Frequency

The 2007 transportation carbon footprint was not a significant contributing factor to EALCF, and independent T-tests showed there was no significant difference between mean transportation carbon footprint for green building certification or gender. However, the reported vehicle-driving frequency revealed differences dependent on the time of year. The participants were asked to report on their driving frequency when residing on-campus during the school year (on-campus) and then when residing off-campus during school breaks (off-campus). The driving frequency of participants when living on-campus was reported on average as yearly (n = 10, mean = 4.10, SD = 1.52) and was significantly less (independent T-test: $t_{(1,17.99)} = 3.56$, $p < .05$) than when participants resided off-campus driving an average of weekly (n = 10, mean = 1.70, SD = 1.49) [Residing on-campus driving frequency: Never {5}=7, Yearly {4}=0, Monthly

{3}=1, Weekly {2}=1, Daily {1}=1] [Residing off-campus driving frequency: Never {5}=1, Yearly {4}=1, Monthly {3}=0, Weekly {2}=0, Daily {1}=8] (Figure 3.21).

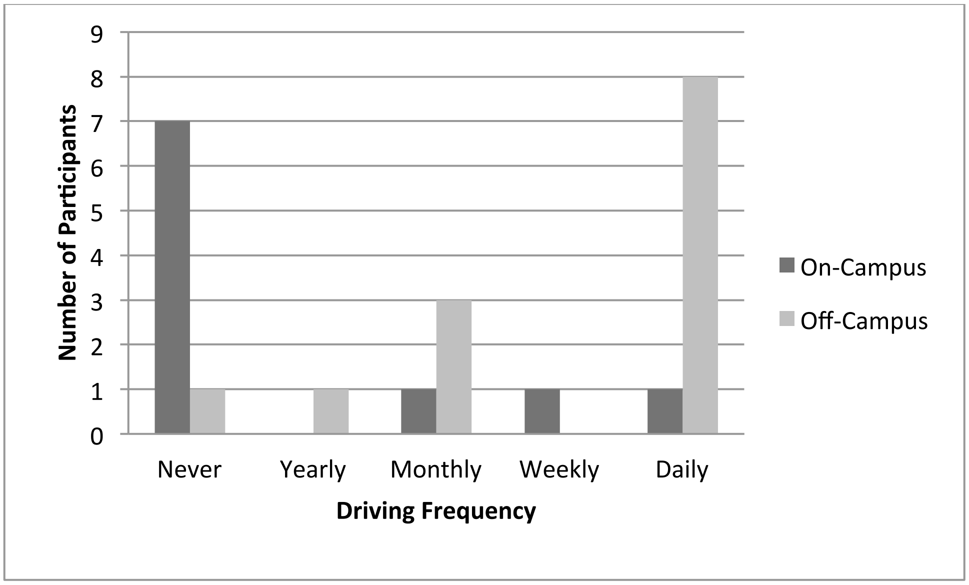


Figure 3.21: Driving Frequency of Participants when residing on-campus or off-campus during the calendar year

CHAPTER 4: DISCUSSION

This study sought to investigate two interventions, green building certifications and energy conservation prompting signage on the lighting conservation habits of each participant. Participant demographic data indicated the age of the participants was comprised mainly of older students with the average age of 21 years old and an average level of education equaling a junior. The majority of the participants lived within the LEED certified building and all but one had selected the building they resided in as their first choice in the dormitory selection process. Because the dormitories are assigned based on a lottery process only 1 participant was placed in a dormitory that was not of there first choice. None of the participants were aware of the LEED certification process before the start of the study, despite the large plaque that was awarded to the university by the U.S. Green Building Council (USGBC). This plaque is predominately displayed on one wall of the lobby within the LEED certified dormitory. This is in contrast to the USGBC's claim that simply investing in the strategy to pursue and be awarded any level of LEED certification will naturally promote pro-environmental stewardship (Kubba, 2010). One would argue that for a building to be most effective in promoting energy conservation, the occupants should be aware of the pro-environmental design, especially considering the occupants can effect up to 55% of the total energy usage within a building based on their behavior (Schipper et al., 1989). Others argue that information alone may influence intention and beliefs, but does not tend to influence behavior, and the need to know whether or not a building is certified has little impact on the occupant's energy conservation behaviors (Abrahamese et al., 2005; Costanzo, Archer, Aronson, & Pettigrew 1986; Stern & Dietz, 1994). This research focused on investigating these claims.

4.1 Estimated Annual Lighting Carbon Footprint

When looking further into the motivators of energy conservation behaviors, the study investigated the impact of an educational institution's participation in efficiency behaviors through voluntary participation in an energy conservation program, LEED, on a participant's estimated annual lighting carbon footprint (EALCF). An additional method was tested for promotion of pro-environmental behaviors among these same participants in an effort to reduce their lighting energy usage by encouraging them to practice curtailment behaviors. Both interventions were examples of antecedent strategies; chosen because these strategies are able to reach larger audiences with lower costs compared to consequence strategies. As discussed in further detail below, overall one of the two interventions showed success in reducing a participant's lighting carbon footprint (the green building certification variable), however the second intervention (the energy conservation signage variable) required the aid of additional external factors to reveal any significance.

4.1.1 Green Building Certification

The first hypothesis predicted participants in the LEED certified dormitory would utilize less artificial lighting than their counterparts and thus result in a smaller EALCF. This was based on two main principles: USGBC's LEED design guidelines and energy usage research on LEED certified buildings. One of the design differences between the two buildings being researched was the lighting plan within each dormitory. Because the university supplied lighting in the LEED certified building was selected by the designer to be in accordance to LEED energy prerequisite guidelines[9] (Kubba, 2010) the overall wattage of the luminaire supplied was more energy efficient than the luminaire supplied in the non-LEED certified building. For the non-LEED building the designers chose not to adhere to these same guidelines despite the idea that the building was to mimic the LEED building already built (Alice Cook House). The reason for this design change was not made known to the researchers of this study. Additionally, previous research studies claimed LEED certified buildings utilize 10-39% less energy than traditional buildings (Baylon & Storm, 2008; Fowler et al., 2010; Newsham et al., 2009).

The findings from this study were consistent with those previous studies and USGBC claims that green building design can influence an occupant's energy consumption. There was evidence of a decrease in the participant's estimated annual lighting carbon footprint depending on which dormitory they resided. The results were similar to a study conducted by Kneifel (2010), where he was able to show that implementing low cost energy-efficient devices within a new construction building, lowered the energy usage by 20-30% on average and reduced the building's carbon footprint by 16%. Since the participants were unaware of the USGBC claims regarding LEED's impact on energy conservation, and results were seen solely on the types of lighting supplied to the occupants by the university, this creates an opportunity to continue to improve results by promoting pro-environmental behaviors among occupants.

4.1.2 Energy Conservation Prompting

The second hypothesis tested the theory that occupants could be motivated to practice pro-environmental behaviors, further improving the energy conservation within the buildings.

[9] Energy and Atmosphere – Prerequisite 2: Minimum Energy Performance

Prompting was chosen as a second variable to examine since it is cost effective and has been shown in some cases to motivate individuals to act appropriately in certain situations (Hopper, 1991). The hypothesis stated the energy conservation prompting signage would cause a reduction of estimated EALCF by influencing the pro-environmental behaviors of the occupants. However, the results showed no evidence of the prompt signage acting as main significant variable to affect energy conservation behavior. This result is in contrast to a number of studies that cite prompting as an effective means of behavior change. However, as previously mentioned, a number of factors must be in place for an individual to act on a request to practice conservation behaviors. For example, in the Theory of Planned Behavior (TPB) after a person develops an intention to be environmentally conscious they must conquer the behavioral, normative and control beliefs (Ajzen, 1991; Ajzen & Fishbein, 1980; Harland et al., 1999) to act on that intention. Hopper (1991) reported that while the prompting was an effective way to encourage pro-environmental behavior, it did not appear to influence norms or attitudes. In this study, the action of lighting energy usage was tested. The intent to perform the action was not tested, therefore making it difficult to ascertain if there were additional factors influencing an individual's choice to not reduce their energy conservation after being prompted to do so.

Additionally, while some research states that prompting can be an effective way to influence pro-environmental behavior (Winett & Kagel, 1984), there is also a belief that certain design requirements are needed to have an effective prompt. While an attempt was made to include all of the 6 elements that are rarely included in prompting studies (Abrahamese et al., 2005), the actual prompt used for the study was not placed through rigorous testing to ensure it followed the recommendations set forth by Winett & Kagel (1984). Other studies indicate compliance can be affected by the location of the prompt, how the prompt is displayed and the demographic of the individual to whom the prompt is being displayed (Geller et al., 1985; Wlliams et al., 1989). It is unclear at this time if any of these factors played a significant role in the lack of full compliance with the posted prompt, and is an area to be investigated in further research.

4.1.3 Combined Interventions

With regards to the third and final hypothesis, it was predicted that the LEED certification and the energy conservation signage together would encourage a lower EALCF than no signage in the non-LEED building. Based on the data, there was little support for this specific hypothesis, however when considering several other variables during analysis, including number of luminaires and gender, there were specific scenarios where signage and efficient lighting design had an impact on the occupant's lighting conservation behaviors. Significant results were seen when looking at a combination of variables including green building certification, signage and gender. The results included:

- Among female participants
  - In the non-LEED building, females had a lower EALCF during the sign condition than females during the no sign condition.
  - During the no sign condition, females in the LEED building had a lower EALCF than females in the non-LEED building.
- Among male participants
  - During the sign condition, males in the LEED building had a lower EALCF than males in the non-LEED building.
- Between female and males participants

- In the non-LEED building, during both the sign and no sign conditions, males had a lower EALCF than females.

Gender has been a debated variable when attempting to understand the reasons behind individual tendencies towards pro-environmental behavior. While not included in the hypothesis, during data analysis a significant interaction effect was discovered with the green building certification, signage and gender. Some studies have shown that women by nature are more altruistic than men because they have more desire to consider and act on the wishes of others (Gillian, 1982). A number of studies have also shown that on average women tend to place more concern on the environment, or show altruistic values, than men (Dietz & Stern, 2002; Maineri, Barnett, Valdero, Unipan, & Oskamp, 1992; Widegren, 1988;), while other studies do not revealed any evidence that women value the environment more than men (Arcury & Christianson, 1993; Widegren, 1988). While there has been debate on the mediator that causes a belief or value to become an action, there is overwhelming evidence that women on average participant in pro-environmental behaviors more than men. (Baldassare & Katz, 1992; Roberts, 1993; Schann & Holzer, 1990; Hunter & Hatch, 2004)

Findings revealed, depending on the circumstances, men and women engage in pro-environmental behavior differently from the research stated above. In this present study, there was little evidence to support the idea that women exhibited more pro-environmental behavior than men. On average the female participants in this study had higher EALCFs than males, suggesting they participated in pro-environmental actions less often than males. The results also show only women in the non-LEED building were affected by the signage variable. However, results also show that females in the LEED building had significantly lower EALCFs than those in the non-LEED building. There is a possibility the signage variable was not a factor for females in the LEED building, because the females in the LEED building were already using a relatively low amount of lighting energy. Subsequently, this would make it more difficult to reduce their usage to a level that would produce a significant difference.

The results also indicated that the male participants in the non-LEED building, once the signage was introduced were able to significantly reduce their EALCFs over the participants in the LEED building. Overall in the non-LEED building male participants were still using less lighting energy than female participants. As seen with the female participants, the lack of significance within the LEED, building when the sign was introduced, could be a result of a low lighting energy usage among males in the non-LEED building during both of the signage conditions.

There were also significant results that included green building certification, signage, and number of luminaires:

- Participants with only 3 luminaires:
  - In the non-LEED building, participants had lower EALCF during the sign condition than the no sign condition.
  - During the no sign condition, participants had lower EALCF in the LEED building than the non-LEED building.
- Participants with only 4 luminaires:
  - During the sign condition, participants had lower EALCF in the LEED building than the non-LEED building.
- Participants with varying number of luminaires:

- During the sign condition, in the LEED building, participants with 2 luminaires had lower EALCF than participants with 4 luminaires.
- During the sign condition, in the non-LEED building, participants with 3 luminaires had lower EALCF than participants with 4 luminaires.

These results indicated a number of trends. When considering participants that have an identical number of luminaires, the effects of both green building certification and signage conditions within certain luminaire conditions can be seen. For example, results indicated participants with 3 luminaires, the sign condition were successful at reducing the EALCF within the non-LEED building. While results were not consistent across all number of luminaires, this data opens the discussion regarding the impact of this research on future green building design guidelines.

Results also indicated in a few instances, the number of luminaires participants had in their dormitory room resulted in significant difference in EALCF. One would assume access to fewer luminaires would consistently result in a lower EALCF. However, this was only the case in two situations and each case occurred in separate buildings under the sign condition. Further research would be needed to uncover the underlying causes in the differences of the significant results.

4.2 Lighting Wattage and Usage

The study investigated the two basic elements impacting each participant's carbon footprint including the total luminaire wattage available to each participant and the total luminaire usage per day per participant. Similar to the EALCF results, the total wattages available to each participant were significantly dependent on three main variables: green building certification, gender, and the number of luminaires within the dormitory room. Overall participants within the green certified building, or who were male, or who had the fewest number of luminaires, had on average, significantly lower total luminaire wattage available for use than their counterparts. Results also indicated a unique interaction between the variables and found that gender and green building certification had a significant impact on the total available wattage. Males in the LEED building had access to significantly lower total luminaire wattage than their female counterparts in the non-LEED building.

When comparing these results to the EALCF interaction results, similarities could be found between the two groups. The available wattage may help to explain why there was evidence towards males in the LEED building participating in more pro-environmental behaviors than females in the non-LEED building. If luminaire wattage leads directly to carbon footprint results, then behavior becomes a smaller part of the carbon footprint equation. This data is again in contrast to the current research that females tend to be more participatory in pro-environmental behaviors than men.

A link was also found between green building certification, the number of luminaires and the available total wattage. Depending on the green building certification, the number of lights had a different effect on the total available wattage. In the LEED building the available wattage was lower than participants in the non-LEED building only if they had 3 luminaires. However, if the participant had 4 luminaires in the LEED building their available wattage was higher than those in the non-LEED building. Only a portion of these results align with the EALCF results revealing the number of luminaires had less of an impact on the EALCF results than the gender results.

In the average total luminaire daily usage in hours calculation (TLD*h*) used to determine overall luminaire usage within the EALCF equation, green building certification was found to be significant main variable. The results indicated that LEED building participants on average used the luminaires less often than the participants in the non-LEED building during both the signage and no signage conditions. The same sets of interaction sets were found in the TLD*h* as in the total wattage calculations. For usage, the lowest luminaire usage was participants in the LEED building with 4 luminaires during the sign condition and the highest was participants with 4 luminaires in the non-LEED building during the signage condition. With regards to the number of luminaires and within both buildings, when signage was present the lighting usage reduced significantly. Within the gender, green building certification, and signage interaction, the same result appears, when the signage was present for each group the lighting usage significantly dropped. Within the signage condition the lowest usage was among the male participants in the LEED building and the highest was male participants in the non-LEED building during the no signage condition.

The results also examined the influence of the university's lighting design on the lighting usage of the participants. The investigator separated the total usage of each luminaire by supplier and discovered the university-supplied luminaires (ambient and task lighting combined) were used significantly more hours during the day than participant supplied luminaires (ambient and task lighting combined). Further analysis found that the total university supplied luminaire utilization was significantly more in the non-LEED building than the LEED building and significantly more for males than females. An interaction was also detected for green building certification and gender. On average when the participants were divided by gender within their respective buildings and signage was present a decrease in luminaire usage was significant compared to the absence of signage. Among the signage conditions, the lowest luminaire usage was by female participants in the non-LEED building during the signage condition and the highest usage was by the male participants in the non-LEED building during the no sign condition. Of these conditions the males in both non-LEED building under both signage conditions utilized the university-supplied luminaires more than any other group within either signage condition.

These findings when combined with the findings from the EALCF results help to explain some of the key factors influencing participants lighting usage. Participant supplied luminaires, on average, used more electrical power than university supplied luminaires. When a participant supplied luminaire was available for use, participants continued to utilize the university supplied luminaires more often. Because the university-supplied luminaires required less wattage to operate, participants that used these luminaires more often than their participant-supplied luminaire experienced a smaller lighting carbon footprint. Consequently, the building with the least amount of participant-supplied luminaires was in fact the LEED certified building, believed to result in the significant results previously reported. The same could also be reported for the gender variable as the overall usage of lights was low for females but the wattage available to them was high resulting in a high EALCF results compared to males who had a high usage but low available wattage.

The results from the self-report surveys also lend insight into why individuals may have felt the need to supply their own luminaires in addition to the university-supplied lights. Participants cited problems with the university-supplied lights including: lack of brightness; inacceptable range of adjustability; type of lighting provided; and not enough luminaires to meet the needs of the participants. Because the university did not restrict the type of lights that were allowed into either the dormitory, with the exception of halogen torches (for risk of fire) the students were able to bring any luminaire they felt was necessary.

Very little research exists looking into the specifics of lighting wattage and subsequent carbon footprints. However, it is clear that individuals are creatures of habit and if there is access to additional lighting, little thought is generally given by the user as to which light would be more appropriate for the situation. Instead most individuals move towards habit and turn on lights they are familiar with, or are just available with little regard for how well they are working for the user (Reinhart & Voss, 2003). Using the data from this research study and the information gathered in other lighting and behavior studies, there are implications for using administrative and engineering controls to reduce excess lighting energy usage and subsequently reduce the building's overall carbon footprint (Kneifel, 2010).

4.3 Pro-environmental Behavior

To further understand the personal norms toward pro-environmental behavior, participants reported on their recycling, composting, driving frequency and environmental program involvement. In previous studies, researchers have indicated beliefs and values have influenced how people perceive and react to different environmental situations (Stern & Dietz, 1994). Contrary to studies conducted by Bamberg (2003), participants within this study showed no connection between current pro-environmental behaviors and their tendency to participant in additional pro-environmental behaviors, with or without signage prompting. Within this study all individuals reported recycling more than 50% of the time, while 40% reported never composting. This could be related to the mandatory recycling policies with the State of New York (New York State, 2012) and the limited availability of composting stations on-campus and in the surrounding areas. Additionally, the driving frequency of participants did not contribute to each participant's overall EALCF. This study did show on average participants drove less when living in the dormitory then when living away from the campus. This result may be reflective of the elaborate public transportation system provided by the university and the relatively small traveling distance students are required to make on a daily basis, compared to living and working in a city or town away from the campus. All participants had some level of environmental program involvement with the highest participation being classroom involvement and evenly spread among other levels of involvement. Conclusions were drawn based on statistical analysis, that the lack of understanding in the LEED certification and the skewed results on recycling, composting, driving frequency, and organizational involvement, did not affect each participant's dormitory selection preference.

Comparison of these results to the idea that basic values help govern action was not seen in this study. The participants within this study did exhibit interest or involvement in pro-environmental behaviors outside of their lighting energy usage. This behavior, however, was not a determining factor in how they utilized the luminaires in their room or how they responded to the posted lighting conservation signage. Future research should be conducted to understand this gap in conservation behaviors and how they may relate to the Theory of Planned Behavior (TPB). Because this theory claims to fully explain pro-environmental behavior, (Ajzen, 1991; Ajzen & Fishbein, 1980; Bamburg, 2003; Harland et al., 1999) testing a person's decision to use energy efficient lighting when non-energy efficient lighting is available, and testing the motivating factors behind choosing to respond appropriately to prompting signage, may lend insight into the best way to mitigate the over usage of lighting energy. Once motivators for this behavior have been determined for building occupants that are not financially motivated to save energy, these results could be used to devise a specific design requirement in LEED that would insure an increased chance of success rate for reduced occupant energy usage.

4.4 Limitations and Future Research

Although significant results were concluded for portions of this study, a number of study limitations show room for improved research and data generalization to a larger population. Multiple measurement methods were utilized to ascertain lighting energy usage in an effort to improve reliability and validity; however these results were then transformed into large quantifiable measurements to determine the global impact (carbon footprinting) of the lighting energy usage. It is unclear at this time if this transformation of measurements had any impact on the corresponding results. While carbon footprinting was an important result for analyzing the overall impact on behavior and green building designs, the use of this technique produced results which had to be interpreted by the investigator.

The first measurement to be interpreted was the overall data collection. As noted previously, a disruption effect was detected in the data for the 1st day of the intervention during both weeks of data collection. This anomaly when kept in the data results, showed inconsistent measurements with reference to the rest of the days. The investigators decided to remove this inconstant data. While assumed to be a result of the perceived disruption effect this leaves questions towards experimenter interpretation of the data. To avoid this discrepancy in future studies, a period of no data collection is recommended after the initial equipment and interventions have been installed.

Another area of concern is the final dependent measurement of EALCF. This measurement was calculated by estimating the overall lighting carbon footprint of an individual based on average lighting usage within a room during a 24-hour time frame. Additional factors used in the calculations were: number of school days – which could vary depending on the school year; wattage of luminaire – does not infer any information regarding the participant's behavior; estimation of carbon output based on kilowatt hours used – which depends on the source referenced to supply this data. A better estimation of lighting usage behaviors, with reduced influence from external variables, would have been to use the minutes a luminaire was used and the subsequent kilowatt hours that resulted during a 24-hour period to determine the effect of the variables being tested.

Data collection methods used for collecting the kWh measurements could also be improved. Because one of the university supplied lights in each dormitory room was hard-wired to the building electrical supply and the measurement device used to measure the plugged in luminaires (kill-o-watt meter) captured only total kWh for the entire week, the HOBO loggers were the main source of capturing the lighting usage measurement. A limitation to the loggers was the method in which the device captured the light usage. Because the device did not capture the on/off status of the luminaire, but instead its light output in lumens over a length of time, interpretation of the results was necessary. A lumen threshold was used to categorize the luminaires as either on or off, however this threshold could be open to debate by other researchers. Additionally, the HOBO measured the lumen levels once every 5 minutes as outlined by the methods developed. When viewing this within the 24-hour period of data collection there is a chance for miscalculations on the length of time a luminaire was utilized in this time frame. In future research a different device or technique should be used for capturing the on/off status and subsequent duration of the usage of each lighting in a 24-hour period. This would reduce interpretations of the lighting energy usage throughout the data collection period.

Another measurement utilized within the study was a method of self-report to ascertain the participant's pro-environmental involvement in multiple areas of their lives throughout the calendar year. A self-report measurement is less expensive and time consuming than measurements taken through quantitative and observation methods, it is open to subjective opinion on the part of the participant. Because a part of the survey asked questions regarded past behavior, this relies on the participant to correctly remember and answer these questions. Depending on the mood, memory, or participant's influence of perceived experimenter expectation, the results could become skewed and affect the outcome of the pro-environmental behavior tendency measurement. Subsequent studies should consider observation and self-report questionnaires that focus more on events of the immediate past. Additionally this research, while interested in the motivators behind pro-environmental behavior, had no provisions to test for the motivators. A post-intervention questionnaire surrounding the participants' behavioral response to the signage factor would help to understand the motivations to the switching behavior recorded.

The number of participants, the overall number of days measured, and the number of buildings tested, based on the construct being tested was a possible limiting factor in the generalization of the results to a larger population. To compensate for this issue the repeated measures were treated as multiple observation points within each participant's observation period, and consequently helped to improve statistical power of the results. However there is a probability this method raised the chance for a type II error. It is suggest in future research, the overall sample size of the buildings, participants and observation period be increased to decrease the argument for a type II error.

Lastly, this study aimed to measure the luminaire usage within each dormitory room based on the individual's prior environmental tendencies and the design of the building. Significant results indicated the lighting design of the building influenced the EALCF. However the investigators were unable to ascertain if the lighting provided by the university or the participant fell within the Illumination Engineering Society's (IES) recommended lumens for the tasks being performed throughout the 24-hour period. According to the IES, a particular light level is recommended in a space when a person is attempting to perform a task. For example, when reading a book it is recommended the light level of the environment be between 200-500 lumens to ensure minimal eye discomfort and musculoskeletal strain (DiLaura, Houser, Mistrick, & Steffy, 2011). If individuals are performing this task in lower than recommended light levels for prolonged periods of time this would result in a loss of productivity (Juslen, Wouters, & Tenner, 2007) and health (Van Bommel, 2006). As mentioned in previous dormitory challenges, it was uncertain if students had changed their behavior and reduced energy usage to a point that was unsustainable (for example: using flashlights to study, bathing at a gym instead of in the dormitory, etc.) (Petersen, Shunturov, Janda, Platt, & Weinberger, 2007). In this study it is unclear if the reduced lighting energy used was driven by the participant's physical need or by their response to the intervention. As seen in the LEED building, individuals who had two luminaires saw no reduction in lighting usage during the signage condition. It is unclear at this time if participants in this condition chose not to reduce the light usage or if they were unable to as a function of physical need. While the basis of the study is sound and the results lend insight into the effect of building design and the energy conservation signage, a number of these limitations make the argument that further research is needed to understand the construct being measured.

4.5 Conclusion

While the main purpose of this study was to research pro-environmental behavioral responses to green building certification and conservation signage, the data is relevant to the broader issue of the role of governmental and private agencies in reducing the environmental impact of energy usage. As previously stated, climate change has become and continues to evoke global concern. While scientists may be unable to agree on the magnitude of the current ecological crisis, many believe considering mitigation techniques at the present time are globally favorable. As seen, in the literature, many believe the solution to climate change issues are routed in many areas of the global economy and governmental structures, and when looking at the basis for structures it is evident that consumer choices and behavior play an influencing role in the future path of these organizations (Bin & Dowlatabadi, 2005). Based on this information, it would stand to reason a basic understanding of the motivation behind a person's decision to act in a pro-environmental manner would have a substantial impact on the future of climate change mitigation.

The most recognized global organization for climate change mitigation, the UNFCCC, utilizes the Kyoto Protocol to reduce our global dependence on fossil fuels. The UNFCCC attempts to encourage countries to reduce the amount of GHG emissions released into the atmosphere by structuring the Kyoto Protocol as a cape and trade program. (UNFCCC, 2011). Because some individuals feel so strongly about cape and trade, it has continued to be the basis for many national governmental and private agencies' mitigation programs (Brooks, 2010; Waxman, 2009) thus influencing local organizations, public and private, efforts to address climate change in this manner (CORE, 2012). However, in the past few years there has been a recent disassociation with the cap and trade system for fear there are too many variables that must be considered, politically and financially for the program to work as intended (Broder, 2010). One of those variables is compliance to the cap and trade regulations and how to insure organizational and consumer compliance, even in the event an individual is not confident the program is making a difference in the global climate change (Barnes, 2010).

As previously mentioned, one of the largest markets in which a cap and trade system could have a positive impact on is the building industry, especially within the United States. However, insuring that building standards created to help with this mitigation of GHG emissions are productive and do not create a false hope of reductions, is the first step towards cap and trade effectiveness and compliance. Because the many governmental cap and trade programs offered in the United States are currently up for a legislative vote and Voluntary Emission Reductions (VERs) programs are still in the beginning stages of attracting consumers, it is important to ensure consumers understand how they can have significant impact on the outcome of future regulations and programs (Broder, 2010; TFS Green, 2012). Some individuals look at the USGBC's LEED program as an opportunity to be a positive part of the cap and trade system as a pre-approved GHG offset project, and help organizations meet their regional and VERs stewardship initiatives. The issue then becomes proving the LEED program is effective at reducing carbon emissions to a point in which an organization can quantifiably measure the efficiency of their buildings compared to building non-LEED certified buildings. A number of studies exist showing evidence that LEED buildings reduce dependence on fossil fuels and can reduce the overall carbon footprint of a building (Baylon & Storm, 2008; Fowler & Rauch, 2008; Fowler et al., 2010; Newsham et al., 2009). However, others debate the validity of these studies and whether or not they can be generalized to a larger population of buildings independent of the certification level of the new or renovated building (Diamond et al., 2006; Newsham et al., 2009). Renewable or Green Energy planning companies often advertise the ability to offset a LEED building's future energy usage through other VERs programs (Renewable Choice Energy, 2012). Which leads to the main focus of this research, how effective are the LEED certification standards at increasing lighting energy conservation when considering the design of the building and then when considering the impact occupants can have on the lighting energy usage outcome?

To investigate the effectiveness of LEED guidelines on an occupied building, the study focused on an aspect of a building's design that could easily be measured (lighting design) and analyzed the data to look for environmental and behavioral influences on energy usage in the building. As proven in this study, there was evidence that the design of a building can have an effect on a building's overall energy consumption, especially when considering the impact of lighting design and its usage on a building. However, there was evidence that by not applying administrative controls to building occupants to control lighting energy usage, this effect can be diminished or even reversed. In situations where an individual was allowed to bring in luminaires to their room, with no regard to the luminaire's energy consumption, energy usage was higher than those who primarily used luminaires supplied by the university. However, one area of optimism was evidence that occupants, on average, preferred to use the university-supplied lights to their own personal lights. Although, from this result, it can be seen that even the slightest use of a personally installed luminaire had a negative impact on the building's overall energy usage. Not controlling luminaire selection in a LEED building could prove to be a setback in trying to place LEED certification projects as pre-approved GHGs offset programs. As green certification programs continue to evolve considerations need to be given to how buildings will be used by the occupants and ways to reduce excess energy usage caused by devices or equipment not accounted for in the original design plan. The main reason for these considerations, as we were able to see in this study, is consumer or occupant behavior has an impact on the overall energy usage of a building (Bin & Dowlatabadi, 2005).

To consider the effects of consumer or occupant behavior numerous studies have been conducted to understand pro-environmental behavior and its motivators. As previously mentioned, one of the methods for predicting consumer pro-environmental behavior is the Consumer Lifestyle Approach (CLA) which states an individual has a direct and indirect impact on the success of an organization's ability to meet environmental goals through their product purchasing and usage habits (Bin & Dowlatabadi, 2005). The TPB to helps to explain the motivators behind an individual's initial decision to act in a pro-environmental manner (Ajzen & Fishbein, 1980). For example, what motivators cause occupants to first bring in personal luminaires, and secondly decide to utilize them with little regard for energy efficiency? While this topic was not the focus of this research, based on the results seen, it is recommended this issue should be considered in future research.

This study was more focused on the effect after the person had already chosen to bring in and use a personal light for any reason they deemed necessary. It also looked at whether or not the usage could be reduced by trying to convince the occupant to change their behavior based on new information provided to them about the dormitory. According to TPB, the intervention placed into effect must coincide with a person's beliefs in order for them to want to respond to the request for action including: the behavioral belief; the normative belief; and the control belief. The investigator of this study predicted each belief was capable of being acted upon with little effort from the participant and consequently the requested action, turning off the lights, would be adhered to on a daily basis.

The results of the introduction of a prompting signage to conserve energy, proved to be ineffective at significantly reducing the occupants' energy usage throughout each dormitory. Nor did the presence of the signage within the LEED certified dormitory have a greater effect than having no sign within the non-LEED building. It is unclear why this signage alone had no significant effect on the occupants. Significant results were seen when considering other variables into the equation, including the number of luminaires in the room and gender. Both of these results were unexpected, but may help lend insight into which variables should be considered in future research when investigating prompting interventions. Testing the effectiveness of signage design and its validity should be considered in future studies. Within a number of the pro-environmental behavioral studies, researchers found that a person's tendency towards energy conservation is generally guided by previous participation in pro-environmental activities or behaviors (McCalley & Midden, 2002; Thogersen, 2003). Within the parameters of this study previous activities or behaviors did not appear to have an influencing factor towards an occupant's tendency to participate in lighting energy conservation. With the multiple elements that were expected to been seen in this study, and based on previous research on pro-environmental behaviors, assumptions could be made that there was either a flaw in this experimental design or the ability to predict pro-environmental behaviors are still unreliable in most situations.

Despite the inconsistent results seen within this study, this research has implications for future research within the LEED building designs and ways to apply engineering and administrative controls within buildings that contain a large number of occupants. Through this research results revealed that with effective planning, pre-approved GHG offset projects are a viable option within the cap and trade system. Additionally, occupants of a building including their CLA behaviors should be considered within the planning stages of a green certified building. While there were multiple limitations within this study, it lends insight into the creation of more robust and tested interventions to be placed in research regarding building design and pro-environmental behavior. The intention behind this research was to broaden the idea of what constitutes green building design and to investigate how to ensure that the intended outcomes are achieved following the completion of the building construction. The investigators feel this study; while not exhaustive nor predictive, helped build those ideas and future building requirements. More specifically, and perhaps more significantly, this study shows the importance of the human factor in green building design, a factor that can totally reverse green design intentions. It also highlights the limitations of LEED certification as a guarantor of high building performance.

REFERENCES

110th Congress. (2007). H.R.6 Energy Independence and Security Act of 2007. United States House of Representative and United States Senate.

Abrahamese, W., Steg, L., Viek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology, 25* (3), 273-291.

Ajzen, I. (1991). Theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179-211.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior.* Englewood Cliffs, NJ: Prentice Hall.

American Coalition for Clean Coal Electricity. (2012). *Low-cost coal ensures affordable energy for american families*. Retrieved April 14, 2012, from America's Power: http://www.americaspower.org/low-cost-coal-ensures-affordable-energy-american-families

Architecture 2030. (2012). *Architecture 2030: The 2030 Challenge.* Retrieved April 15, 2012, from Architecture 2030: http://architecture2030.org/2030_challenge/the_2030_challenge

Arcury, T., & Christianson, E. (1993). Rural and urban differences in environmental knowledge and action. *Journal of Environmental Education, 25*, 19-25.

Bagozzi, R., Youjae, Y., & Baumgartner, J. (1990). The level of effort required for behavior as a moderator of the attitudes-behavior relation. *European Journal of Social Psychology , 20*, 25-59.

Baldassare, K., & Katz, C. (1992). The personal threat of environmental problems as a predictor of environmental practices. *Environment and Behavior, 24*, 602-617.

Bamburg, S. (2003). How does environmental concern influence specific environmentally related behaviors? A new answer to an old question. *Journal of environmental psychology, 23* (1), 21-32.

Bandura, A. (1977). *Social Learning.* New York, NY: Prentice-Hall.

Barnes, E. (2010, November 9). *Collapse of the Chicago Climate Exchange Means A Strategy Shift on Global Warming Curbs.* Retrieved April 9, 2012, from FoxNews.com: http://www.foxnews.com/politics/2010/11/09/collapse-chicago-climate-exchange-means-strategy-shift-global-warming-curbs/

Baylon, D., & Storm, P. (2008). Comparison of commercial LEED buildings and non-LEED buildigns within the 2002-2004 Pacific Northwest commercial building stock. *ACEEE Summer Study on Energy Efficiency in Buildings: 4/1 to 4/12.*

Becker, L. (1978). Joint effect of feedback and goal setting on performance: a field study of residential energy conservation. *Journal of Applied Psychology, 63* (4), 428-433.

Bin, S., & Dowlatabadi, H. (2005). Consumer lifestyles approach to US energy use and the related CO2 emissions. *Energy Policy, 33*, 197-208.

Bourgeois, D., Reinhart, C., & MacDonald, I. (2006). Adding advanced behavioral models to whole building energy simulation: A study on the total energy impact of manual and automated lighting control. *Energy and Buildings, 38*, 814-823.

Bracht, G., & Glass, G. (1968) The external validity of experiments. *American Educational Research Journal, 5,* 437-474.

Bradley, R., & Jones, P. (1993). "Little Ice Age" summer temperature variations: their nature and relevance to recent global warming trends. *The Holocene, 3*, 367-376.

Brandon, G., & Lewis, A. (1999). Reducing household energy consumption: A qualitative and quantitative field study. *Journal of Environmental Psycholgoy, 19*, 75-85.

Brechin, S. (2003). Comparative public opinion and knowledge on global climatic change and the kyoto protocol: The U.S. versus the world? *International Journal of Sociology and Social Policy, 23* (10), 107-134.

Broadbent, D. (1977). Language and ergonomics. *Applied Ergonomics, 8*, 15-18.

Broder, J. (2010, March 26). Tracing the Demise of Cap and Trad. *The New York Times*, p. A13.

Brooks, D. (2010, April 29). American Power Act. *The New York Times*, p. A25.

Bureau of Labor Statistics. (2001, May). *Consumer Expenditures 1999.* Retrieved 2012 15-June from U.S. Bureau of Labor Statistics: http://www.bls.gov/cex/csxann99.pdf

Bureau of Transportation Statistics. (1997). *1995 American Travel Survey Profile.* Washington, D.C.: U.S. Department of Transportation.

Carbon Trust. (2012). *Carbon Trust*. Retrieved April 13, 2012, from Carbon Trust: http://www.carbontrust.com

Chestnut, B. (2012, April 1). *The Future of Cap and Trade in the U.S. and Europe.* Retrieved April 9, 2012, from Georgetown International Environmental Law: http://gielr.wordpress.com/2012/04/01/the-future-of-cap-and-trade-in-the-us-and-europe/

Civic Impulse, LLC. (2012). *S.2877 (111th): Carbon Limits and Energy for America's Renewal (CLEAR) Act*. Retrieved April 9, 2012, from Gov Track.us: http://www.govtrack.us/congress/bills/111/s2877

Civic Impulse, LLC. (2012). *H.R.6 (110th) Energy Independence and Security Act of 2007*. Retrieved 2012 йил 12-June from Gov Track.us: http://www.govtrack.us/congress/bills/110/hr6

Cohn, D. (1992, March 11). Per-can fees catch on as area's trash mounts. *Washington Post* .

Cone, J. & Hayes, S. (1980). *Environmental Problems: Behaviorial Solutions.* Monterey, CA: Brooks/Cole.

CORE. (2009). *CORE: MGGRA*. Retrieved April 9, 2012, from Carbon Offset Research & Education: http://www.co2offsetresearch.org/policy/MGGRA.html

CORE. (2012). *CORE: Mandatory vs Voluntary Markets.* Retrieved April 9, 2012, from Carbon Offset Research & Education: http://www.co2offsetresearch.org/policy/MandatoryVsVoluntary.html

Costanzo, M., Archer, D., Aronson, E., & Pettigrew, T. (1986). Energy conservation behavior: The difficult path from information to action. *American Psychologist, 41*, 521-528.

Crowley, T., & Lowery, T. (2000). How Warm was the Medievial warm period? *Ambio , 29*, 51-54.

Cummins, P. (2012). *The WCI Cap & Trade Program*. Retrieved April 9, 2012, from Western Climate Initiative: http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program

Deming, D. (1995). Perspective: Climate warming in north america: Analysis of Borehole Temperatures. *Science, 268*, 1576-1577.

Denton, G., & Karlen, W. (1973). Holocene climatic variations - their pattern and possible cause. *Quaternary Research, 3*, 155-205.

Department of Energy. (2009). *2009 Buildings Energy Data Book.* Retrieved March 6, 2011, from Department of Energy: http://buildingsdatabook.eren.doe.gov/docs%5CDataBooks%5C2009_BEDB_Updated.pdf

Diamond, R., Opitz, M., Hicks, T., Vonneida, B., & Herrera, S. (2006). Evaluationg the energy performance of the first generation LEED-certified commercial building. *ACEEE Summer Study on Energy Efficiency in Buildings* (pp. 41-52). Washington, DC: American Council for an Energy-Efficienct Economy.

Dietz, T., Kalof, L., & Stern, P. (2002). Gender, Values, and Environmentalism. *Social Science Quarterly , 83*, 353-364.

DiLaura, D., Houser, K., Mistrick, R., & Steffy, G. (2011). *The lighting handbook: 10th Edition.* New York, NY: Illumination Engineering Society of North America.

Durkin, M. (Director). (2007). *The great global warming swindle* [Motion Picture].

Eckersley, R. (1992). *Environmentalism and political theory.* Albany, NY: State University of New York Press.

Eilperin, J., & Mufson, S. (2010, February 27). Senators to propose abandoing cap-and-trade. *The Washington Post* .

Energy Information Administration. (2008, May). Greenhouse gases, climate change and energy. Washington, D.C.: National Energy Information Center.

Energy Information Agency. (1999). *A look at residential energy consumption in 1997.* Washington, D.C.: Department of Energy.

Environmental Protection. (2010, May 24). *Regional Climate Initiatives Share Cap and Trade Know-How.* Retrieved June 6, 2010, from Environmental Protection Online: http://eponline.com/articles/2010/05/24/regional-climate-initiatives-share-cap-and-trade-knowhow.aspx

Ester, P., & Winett, R. (1981-1982). Toward more effective antecedent strategies for environmental programs. *Journal of Environmental Systems, 11* (3), 201-221.

Estes, J. (2009). *Smart Green: How to implement sustainable business practices in any industry and make money.* Hoboken, New Jersey: John Wiley & Sons, Inc.

Evans, D., & Ginsburg, A. (1985). Contrast sensitivity predicts age-related differences in highway sign discriminability. *Human Factors, 27*, 637-642.

Finus, M. (2008). The enforcement of mechanisms of the Kyoto protocol: flawed or promising concepts? *Letters in Spatial and Resource Sciences, 1*, 13-25.

Fitzhugh, W., & Ward, E. (2000). *Vikings: The north atlantic saga.* Washington, D.C.: Smithsonian Institution Press.

Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T., Betts, R., Fahey, D., et al. (Eds.) (2007). Changes in atmospheric constituents and in radioactive forcing. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, & K. Avery (Eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmetal Panel on Climate Change.* New York, NY: Cambridge University Press.

Fowler, K., & Rauch, E. (2008). *Assessing green building performance: A post occupancy evaluation of 12 GSA buildings.* Richland, WA: Pacific Northwest National Laboratory.

Fowler, K., Rauch, E., Henderson, J., & Kora, A. (2010). *Re-assessing green building performance: a post-occupancy evaluation of 22 GSA buildings.* Richland, WA.: Pacific Northwest National Laboratory.

Fuerst, F., & McAllister, P. (2010). Green Noise or green value? Measuring the effects of environmental certification on office values. *Real Estate Economics, 39*, 45-69.

Geller, E. (1981). Energy conservation programs: Is verbal reporting enough? *The Journal of Consumer Research, 8* (3), 331-335.

Geller, E. (1990). Preventing injuries and deaths from vehicle crashes: Encouraging belts and discouraging booze. In J. Edwards, R. Tindale, L. Health, & E. Posavac, *Social Influence Processes and Prevention* (pp. 249-277). New York, NY: Plenum Press.

Geller, E., Berry, T., Ludwig, T., Evans, R., Gilmore, M., & Clarke, S. (1990). A conceptual framework for developing and evaluating behavior change interventions for injury control. *Health Education Research: Theory and Practice, 5* (2), 125-137.

Geller, E., Bruff, C., & Nimmer, J. (1985). "Flash for life": Community-based prompting for safety belt promotion. *Journal of Applied Analysis, 18*, 309-314.

Geller, E., Winett, R., & Everett, P. (1982). *Preserving the environment: New strategies for behavior change.* New York, NY: Pergamon Press.

Gilbertson, T., & Reyes, O. (2009). *Carbon Trading: How it works and why it fails.* Uppsala: Dag Hammarskjold Foundation.

Gillian, C. (1982). *In a different voice.* Cambridge: Harvard University Press.

Hanley, R. (1988, November 24). Pay-by-Bag trash disposal really pays, town learns. *The New York Times* .

Hansen, J., Makiko, S., Lacis, A., Ruedy, R., Tegen, I., & Matthews, E. (1998). Climate Forcings in the industrial era. *Proc. National Academy of Science USA, 95*, 12753.

Hansen, J., Sato, M., Lacis, A., Ruedy, R., Tegen, I., & Matthews, E. (1998). Perspective: Climate forcings in the Industrial era. *Proceedings of the Nationa Academy of Science, USA, 95*, 12753-12758.

Hare, B., & Meinshausen, M. (2006). How much warming are we committed to and how much can it be avoided. *Climate Change, 75*, 111-149.

Harland, P., Staats, H., & Wilke, H. (1999). Explaining proenvironmental intention and behavior by personal norms and the theory of planned behavior. *Journal of Applied Social Psychology, 29* (12), 2505-2528.

Harris, R., & Chapman, D. (1997). Borehole temperatures and a baseline for 20th-Century global warming estimates. *Science, 275*, 1618-1621.

Hayes, S., & Cone, J. (1981). Reduction of residential consumption of electricity through simple monthly feedback. *Journal of Applied Behavior Analysis, 14*, 81-88.

Heberlein, T. (1977). Norm activation and environmental actions: A rejoinder to R. E. Dunlap and K. D. Van Liere. *Journal of Social Issues, 33* (3), 207-211.

Held, I., & Soden, B. (2000). Water vapor feedback and global warming. *Annual Review of Energy and the Environment, 25*, 441-475.

Hendriks, C. (1994). *Carbon dioxide removal from coal-fired power plants.* New York: Kluwer Academic Publishers.

Herivel, J., & Williams, L. (1975). Joseph Fourier: The man and the Physicist. *Physics Today, 28* (11), 65.

Higgs, A., & McMillan, V. (2006). Teaching through modeling: Four schools' experiences in sustainability education. *The Journal of Environmental Education, 38*, 39-53.

Hodges, P. (2010, May 12). *New Climate bill set in US Senate, draws fire and support.* Retrieved April 4, 2012, from ICIS News: http://www.icis.com/Articles/2010/05/12/9358895/new-climate-bill-set-in-us-senate-draws-fire-and-support.html

Hopper, J. (1991). Recycling as altruistic behavior: Normative and behavioral strategies to expand participation in a community recycling program. *Environment and Behavior, 23*, 195-220.

Houghton, G. J. (1990). *Report prepared for Intergrovernmental Panel on climate change by working group I.* New York, NY: Cambridge University Press.

Houghton, J., Ding, Y., Griggs, D., Noguer, M., van der Linden, P., Dai, X., et al. (Eds.), (2001). Observed climate variability and change. In C. Folland, T. Karl, J. Christy, R. Clarke, G. Gruza, J. Jouzel, et al., *Climate Change 2001: The Scientific Basis. Contributions of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 99-181). New York, NY: University Press.

Houghton, J., Jenkins, G., & Ephraums, J. (1990). *Report prepared for Intergovernmental Panel on climate change by working group I.* New York, NY: Cambridge University Press.

Houwelingen, J., & Van Raaji, W. (1989). The effect of goal-setting and daily electric feedback on in-home energy use. *Journal of Consumer Research, 16* (1), 98-105.

Hunt, D. (1979). The use of artificial lighting in relation to daylighting levels and occupancy. *Building and Environment, 14*, 21-33.

Hunter, L., & Hatch, A. J. (2004). Cross-National Gender Variation in Environmental Behaviors. *Social Science Quarterly, 85*, 677-694.

Hutton, R., & McNeill, D. (1981). The value of incentives in stimulating energy conservation. *The Journal of Consumer Research, 8* (3), 291-298.

IPCC. (2007). Summary for Policymakers. In S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K. Averyt, et al. (Eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* New York, NY: Cambridge University Press.

IPCC. (2011, July 17). *IPPCC - Intergovernmental Panel on Climate Change*. Retrieved from IPPCC: http://www.ipcc.ch/organization/organization.htm

IPCC. (2011, July 24). *IPCC- Intergrovernmental Panel on climate change*. Retrieved from IPCC: http://www.ipcc.ch/organization/organization_history.shtml

Jones, P., Briffa, K., Barnett, T., & Tett, S. (1998). High-resolution palaeoclimatic records for the last millennium: interpretation, integration and comparison with General Circulation Model control run temperatures. *The Holocene, 8*, 455-471.

Junnila, S. (2007). The potential effect of end-users on energy conservation in office buildings. *Facilities, 25* (7/8), 329-339.

Juslen, H., Wouters, M., & Tenner, A. (2007). The influence of controllable task-lighting on productivity: a field study in a factory. *Applied Ergonomics, 38*, 39-44.

Kamenetz, A. (2007, October 1). The Green Standard? *Fast Company* .

Kato, H., Hayashi, Y., & Tanaka, K. (2003). A basic study with feasibility of applying clean development mechanism to the transportation projects. *Mitigation and Adaptation Strategies for Global Change, 8*, 281-291.

Katz, A. (2012, March 27). *LEED-Certified Green Building Projects Hit 12,000 Mark.* Retrieved April 12, 2012, from USBGC.org: https://www.usgbc.org/ShowFile.aspx?DocumentID=18681

Katzev, R., & Johnson, T. (1983). A social psychological analysis of residential electricty consumption: The impact of minimal justification techniques. *Journal of Economic Psychology, 3*, 267-284.

Keeling, C. (1998). Rewards and penalties of monitoring the earth. *Annual Review of Energy and Environment, 23*, 25-82.

Keeling, C. (1961). The concentration of isotopic abundances of carbon dioxide in rural and marine air. *Geochimica et Cosmochimica Acta, 24*, 277-298.

Kerry, J. (2012). *American Power Act.* Retrieved April 9, 2012, from John Kerry - United States Senator for Massachusetts: At Work for You in Congress: http://kerry.senate.gov/imo/media/doc/APAbill3.pdf

Kill, J., Ozinga, S., Pavett, S., & Wainwright, R. (2010). *Trading carbon: How it works and why it is controversial.* United Kingdom: FERN.

Klein, R., & Maciver, D. (1999). Adaptation to climate variability and change: methodological issues. *Mitigation and Adaptation Strategies for Global Change, 4*, 189-198.

Kneifel, J. (2010). Life-cycle carbon and cost analysis of energy efficency measures in new commercial buildings. *Energy and Buildings, 42*, 333-340.

Koch, J., & Clague, J. (2011). Extensive galciers in the northwest North America during Medieval time. *Climatic Change*.

Koenig, B. (2011, October 24). *California First State to Enact Cap-and-Trade.* Retrieved April 9, 2012, from The New American: http://thenewamerican.com/tech-mainmenu-30/environment/9483-california-first-state-to-enact-cap-and-trade-program

Kotchen, M. (2009). Offsetting Green Guilt: Do voluntary carbon offsets help counteract greenhouse gases, or are they just a way for guilt-ridden consumers to buy their way out of bad feelings? *Stanford Social Innovation Review, 7* (2), 26-31.

Kubba, S. (2010). *LEED Practices, Certification and Accreditation Handbook.* Burlington: Butterworth-Heinemann.

Lamb, H. (1965). The early Medieval warm epoch and its sequel. *Palaeogeography, Palaeoclimatology, Palaeoecology, 1*, 13-37.

Le Treut, H., Somerville, R., Cubasch, U., Ding, Y., Mauritzen, C., Mokssit, A., et al. (2007). Historical Overview of Climate Change. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. Averyt, et al. (Eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* New York, NY: Cambridge University Press.

Love, J. (1998). Manual switchng patters observed in private offices. *Lighing Research and Technology, 30*, 45-50.

Luyben, P. (1982). Prompting thermostat setting behavior: Public response to a presidential appeal for conservation. *Environment and Behavior, 14*, 113-128.

Luyen, P. (2002). Prompting thermostat setting behavior: Public response to a presidential appeal for conservation. *Environment and Behavior, 14* (1), 589-603.

Maineri, T., Barnett, E., Valdero, T., Unipan, J., & Oskamp, S. (1992). Green buying: The influence of environmental concern on consumer buying. *Journal of Social Psychology, 137*, 189-204.

Mann, M., Bradley, R., & Hughes, M. (1998). Global-scale temperature patterns and climate forcings over the past six centuries. *Nature, 392*, 779-787.

Manzi, J. (2010, Winter). Keeping America's Edge. *National Affairs, 2*.

Marcell, K., Agyeman, J., & Rappaport, A. (2004). Cooling the campus: Experiences from pilot study to reduce electricity use at Tufts University, USA, using social marketing methods. *5* (2), 169-189.

Martinez, L. (2005). Post industrial revolution human activity and climate change: Why the United States must implement mandatory limits on industrial greenhouse gas emissions. *Journal of Land Use, 20*, 407-426.

Matthes, F. (1939). Report on committee on glaciers. *Transactions- American Geophysical Union, 20*, 518-523.

McCalley, L., & Midden, C. (2002). Energy conservation through product-integration feedback: The roles of goal-setting and social orientation. *Journal of Economic Psychology, 23* (5), 589-603.

McClelland, L. (1980). Promoting Energy Conservation in Master-Metered Apartmetns through Group Financial Incentives. *Journal of Applied Social Psychology, 10*, 20-31.

Michaelowa, A. (2003). Transaction costs of the Kyoto Mechanisms. *Climate Policy, 3*, 261-278.

Mohai, P., & Bryant, B. (1992). Environmental Injustice: Weighing race and class as factors in the distribution of environmental hazards. *University of Colorado, 63*, 921.

Montgomery, W. (1972). Markets in Licenses & Efficient Pollution Control Programs. *Journal of Economic Theory, 5*, 395-418.

National Research Council. (2006). *Surface temperature reconstructions for the last 2,000 years.* Washington, D.C.: The National Academies Press.

The Nature Conservatory (2011, July 17). *Take Action to Fight Climate Change - The Nature Conservatory*. Retrieved from The Nature Conservatory: http://www.nature.org/ourinitiatives/urgentissues/climatechange/help/

New Oxford Dictionary. (2012). *Definition for carbon-neutral*. Retrieved April 14, 2012, from Oxford Dictionaries Online (World English): http://oxforddictionaries.com/definition/carbon-neutral?q=carbon-neutral

New York State. (2012). *Recycling and Composting*. Retrieved April 23, 2012, from NY Department of Environmental Conservation: http://www.dec.ny.gov/chemical/294.html

Newsham, G., Mancini, S., & Birt, B. (2009). Do LEED-certified buildings save energy? Yes, but... *Energy and Buildings, 41*, 897-905.

Oak Ridge National Laboratory. (1999). *Transportation Energy Data Book: Edition 19.* Oak Ridge, TN: Center for Transportation Analysis Energy Division.

Osso, A., Walsh, T., Gotfried, D., & Simon, L. (1996). *Sustainable Building.* Portland: Public Technology Inc.

Parsons, T., & Shils, E. (1962). *Toward a General Theory of Action.* New York, NY: Harper & Row.

Petersen, J., Shunturov, V., Janda, K., Platt, G., & Weinberger, K. (2007). Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. *International Journal of Sustainability in Higher Education, 8*, 16-33.

Pigg, S., Eilers, M., & Reed, J. (1996). Behavioural aspects of lighting and occupancy sensors in private offices: a case study of a university office building. *ACEEE Summer Study on Energy Efficiency in Buildings.* Washington, DC.

Pollack, H., Huang, S., & Shen, P. (1998). Climate change in subsurface temperatures: A global perspective. *Science, 282*, 279-281.

Poulton, E. (1967). Searching for newspaper headlines printed in capitals or lower-case letters. *Journal of Applied Psychology, 51*, 417-425.

Raper, S. W. (1996). Global sea level rise: past and future. In J. &. Milliman (Ed.), *Sea Level Rise and Coastal subsidence: Causes, Consequences, and Strategies,* (pp. 11-45). Norwell, MA.: Kluwer Academic Publishers.

Rausch, S. M. (2010). Distributional Implications of Alternative U.S. Greenhouse Gas Control Measures. *The B.E. Journal of Economic Analysis & Policy, 10*.

Rausch, S., Metcalf, G., Reilly, J., & Paltsev, S. (2010). *Distributional implications of alternative U.S. greenhouse gas control measures.* Washington, D.C.: MIT Joint Program on Science and Policy of Global Change.

Rea, M. (2000). *The IESNA Lighting Handbook 9th Edition.* New York, NY: The Illumination Engineering Society of North America.

Reinhart, C., & Voss, K. (2003). Monitoring manual control of electric lighting and blinds. *Lighting Research and Technology, 35*, 243-260.

Renewable Choice Energy. (2012). *Green Power for LEED Buildings*. Retrieved 2012 30-June from Renewable Choice Energy: http://www.renewablechoice.com/green-power-for-leed.html

Reschovsky, J., & Stone, S. (1994). Market incentives to encourage household waste recycling: Paying for what you throw away. *Journal of Policy Analysis and Management, 13*, 120-139.

Revkin, A. (2010, May 12). *The American Power Act*. Retrieved April 9, 2012, from NYTimes.com: http://dotearth.blogs.nytimes.com/2010/05/12/the-american-power-act/

RGGI, Inc. (2012). *Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program*. Retrieved April 9, 2012, from RGGI, Inc: http://www.rggi.org/rggi

Roberts, J. (1993). Sex differences in socially responsible consumer's behavior. *Psychological Reports, 73*, 139-148.

Roethlisberger, F., & Dickerson, W. (1939). *Management and the worker.* Cambridge: Harvard University Press.

Salmon, F. (2008, October 20). *The Problem with Cap and Trade Offsets - Market Movers.* Retrieved April 9, 2012, from Portfolio.com: http://www.portfolio.com/views/blogs/market-movers/2008/10/20/the-problem-with-cap-and-trade-offsets

Schahn, J., & Holzer, E. (1990). Studies of individual environmental concern: The role of knowledge, gender, and background variables. *Environment and Behavior, 22*, 767-786.

Schipper, L., Bartlett, S., Hawk, D., & Vine, E. (1989). Linking life-styles and energy use: a matter of time? *Annual Review of Energy, 14*, 273-320.

Schmidt, J. (2010). *Comments on developed country monitoring, reporting & verfication and international assessment & review.* New York, NY: National Resources Defense Council.

Schultz, W. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. *Journal of Environmental Psychology*, 327-339.

Schultz, W., & Oskamp, S. (1996). Effort as a moderator of the attitude-behavior relationship: General environmental concern and recycling. *Social Psychology Quarterly, 59* (4), 375-383.

Schwartz, S. (1977). Normative influences on altruism. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology* (Vol. 10, pp. 221-279). New York, NY: Academic Press.

Schwartz, S., & Howard, J. (1981). A normative decision-making model of altruism. In J. Rushton, & R. Sorrention (Eds.), *Altruism and helping behavior: Social, personality and developmental Perspectives.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Seidel, D., & Lanzante, J. (2004). An assessment of three alternatives to linear trends for characterizing global atmospheric temperature changes. *Journal of Geophysical Research, 109*, D14108.

Seligman, C., & Darley, J. (1977). Feedback as means of decreasing residential energy consumption. *Journal of Applied Psychology, 62* (4), 363-368.

Skinner, W., & Majorowicz, J. (1999). Regional climatic warming and associated twentieth century land-cover changes in north-western North America. *Climate Research , 12*, 39-52.

Slavin, R., Wodanski, J., & Blackburn, B. (1981). A group contingency for electricity conservation in master-metered apartments. *Journal of Applied Behavior Analysis, 14* (3), 341-367.

Spada, H. (1990). Environmental consciousness: Attitudes and behavior. In *Ecological psychology:A handbook on keywords* (pp. 623-631). Weinheim: Psychologie Verlays Union.

Staats, H., Wit, A., & Midden, C. (1996). Communicating the green house effect to the public: Evaluation of a mass media campaign from a social dilemma perspective. *Journal of Environmental Managment, 45*, 189-203.

Starik, M. (1995). Should trees have managerial standing? Towards stakeholder status for non-human nature. *Journal of Business Ethics, 14* (3), 207-127.

Stern, P., & Dietz, T. (1994). The value basis of environmental concern. *Journal of Social Issues, 50* (3), 65-84.

Stern, P., & Gardner, G. (1981). Psychological research and energy policy. *American Psychologist, 36*, 329-342.

Stern, P., Dietz, T., & Kalof, L. (1993). Value orientations, gender, and environmental concern. *Environment and Behavior, 25*, 322-348.

TFS Green. (2012). *Voluntary Emissions Reductions*. Retrieved 2012 йил 30-June from TFS Green: http://www.tfsgreen.com/global-markets/voluntary-emissions-reductions/

The House of Commons Environmental Audit Committee. (2007). *The Voluntary Carbon Offset Market.* London: The Stationery Office Limited.

Thogersen. (2003). Monetary incentives and recycling: behavioural and psychological reactions a performance-dependent garbage fee. *Journal of Consumer Policy, 26*, 197-228.

Three-Regions Offset Working Group. (2010, May). *Ensuring Offset Quality: Design and Implementation Criteria for a High-Quality Offset Program.* Retrieved April 9, 2012, from RGGI.ORG: http://www.rggi.org/docs/Three_Regions_Offsets_Whitepaper_05_17_10.pdf

Torcellini, P., Deru, M., Griffith, B., Long, N., Pless, S., Judkoff, R., et al. (2004). Lessons Learned form Field Evaluation of six high-performing buildings. *ACEEE Summer Study* *on Energy Efficiency in Buildings.* Washington, D.C.: American Council for an Energy Efficient Economy.

Trenberth, K., Jones, P., Ambenje, P., Bojariu, R., Easterling, D., Klein Tank, A., et al. (2007). Observations: Surface and Atmospheric Climate Change. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. Averyt, et al. (Eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* New York, NY: Cambridge University Press.

Tung, C., Huang, C., & Kawata, C. (2002). The effects of different environmental education programs on the environmental behavior of seventh-grade students and related factors. *Journal of Environmental Health, 64*, 24-29.

U.S. Department of Energy. (2012). *Green Power Network: Greenhouse Gas (GHG) Offsets*. Retrieved April 9, 2012, from Energy Efficiency & Renewable Energy: http://apps3.eere.energy.gov/greenpower/markets/carbon.shtml

U.S. Energy Information Administration. (2011). *Annual Energy Review 2012.* Pittsburgh: U.S. Government Printing Office.

U.S. Energy Information Administration. (2012). *How much electricity is used for lighting in the United States?* Retrieved 4 12, 2012, from FAQ-U.S. Energy Information: http://www.eia.gov/tools/faqs/faq.cfm?id=99&t=3

U.S. Green Building Council. (2009). *LEED 2009 For New Construction.* Washington, D.C.: U.S. Green Building Council.

U.S. Green Building Council. (2011). *USGBC: U.S. Green Building Council*. Retrieved April 14, 2012, from U.S. Green Building Council: http://www.usgbc.org/

U.S. Green Buidling Council. (2012). *LEED Rating System Development*. Retrieved April 9, 2012, from USGBC.org: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2360

U.S. Green Building Council. (2012 (a)). *How to achieve certification*. Retrieved April 9, 2012, from USGBC.org: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1991

U.S. Green Building Council. (2012 (b)). *Rating Systems*. Retrieved 9 2012, April, from USGBC.org: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222

U.S. Green Building Council. (2012(c)). *What LEED Is*. Retrieved April 9, 2012, from USGBC.org: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1988

U.S. Green Building Council. (2012 (d)). *What LEED Measures*. Retrieved April 9, 2012, from USBGC.org: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1989

UNFCCC. (2010, May 6). *Registry systems under the Kyoto Protocol*. Retrieved July 17, 2011, from UNFCCC: http://unfccc.int/kyoto_protocol/registry_systems/items/2723.php

UNFCCC. (2011, July 17). *CDM: About CDM*. Retrieved from UNFCCC: http://cdm.unfccc.int/about/index.html

UNFCCC. (2011, July 17(a)). *Fact sheet: The Kyoto Protocol*. Retrieved from UNFCCC: http://unfccc.int/press/fact_sheets/items/4977.php

UNFCCC. (2011, July 17(b)). *Introduction to the UNFCCC and its Kyoto Protocol*. Retrieved from UNFCCC: http://unfccc.int/press/fact_sheets/items/4978.php

UNFCCC. (2011, July 17(c)). *Joint implementation*. Retrieved from UNFCCC: http://unfccc.int/kyoto_protocol/mechanisms/joint_implementation/items/1674.php

UNFCCC. (2011, July 17(d)). *UNFCCC*. Retrieved from The United Nations Framework Convention on Climate Change: http://unfccc.int/essential_background/convention/items/2627.php

UNFCCC. (2011, July 22). *Kyoto Protocol*. Retrieved from UNFCCC: http://unfccc.int/kyoto_protocol/items/2830.php

UNFCCC. (2011, July 22(a)). *Methodological issues, reporting and review under the Kyoto Protocol*. Retrieved from UNFCCC: http://unfccc.int/national_reports/accoutning_reporting_and review_under_the_kyoto_protocol/items/1029.php

UNFCCC. (2011, July 22(b)). *Registry systems under the Kyoto Protocol*. Retrieved from UNFCCC: http://unfccc.int/kyoto_protocol/registry_systems/items/2723.php

UNFCCC. (2011, July 23). *Feeling the Heat*. Retrieved from UNFCCC: http://unfccc.int/essential_background/feeling_the_heat/items/2906.php

United Nations. (1998). *Kyoto Protoco to the United Nations Framework Convention on climate change.* New York: UNFCCC.

Van Bommel, W. (2006). Non-visual biological effect of lighting and the practical meaning for lighting at work. *Applied Ergonomics, 37*, 461-466.

van Houwelingen, J., & Van Raaij, F. (1989). The effect of goal-setting and daily electric feedback on in-home energy use. *Journal of Consumer Research, 16*, 98-105.

van Raaij, F., & Verhallen, T. (1983). A behavioral model of residential energy use. *Journal of Economic Psychology, 3*, 39-63.

Van Raaij, W., & Verhallen, T. (1983). A behavioral model of residential energy use. *Journal of Economic Psychology, 3* (1), 39-63.

Vermaas, W. (1998, March). An introduction to photosynthesis and its applications. *The World & I*, pp. 158-165.

Ward, P., & Brownlee, D. (2000). *Rare earth: why complex life is uncommon in the universe.* New York, New York: Copernicus Books.

Waxman, H. A. (2009, July 23). *Bill Summary & Status - 111th Congress (2009-2010) - H.R.2998*. Retrieved April 9, 2012, from The Library of Congress Thomas: http://thomas.loc.gov/cgi-bin/bdquery/z?d111:hr2998:

Webster, M., Paltev, S., & Reilly, J. (2010). The hedge value of international emissions trading under uncertainty. *Energy Policy, 38*, 1787-1796.

Weigel, R. (1983). Environmental attitudes and the prediction of behavior. In N. Feimer, & E. Geller (Eds.), *Environmental Psychology* (pp. 257-287). New York, NY: Praeger.

Weigel, R., & J., W. (1978). Environmental Concern: The development of a measure. *Environment and Behavior, 10*, 3-15.

Weiss, D. (2010, May 12). *American Power Act Empowers Americans.* Retrieved April 9, 2012, from Center for American Progress: http://www.americanprogress.org/issues/2010/05/american_power.html

Widegren, O. (1988). The new enviornmental paradigm and personal norms. *Environment and Behaviors, 30*, 75-100.

Wigley, T. (1995). Global-mean temperature and sea level consequences of greenhouse gas concentration stabilization. *Geophyscial Research Letters, 22*, 45-48.

Winett, R., & Kagel, J. (1984). Effects of information present format on resource energy use. *Journal of Economic Psychology, 3* (1), 39-63.

Winett, R., & Neale, M. (1979). Psychological framework for energy conservation in buildings: strategies, outcomes, directions. *Energy and Buildings, 2* (2), 101-116.

Winett, R., Kagel, J., Battalio, R., & Winkler, R. (1978). Effects of monetary rebates, feedback and information on residential electricity conservation. *Journal of Applied Psychology, 63* (1), 73-80.

Winett, R., Neale, M., & Grier, H. (1979). Effects of self-monitoring and feedback on residential electricity. *Journal of Applied Behavior Analysis, 12*, 173-184.

Winett. R., L. S., & Kidd, C. (1982-1983). The effectiveness of an energy specialist and extension agents in promoting summer energy conservation by home visits. *Journal of Environmental Systems, 12*, 61-70.

Wlliams, M., Thyer, B., Bailey, J., & Harrison, D. (1989). Promoting safety belt use with traffic signs and prompters. *Journal of Applied Behavioral Anaylsis, 22*, 71-76.

APPENDICES

APPENDIX A

Alice H. Cook House LEED Certification

LEED-NC

West Campus Residential Initiative Phase One
LEED® Project #0897
LEED Version 2 Certification Level: CERTIFIED
May 26, 2005

26 Points Achieved — Possible Points: 69

Certified 26 to 32 points Silver 33 to 38 points Gold 39 to 51 points Platinum 52 or more points

6 Sustainable Sites — Possible Points: 14

Y			
Y	Prereq 1	**Erosion & Sedimentation Control**	
1	Credit 1	**Site Selection**	1
	Credit 2	**Urban Redevelopment**	1
	Credit 3	**Brownfield Redevelopment**	1
1	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
1	Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations	1
	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
	Credit 6.2	**Stormwater Management**, Treatment	1
1	Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
1	Credit 8	**Light Pollution Reduction**	1

2 Water Efficiency — Possible Points: 5

Y			
1	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
1	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
	Credit 2	**Innovative Wastewater Technologies**	1
	Credit 3.1	**Water Use Reduction**, 20% Reduction	1
	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

2 Energy & Atmosphere — Possible Points: 17

Y			
Y	Prereq 1	**Fundamental Building Systems Commissioning**	
Y	Prereq 2	**Minimum Energy Performance**	
Y	Prereq 3	**CFC Reduction in HVAC&R Equipment**	
	Credit 1.1	**Optimize Energy Performance**, 20% New / 10% Existing	2
	Credit 1.2	**Optimize Energy Performance**, 30% New / 20% Existing	2
	Credit 1.3	**Optimize Energy Performance**, 40% New / 30% Existing	2
	Credit 1.4	**Optimize Energy Performance**, 50% New / 40% Existing	2
	Credit 1.5	**Optimize Energy Performance**, 60% New / 50% Existing	2
	Credit 2.1	**Renewable Energy**, 5%	1
	Credit 2.2	**Renewable Energy**, 10%	1
	Credit 2.3	**Renewable Energy**, 20%	1
1	Credit 3	**Additional Commissioning**	1
1	Credit 4	**Ozone Depletion**	1
	Credit 5	**Measurement & Verification**	1
	Credit 6	**Green Power**	1

5 Materials & Resources — Possible Points: 13

Y			
Y	Prereq 1	**Storage & Collection of Recyclables**	
	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Shell	1
	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	**Construction Waste Management**, Divert 50%	1
	Credit 2.2	**Construction Waste Management**, Divert 75%	1
	Credit 3.1	**Resource Reuse**, Specify 5%	1
	Credit 3.2	**Resource Reuse**, Specify 10%	1
1	Credit 4.1	**Recycled Content**	1
	Credit 4.2	**Recycled Content**	1
1	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
1	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
	Credit 6	**Rapidly Renewable Materials**	1
1	Credit 7	**Certified Wood**	1

7 Indoor Environmental Quality — Possible Points: 15

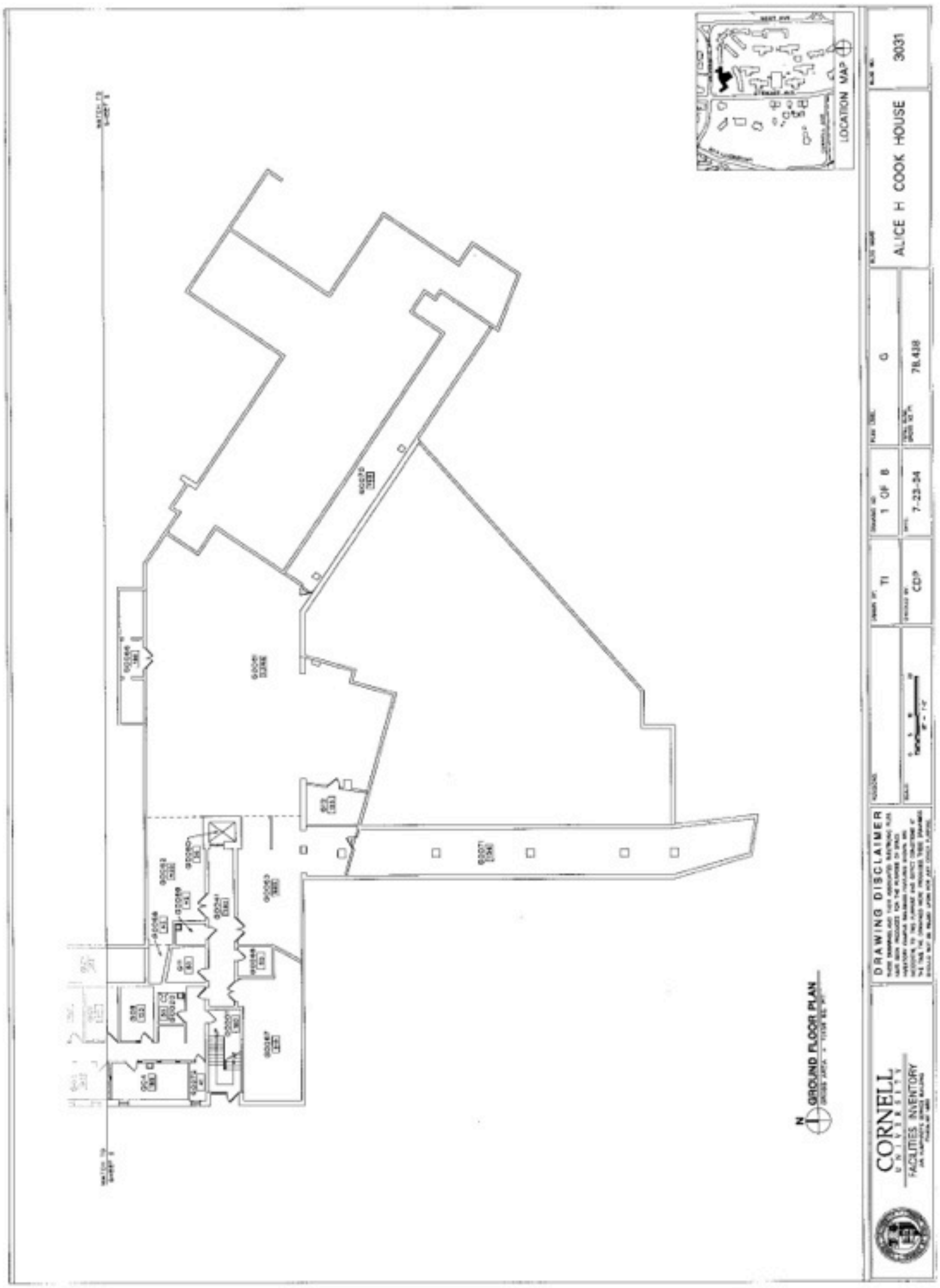
Y			
Y	Prereq 1	**Minimum IAQ Performance**	
Y	Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	
	Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
	Credit 2	**Increase Ventilation Effectiveness**	1
1	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1	Credit 4.2	**Low-Emitting Materials**, Paints	1
1	Credit 4.3	**Low-Emitting Materials**, Carpet	1
	Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
	Credit 6.1	**Controllability of Systems**, Perimeter	1
	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
1	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

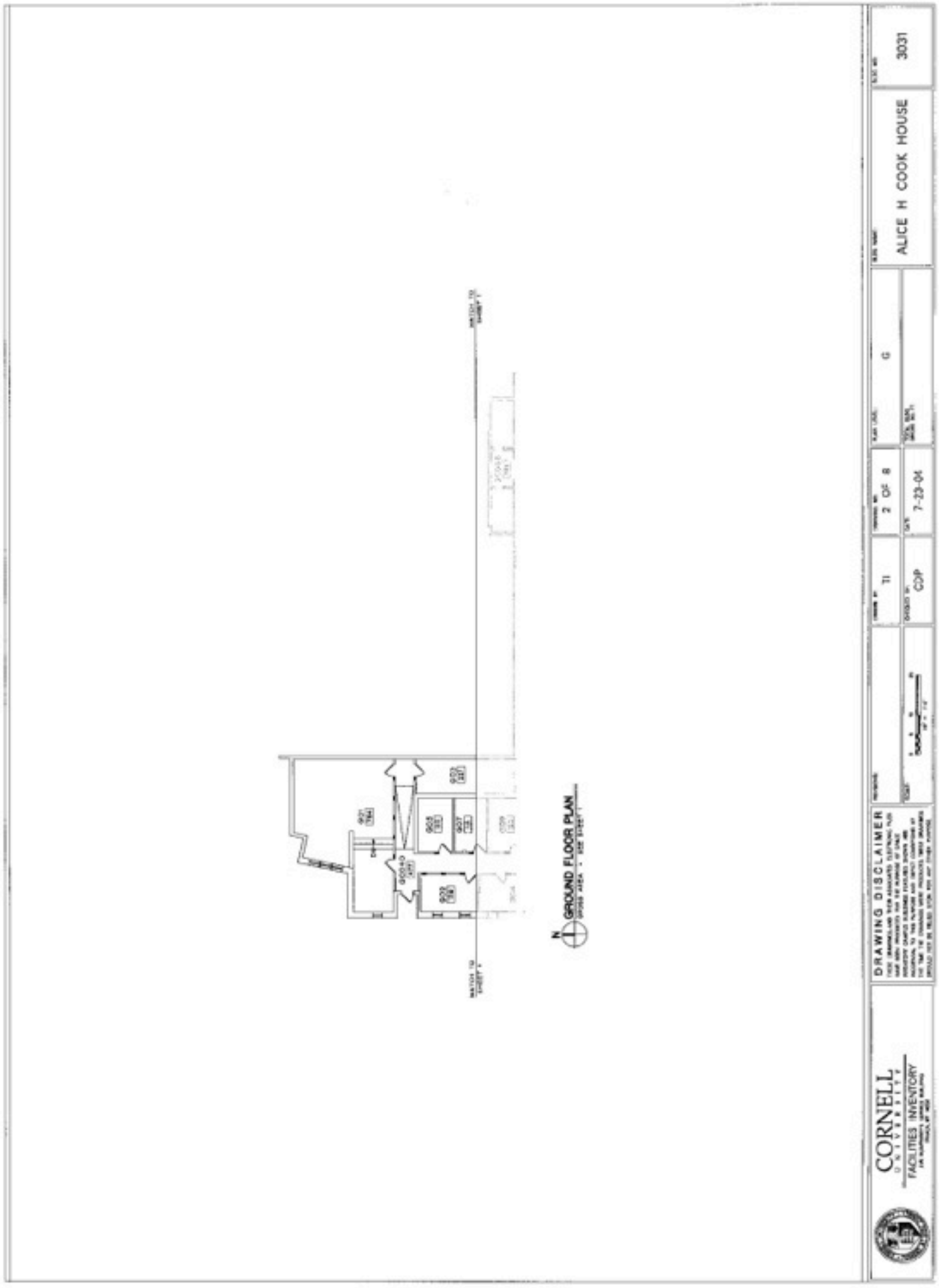
4 Innovation & Design Process — Possible Points: 5

Y			
1	Credit 1.1	**Innovation in Design**: Sustainability Education	1
1	Credit 1.2	**Innovation in Design**: Green Housekeeping Program	1
1	Credit 1.3	**Innovation in Design**: Lake Source Cooling	1
	Credit 1.4	**Innovation in Design**:	1
1	Credit 2	**LEED® Accredited Professional**	1

APPENDIX B

LEED Building (Alice H. Cook House) Floor Plans




GROUND FLOOR PLAN
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ALICE H COOK HOUSE
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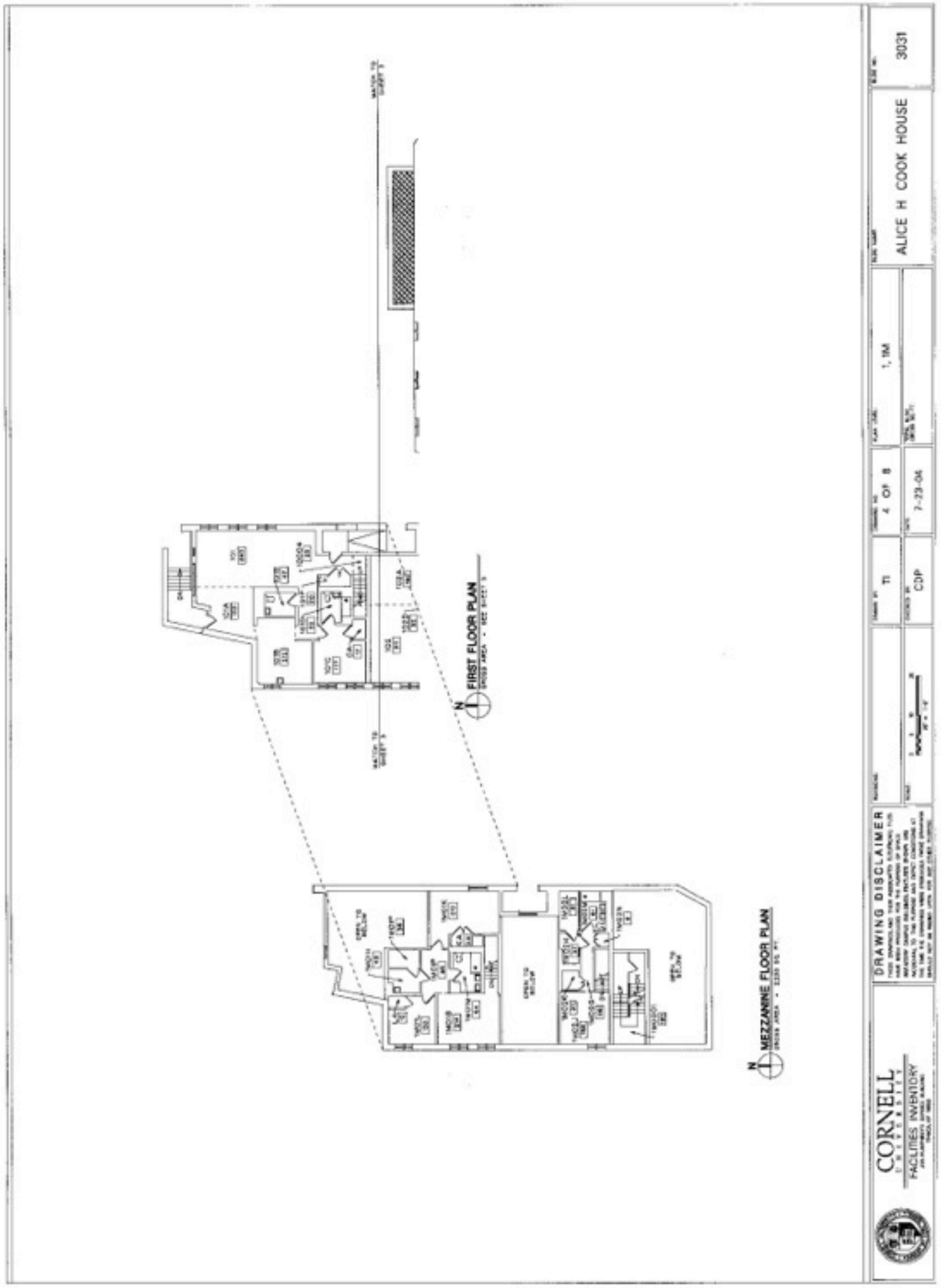
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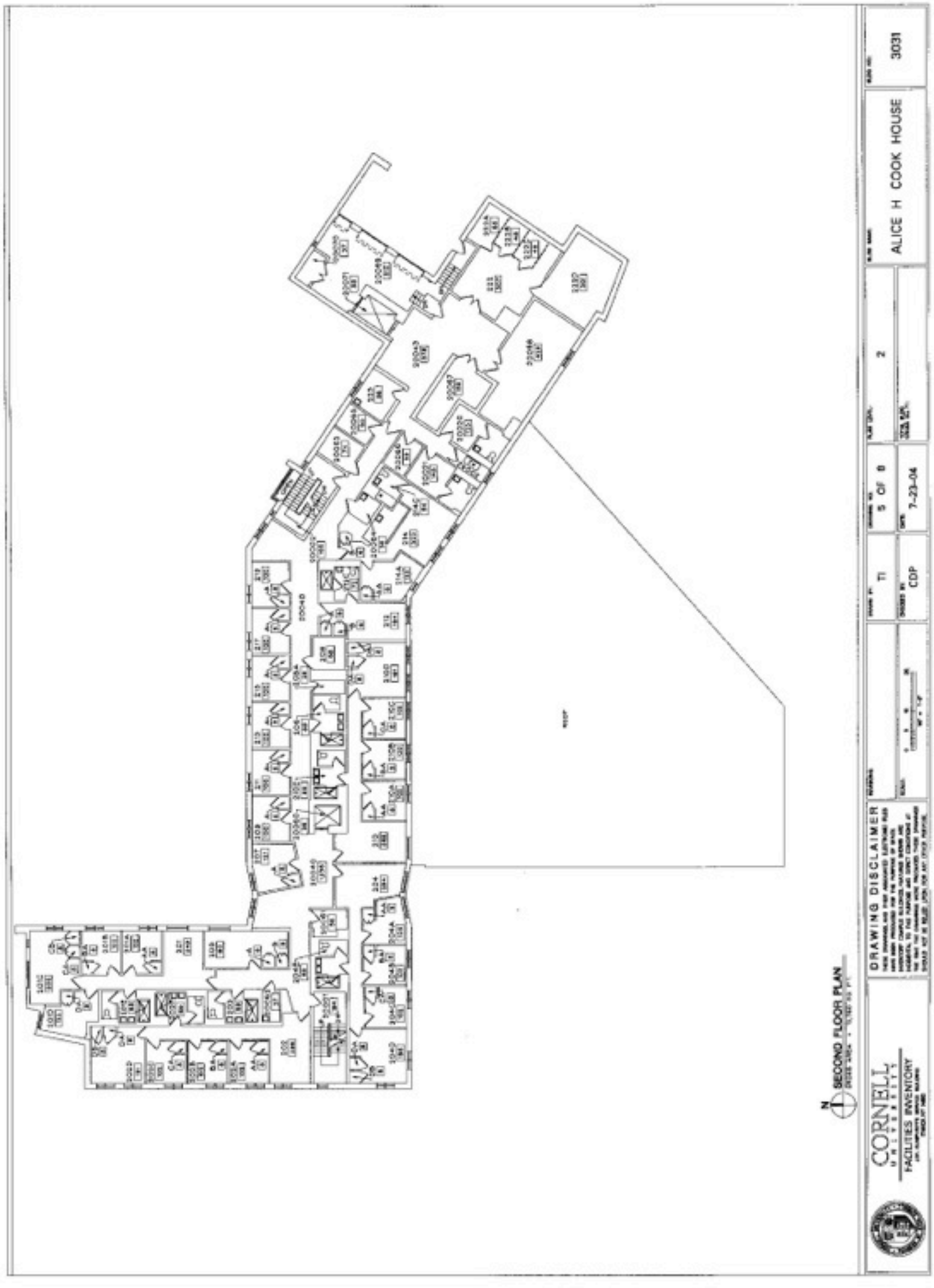
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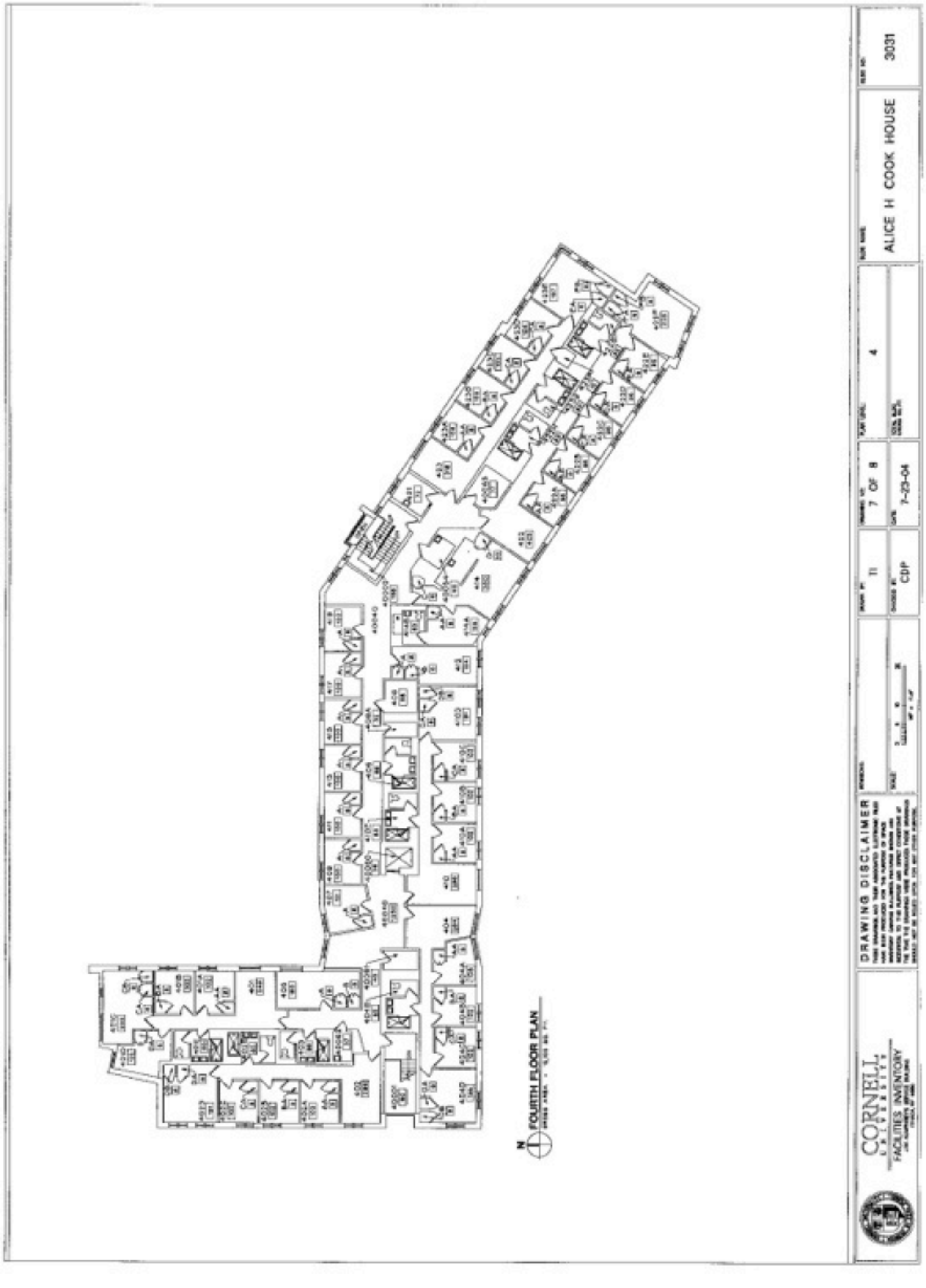
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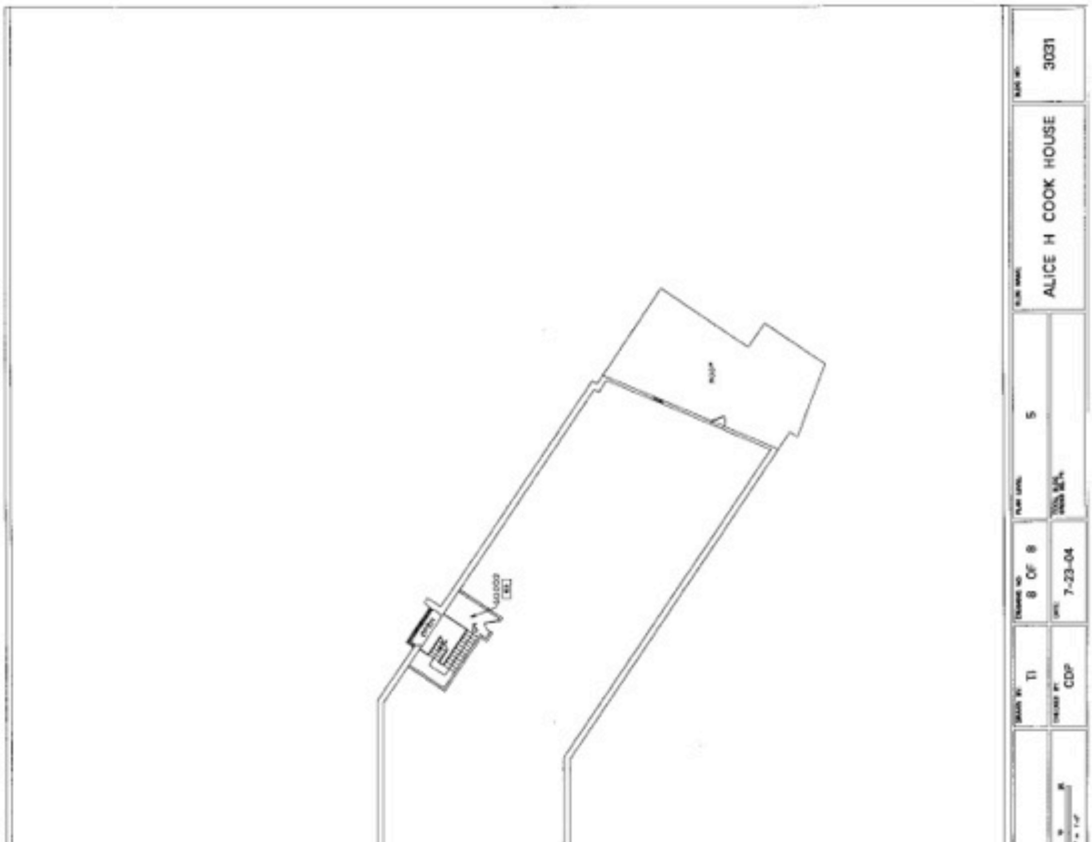
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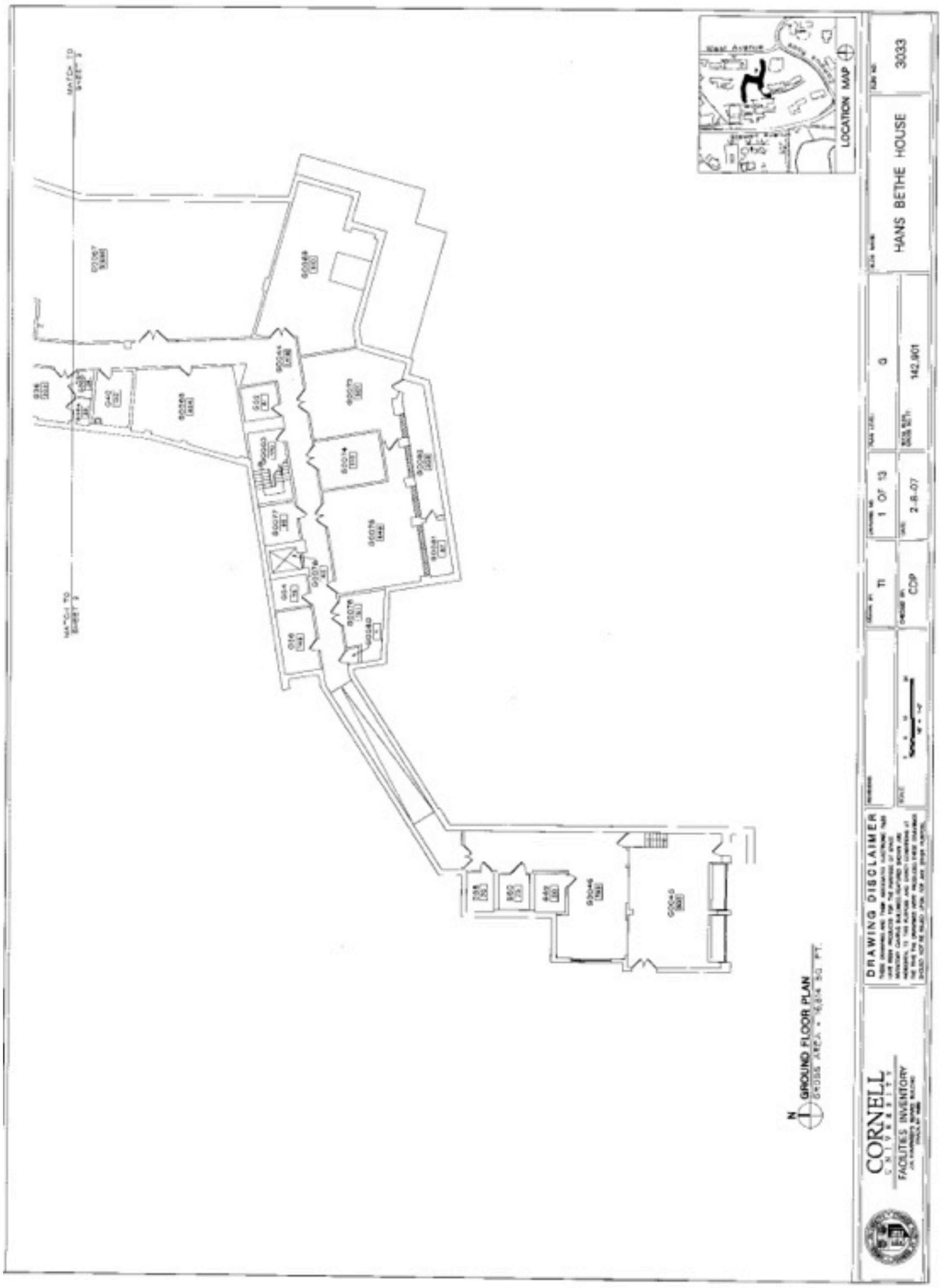
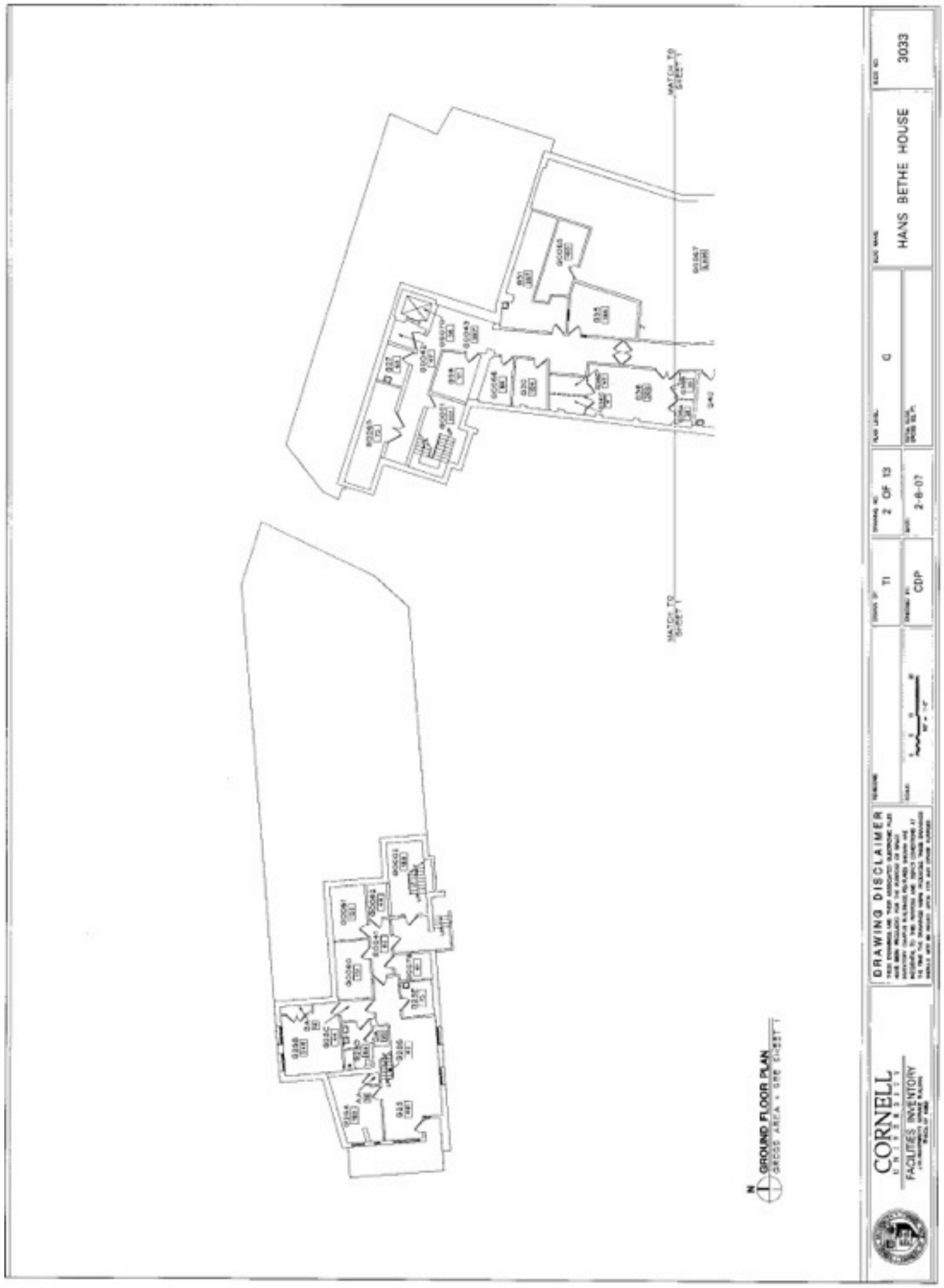
FIFTH FLOOR PLAN

APPENDIX C

Non-LEED Building (Hans Bethe House) Floor Plans

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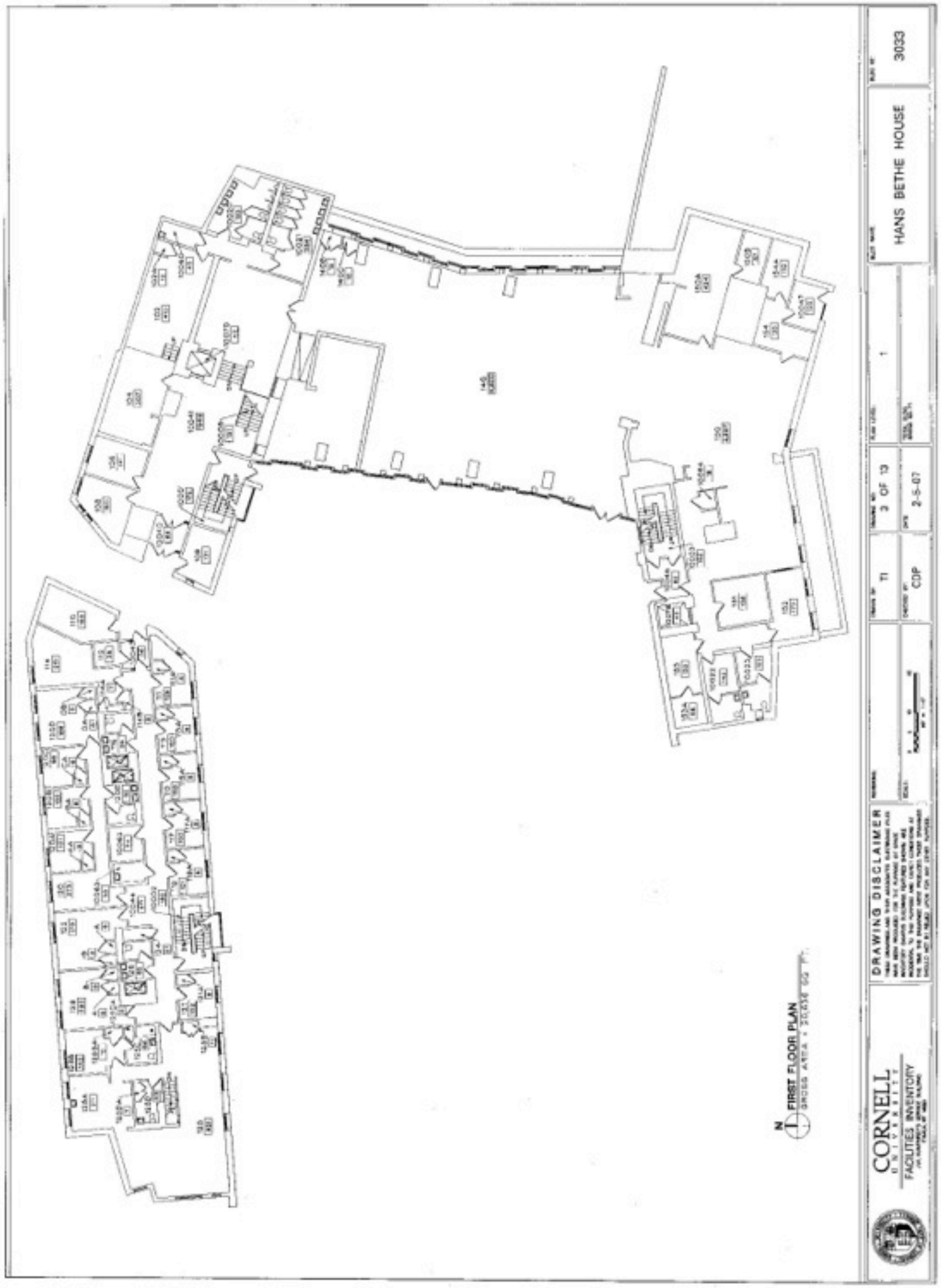

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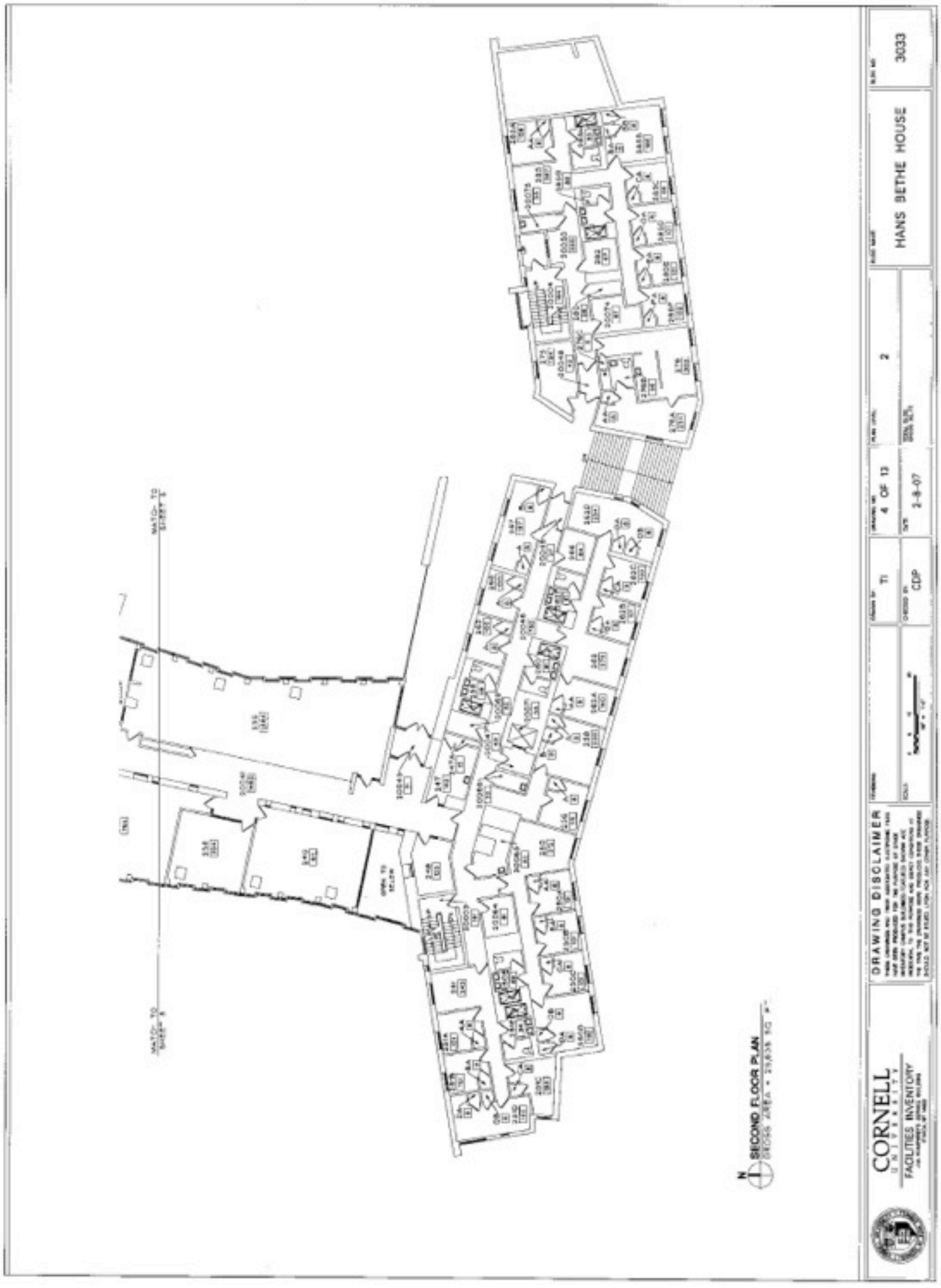
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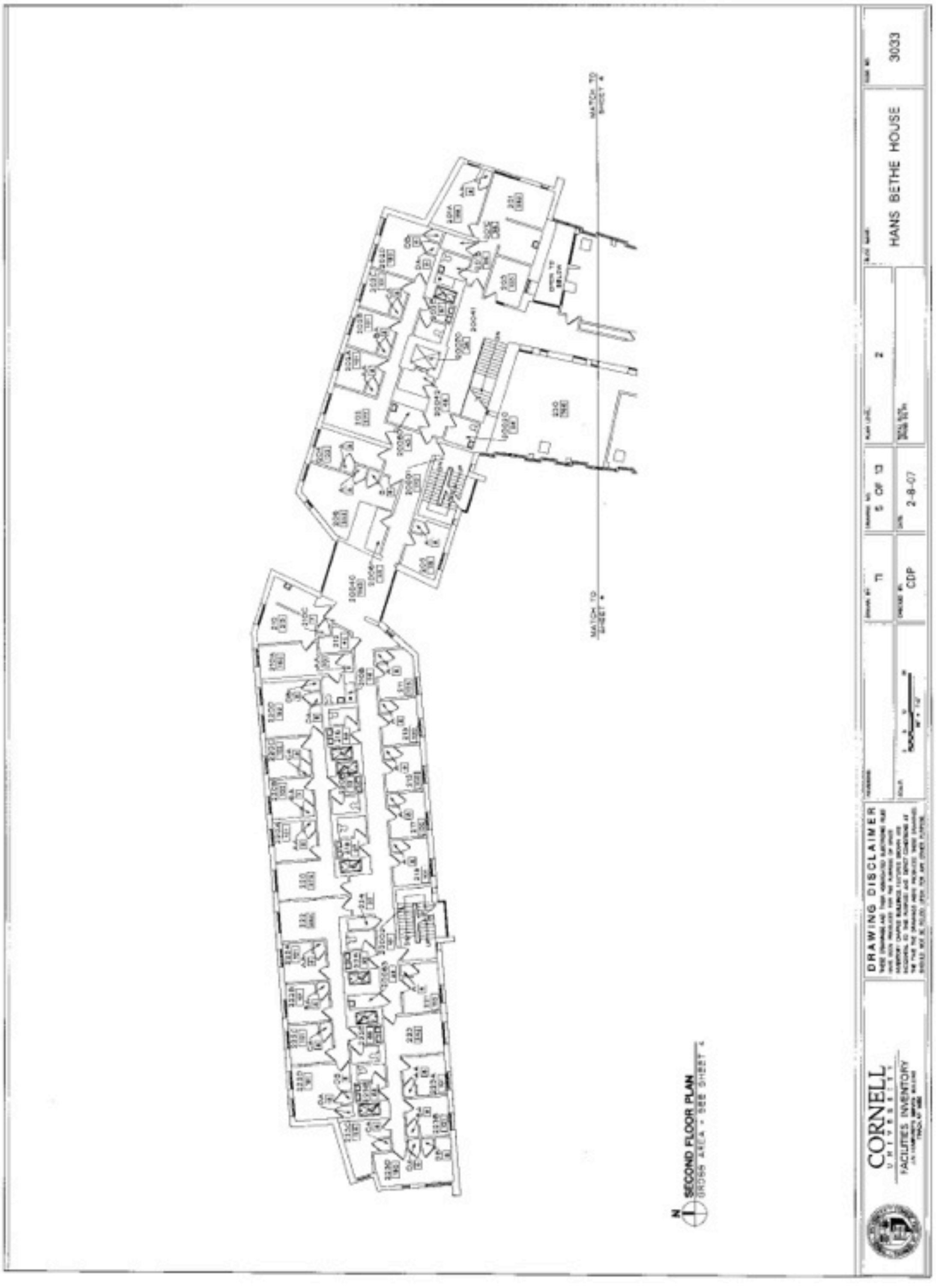
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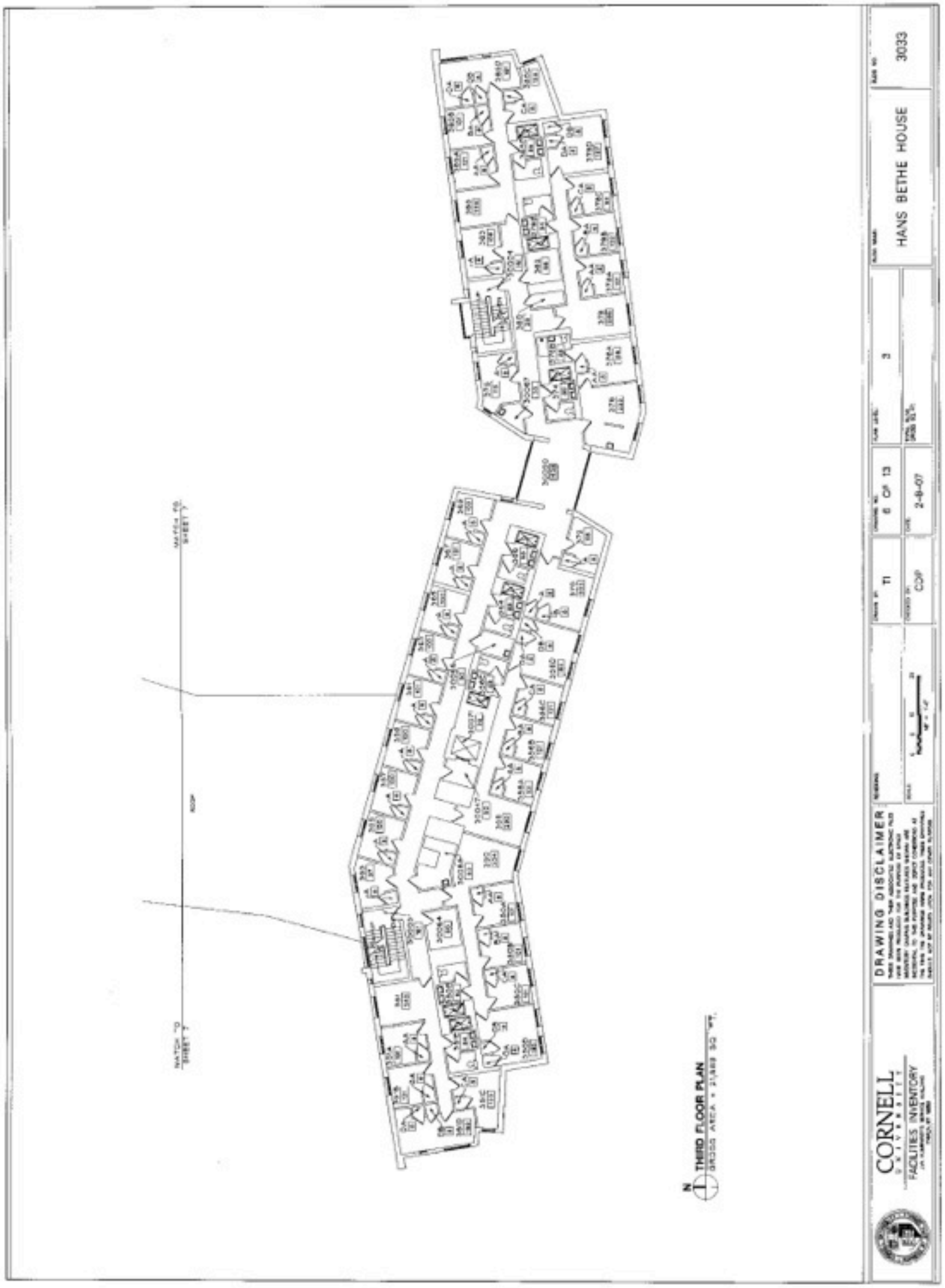
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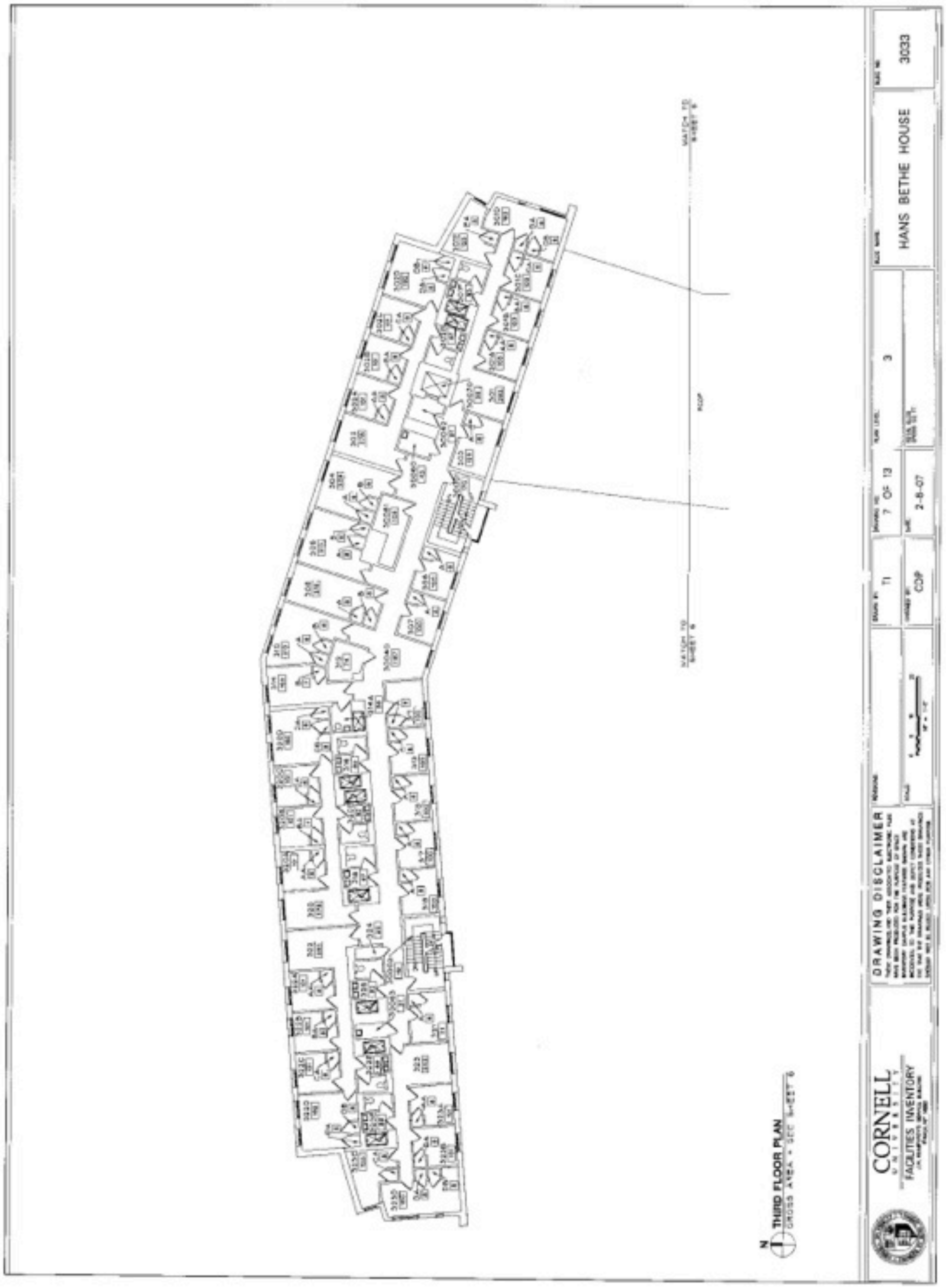
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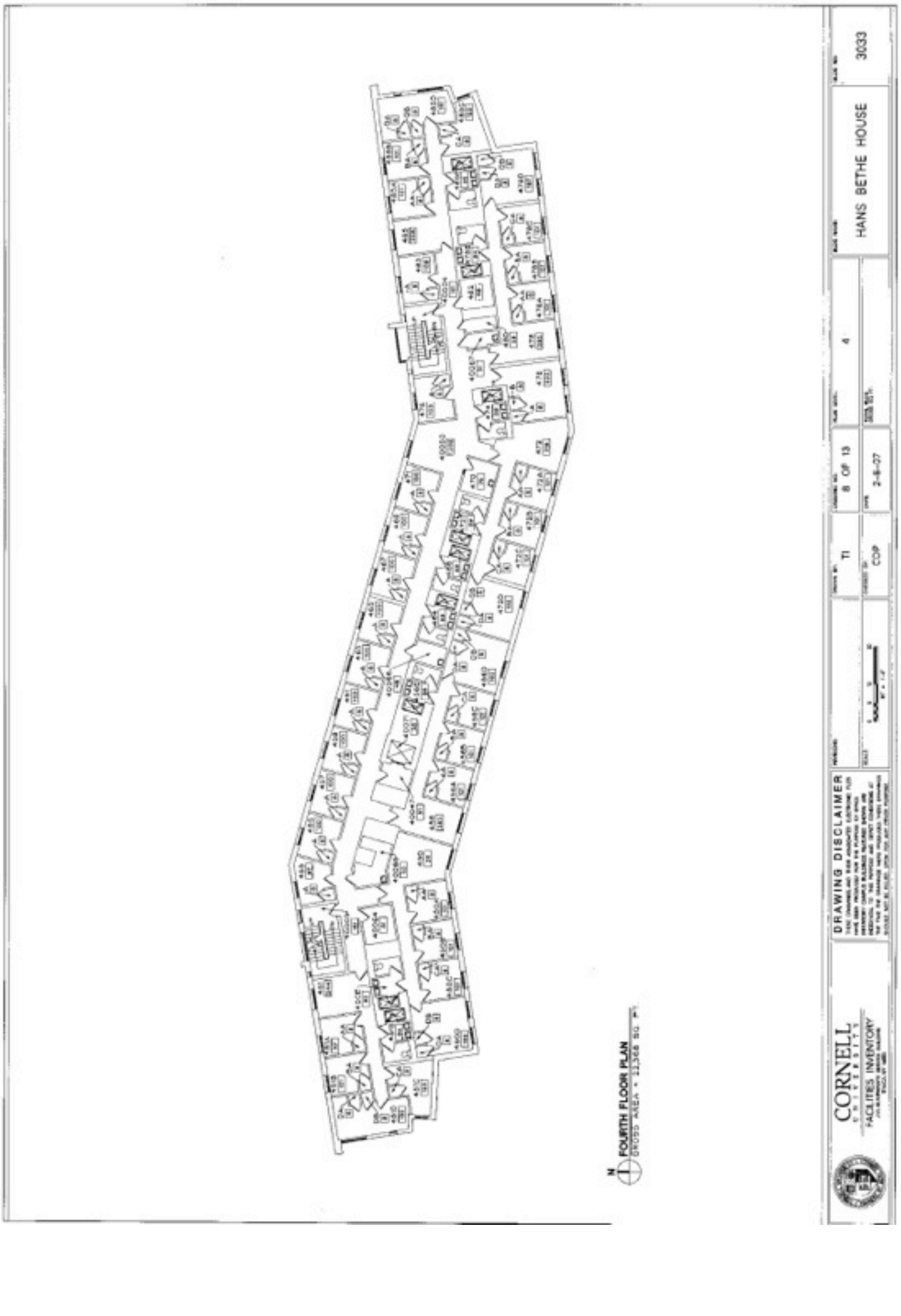
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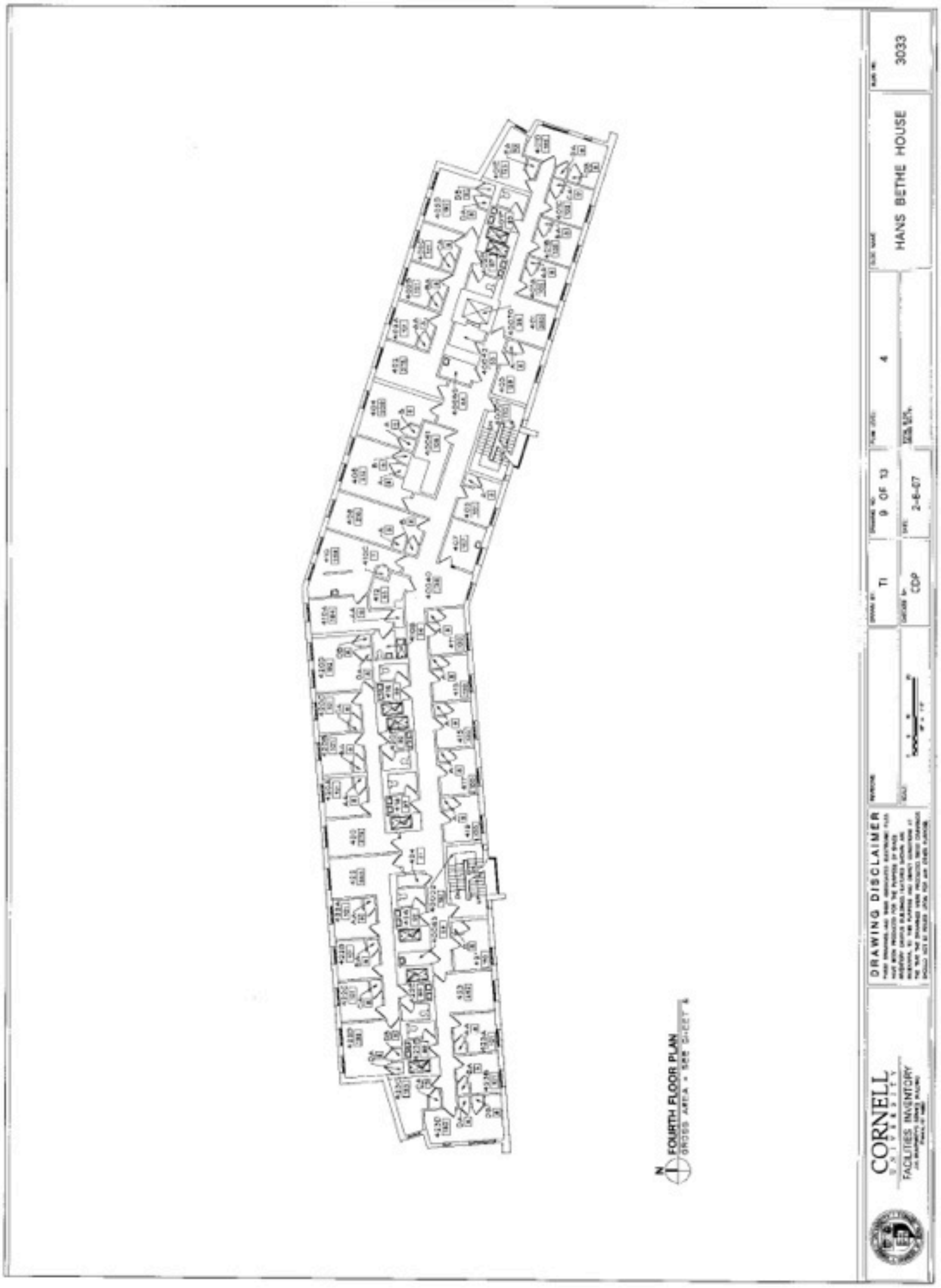
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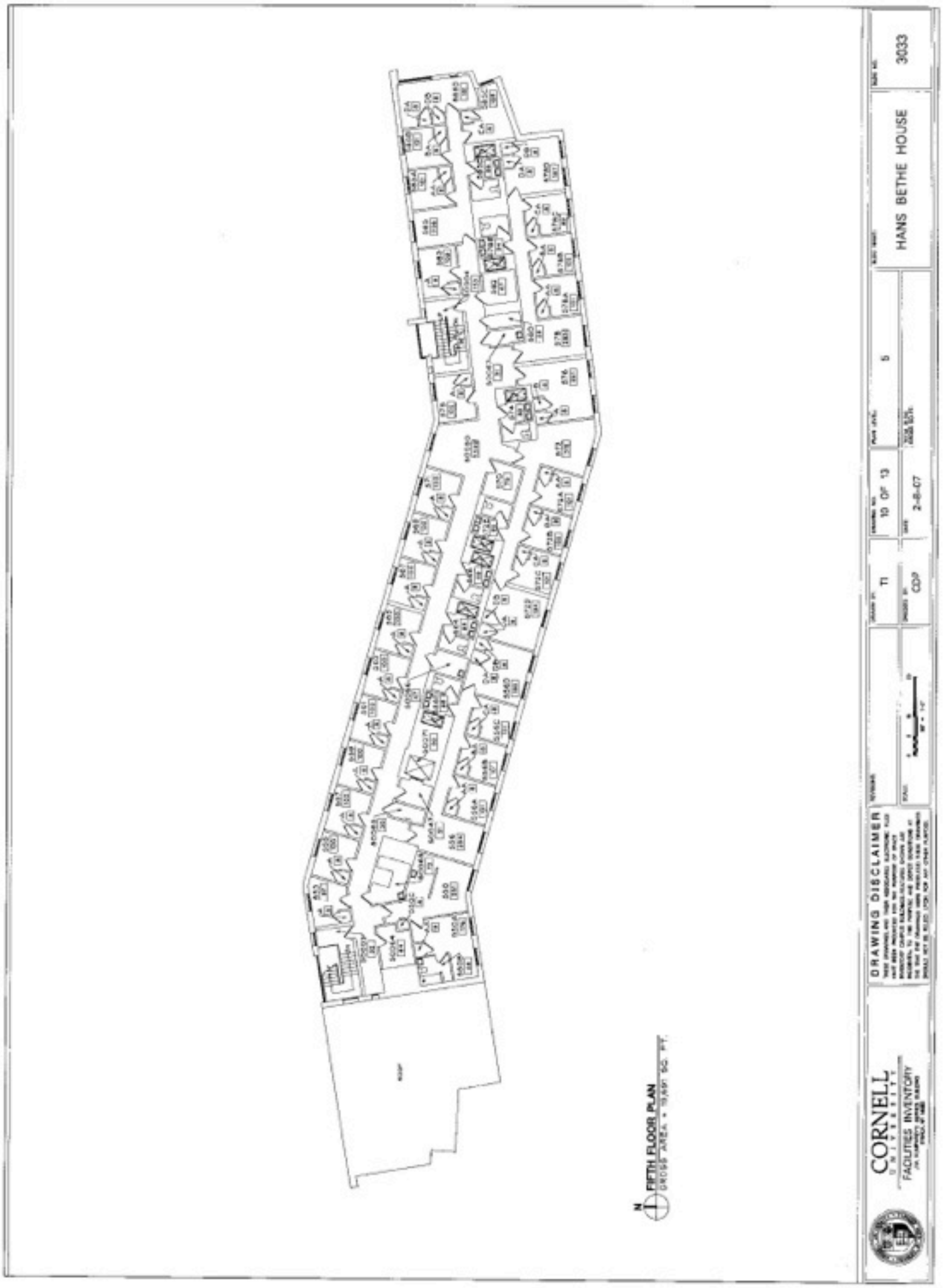
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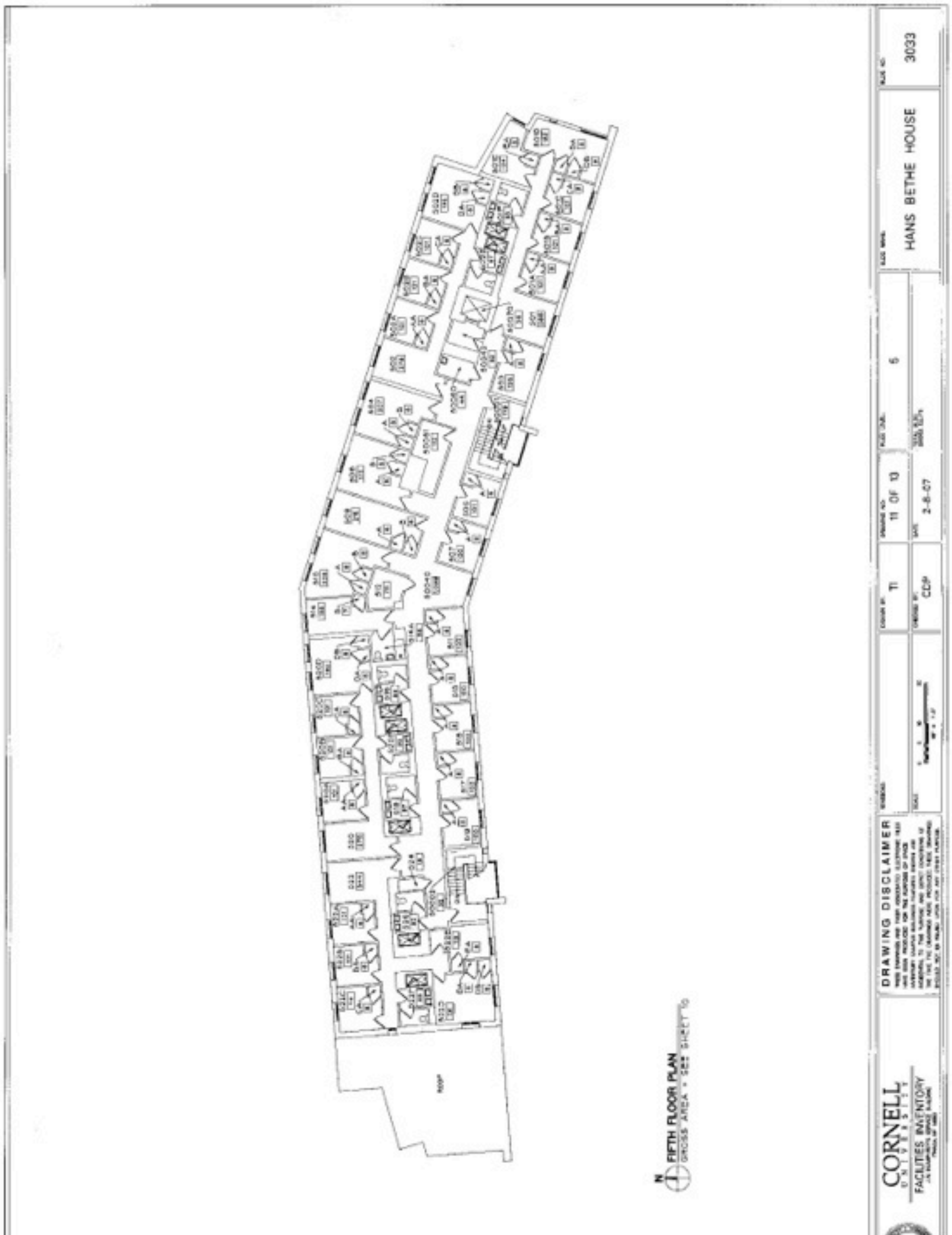
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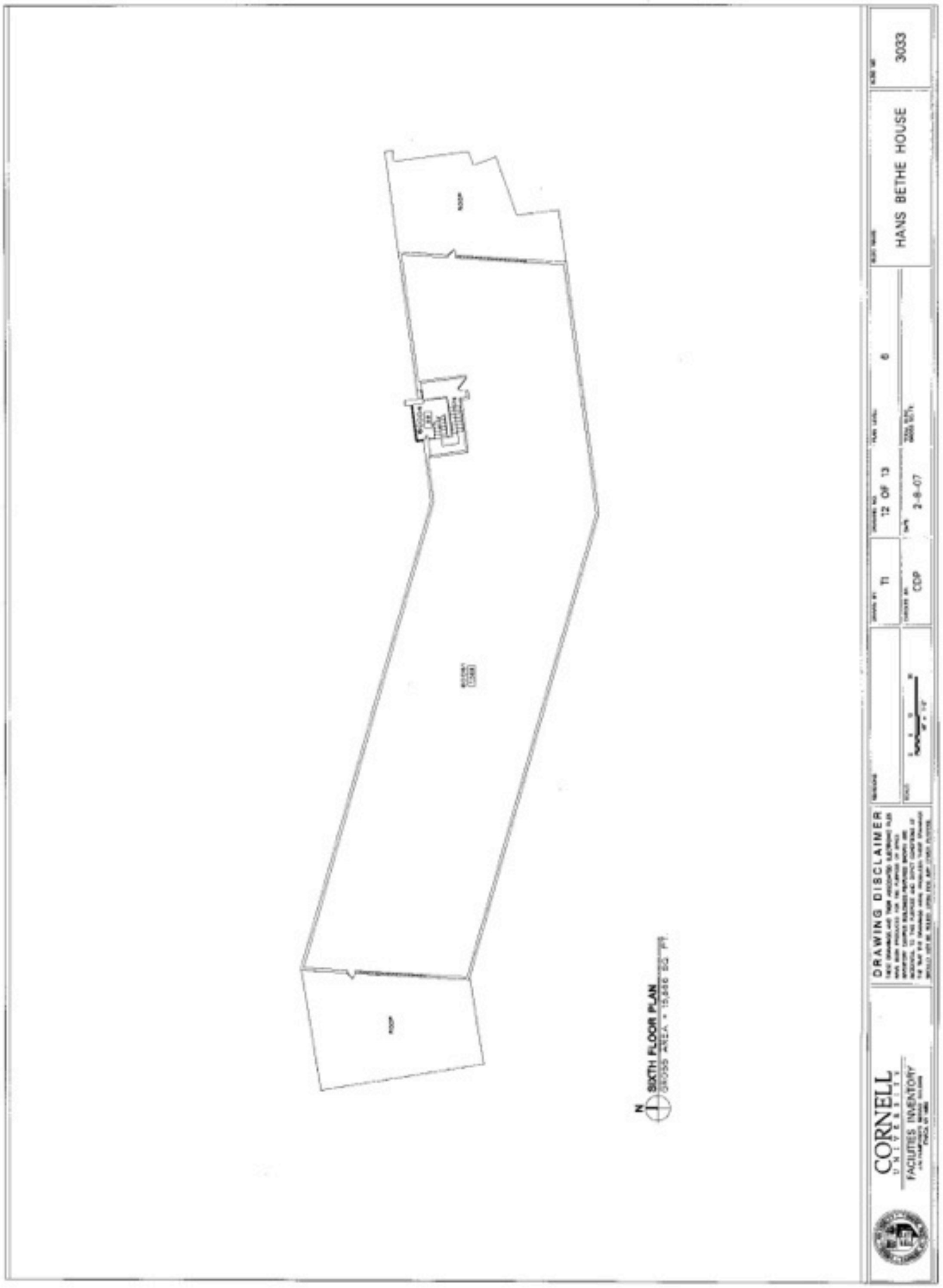

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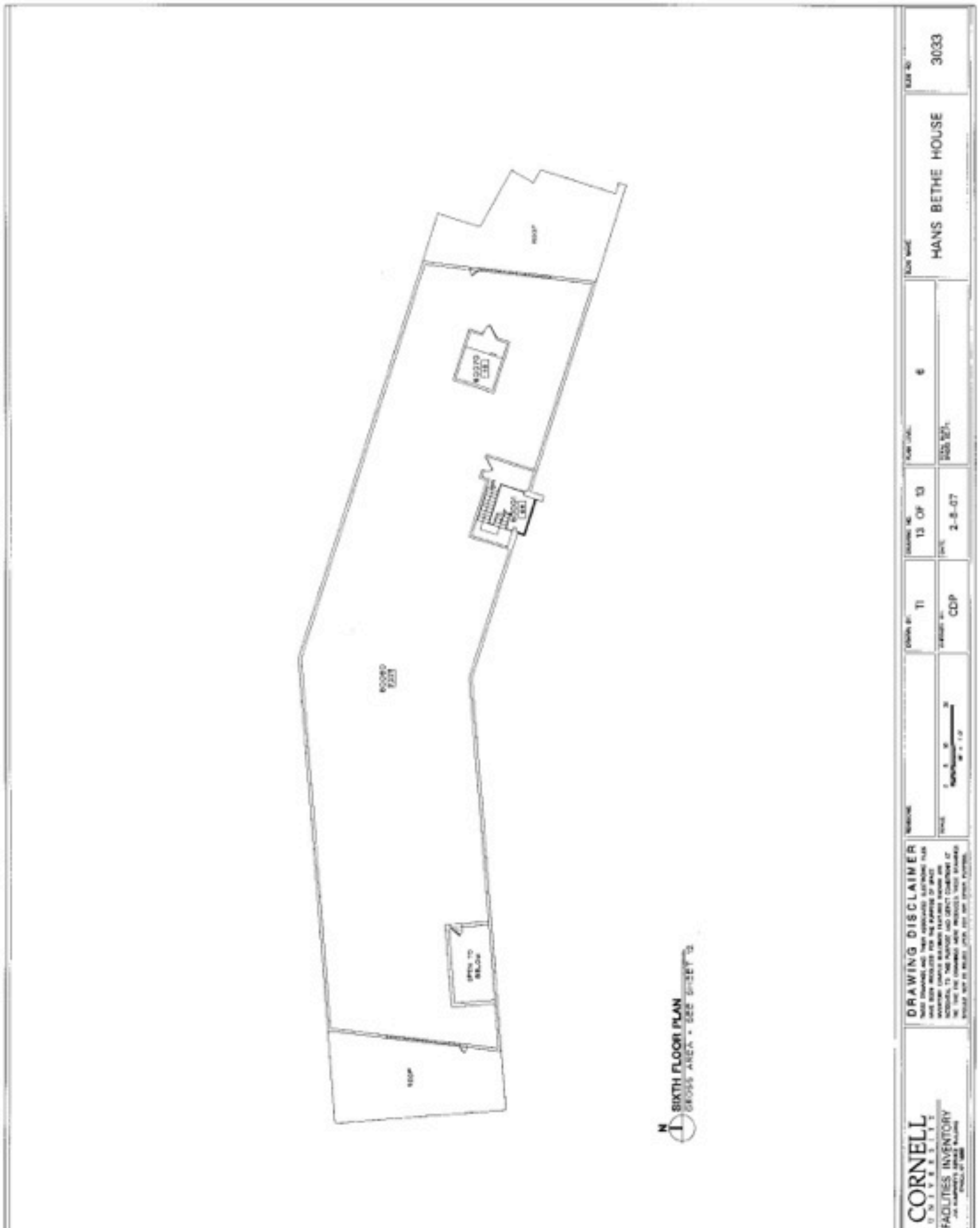

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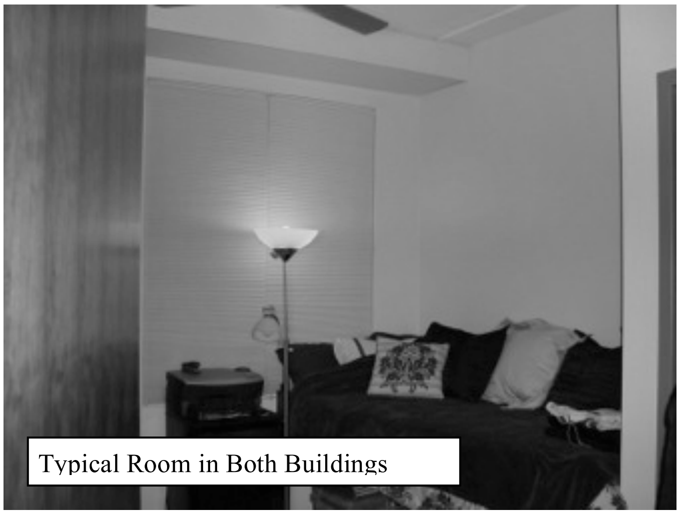
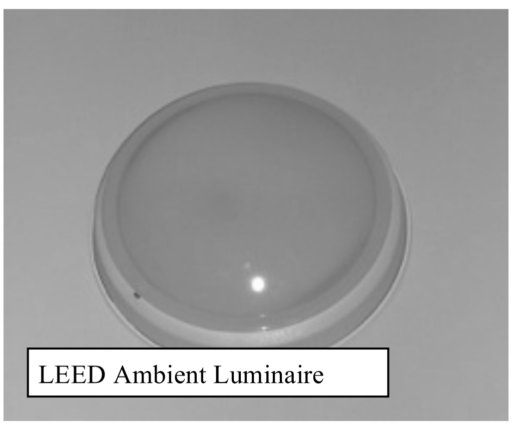
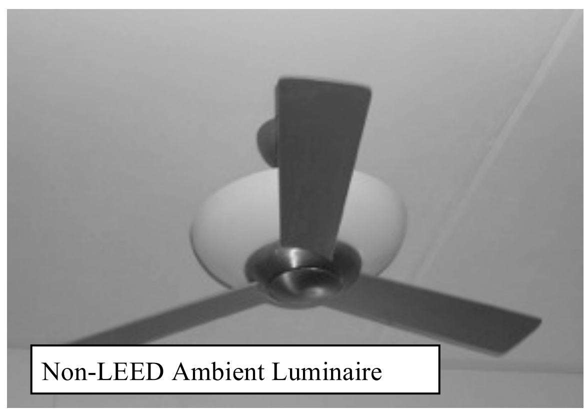
APPENDIX D

TYPICAL PARTICIPANT ROOM AND LUMINAIRES


Typical Room in Both Buildings


Windows in Both Buildings


LEED Ambient Luminaire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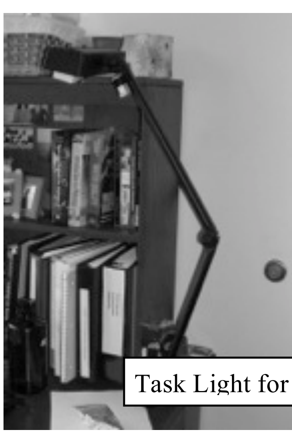
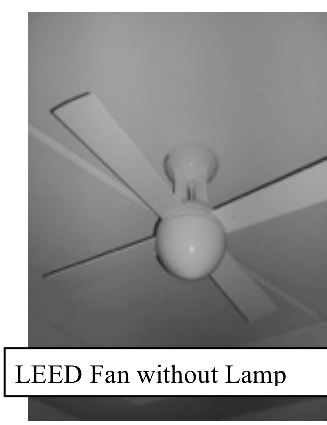


Task Light for Both Buildings


LEED Fan without Lamp

APPENDIX E

Letter to Recruit Participants

Cornell University
College of Human Ecology
Design and Environmental Analysis

Kelly Wilson
M.S. Candidate
E. Martha Van Rensselaer Hall
Ithaca, NY 14853
E-mail: kc292@cornell.edu

November 20, 2007

«First_Name» «Last_Name»
Cornell University
«Room» «House»
Ithaca, NY 14853

Dear «First_Name»:

Congratulations! You are eligible to participate in a spring semester dormitory lighting study. A small number of students from the «House» are eligible and compensation will be given to participants who complete the study. I have included the answers to some common questions you may have about the study.

1. What is the objective of the study?
   - Measuring Lighting Levels in Dormitories.
2. Where will the study take place?
   - In your room.
3. When will the study take place?
   - You will be chosen for one of two following data collection periods: Jan. 26 – Feb. 9 or Feb. 16 – Mar. 2
4. What is my time commitment during the data collection period?
   - 15 minute session on day 1 -You only need to be present during this time.
   - 15 minute session on day 8 -You only need to be present during this time.
   - 30 minute session on day 15 -You will be asked to fill out a survey during this time.
5. If I participate how much will I be compensated for my time?
   - $10 or extra credit through the Cornell University SUSAN extra credit system http://susan.psych.cornell.edu/about2.php (you don't have to chose right now)
6. Who do I contact to participate or if I have questions about the study?
   - Email me (Kelly) at kc292@cornell.edu.

You will receive a copy of this information in the mail next week. «House_Dean» and I hope that you can find the time to participate in this research, and I look forward to hearing from you.

Sincerely,

Kelly Wilson
Kc292@cornell.edu

APPENDIX F

Copy of IRB Exemption Letter

Cornell University
Office of Research Integrity
and Assurance

Institutional Review Board
for Human Participants
35 Thornwood Drive, Suite 500
Ithaca, New York 14850-1285
t. 607.255.5138
f. 607.255.0758
uchs@cornell.edu
www.oria.cornell.edu

NOTIFICATION OF EXEMPT CLASSIFICATION

Protocol ID# 07-02-065

To: Kelly Wilson

From: Sarah J. Demo, UCHS Coordinator Sarah J. Demo

Date of approval: March 5, 2007 (If you are using a consent form, enter this date at the bottom of it now.)

Project(s): ***Electrical Consumption Habits and Attitudes of Occupants in LEED Certified Buildings***

As Coordinator of the University Committee on Human Subjects, I have reviewed the above referenced project and it is Exempt from the Federal Regulation for the Protection of Human Subjects (45 CFR 46). As detailed in the application you submitted, the involvement of human subjects in this research study is ***strictly limited*** to one or more of the exempted categories listed on the attached Citation sheet.

- Exemption does not absolve the investigator from ensuring that the welfare of the research subjects is protected and that methods used and information provided to gain subject consent are appropriate to the activity. It is your responsibility as a researcher to familiarize yourself with and conduct the research in accordance with the ethical standards of the *Belmont Report*.
  Belmont Report: http://ohrp.osophs.dhhs.gov/humansubjects/guidance/belmont.htm

- You must immediately notify the UCHS if any changes or modifications are made in the study's design or procedures that do not fall within one of the categories exempted from the regulations. Any such changes or modifications must be reviewed and approved by UCHS *prior* to their implementation.

- You are not required to submit progress reports or requests for continuing review/approval to UCHS, unless you modify your study protocol.

Attachment: Exemption Citation

c: Alan Hedge (ah29)

Exemption Letter Continued

Cornell University
35 Thornwood Dr., Ste. 500
Ithaca, NY 14850

Telephone: 607 255-5138
Fax: 607 255-0758

University Committee on Human Subjects

Exemption Citation Issued on 3/5/2007

Name of Investigator: **Kelly Wilson** **Protocol ID#** 07-02-065

Title of Project: **Electrical Consumption Habits and Attitudes of Occupants in LEED Certified Buildings**

45 CFR 46.101 (b) Unless otherwise required by [DHHS] department or agency heads, research activities in which the only involvement of human subjects will be in one or more of the following categories are exempt from this policy:

___ (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as
- (i) research on regular and special education instructional strategies, or
- (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

✓ (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
- (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and
- (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

___ (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if:
- (i) the human subjects are elected or appointed public officials or candidates for public office; or
- (ii) Federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (5) Research and demonstration projects which are conducted by or subject to the approval of [DHHS] department or agency heads, and which are designed to study, evaluate, or otherwise examine:
- (i) Public benefit or service programs;
- (ii) procedures for obtaining benefits or services under those programs;
- (iii) possible changes in or alternatives to those programs or procedures; or
- (iv) possible changes in methods or levels of payment for benefits or services under those programs.

___ (6) Taste and food quality evaluation and consumer acceptance studies,
- (i) if wholesome foods without additives are consumed or
- (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

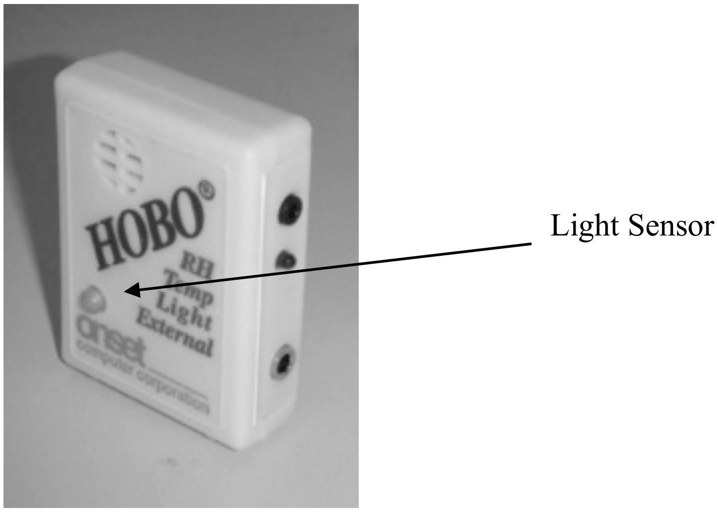
APPENDIX G

Signs using in buildings

Sign used and placement in LEED building

Sign used and placement in non-LEED building

APPENDIX H

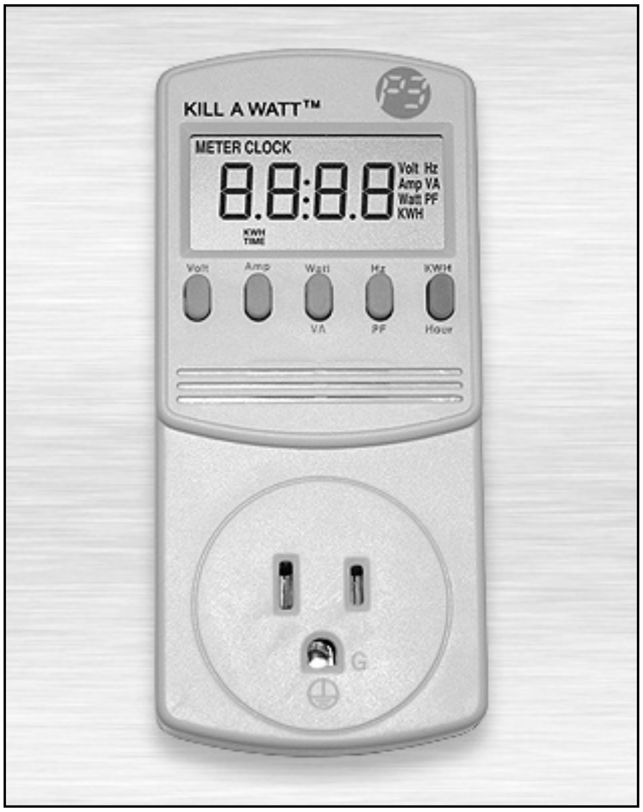


Example of HOBO

Example of HOBO Placement

APPENDIX I

kWh meter used[10]



Kill a Watt Meter

Packaging

In use

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10 Images from http://www.p3international.com/products/special/P4400/P4400-CE.html

APPENDIX J

Consent Form: Lighting Usage in Resident Halls

You are invited to take part in a study that researches lighting usage in college dormitory rooms. All individuals participating in this study have been personally invited to participate by the investigator. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

What the study is about: The purpose of this study is to research the lighting usage habits of college students in different types of resident halls. The participant must be living in a single room with a north- or south- facing window for the spring semester of 2008. The room must be located on the 2nd, 3rd or 4th floor in either the Alice H. Cook House or the Hans Bethe House.

What we will ask you to do: If you agree to be in this study, the researchers will measure your lighting usage for a total of 2 weeks. You have previously agreed to one of the following data collection periods:

January 26-February 10 or
February 16-March 2

On the 1st day of data collection, a researcher will unplug all your lighting fixtures currently plugged into your electrical wall sockets in your bedroom only. A researcher will attach a lighting usage meter to a wall socket, and will then plug all your lighting fixtures, previously plugged into the wall sockets, into the meter. This meter will not affect your lighting fixtures, and you are encouraged to use them in the same manner as before. You will be asked to leave the meter in place during the entire data collection period because data will be lost if the meters are removed from the socket. (If this happens you will need to inform the researcher of the details surrounding its removal.) Please do not plug or unplug items into the meter during the testing weeks. A smaller device will be hung next to or on your overhead or wall lighting fixture, there is no need to do anything with this small unit. It is only measuring lighting levels within the room. This procedure should not exceed 15 minutes.

On the 8th day, the same researcher will return to record data held on the devices and you may get a small sign to post in your room for the remaining days of data collection. This procedure is should not exceed 15 minutes.

On the 15th day, the same researcher will return to remove the meters and will plug your lighting fixtures back into the wall sockets. During this time you will be asked to complete an online survey regarding your lighting usage behaviors for the 2 weeks including some personal background. The survey should not take longer than 20 minutes to complete and the entire procedure should not exceed 30 minutes.

Risks and benefits: The researchers do not anticipate any risks to you participating in this study other than those encountered in day-to-day life.

There are no benefits to you. Cornell is a dedicated to learn more about how students use their resident halls.

Compensation: You will earn $10 at the completion of the 2 weeks. Additionally, if you attracted other students to the study you will earn $3 for every student that mentions or mentioned your name when first contacting the researcher about the study and fully completes the study. The $10 dollars will be paid at completion of the study and the referral money will be paid when the referred participant completes the study.

Taking part is voluntary: Taking part in this study is completely voluntary. If you agree to have your lighting usage measured, you may request certain fixtures not be measured and on the survey you may skip any personal questions that you do not want to answer. If you decide not to take part or to skip some of the questions, it will not affect your current or future relationship with Cornell University. If you decide to take part, you are free to withdraw at any time.

Your answers will be confidential. The records of this study will be kept private. In any sort of report we make public we will not include any information that will make it possible to identify you. Research records will be kept in a secure computer file; only the researchers will have access to the records.

If you have questions: The researchers conducting this study are Kelly C. Wilson and Prof. Alan Hedge. Please ask any questions you have now. If you have questions later, you may contact Kelly Wilson at kc292@cornell.edu or at 1-607-345-2957. You can reach Prof. Hedge at ah29@cornell.edu or 1-607-255-1957. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the University Committee on Human Subjects (UCHS) at 607-255-5138 or access their website at http://www.osp.cornell.edu/Compliance/UCHS/homepageUCHS.htm.

You will be given a copy of this form to keep for your records.

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

Print Your Name: ____

Your Signature:____

Date:______________________Net Id:_____________________

This consent form will be kept by the researcher for at least three years beyond the end of the study and was approved by the UCHS on March 5, 2007.

APPENDIX K

Survey Given to Participants

Lighting Survey Part A – General Information

Thank you for participating in this research, you are almost done.

Not only does this research look at lighting in dorms, but it also looks at the environmental sustainability of the dorms and [their] residents. I could not fully divulge this information in advance, for fear it would change your behavior during the testing period. If you know someone who is participating in the study right now, please do not release this information as it may skew the results of the experiment.

So in this survey you will be asked a variety of questions about your living habits in the past 2 weeks and your environmental habits in the past year. Please answer all questions honestly, I will be the only person to see your answers and nowhere in the report will your name be shown or released.

The survey is divided into the 2 parts below:

Part A: General Information

Part B: Carbon Footprint Information

Thank you for participating.

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1) Your net id: ___________________________

2a) Were you absent from your room for more than 24 hours during the testing period?

- o Yes (move to question 2b)

- No (skip to question 3)

2b) Time you were absent more than 24 hours from your room. (Enter each day separately)

Day Absent	Amount of hours absent from room

3) Amount of time spent in your room during the two testing weeks

- I spent more time in my room during week 2 than week 1
- I spent less time in my room during week 2 than week 1
- I spent the same amount of time in my room during week 2 and 1

4) How many credits were you taking during week 1 of testing? ____________________

5) How many credits were you taking during week 2 of testing? ____________________

6a) Did you have to report to a job on or off campus during week 1 and/or week 2 of testing?

- Yes (move to question 6b)
- No (skip to question 7)

6b) How many hours did you work during each week of testing? (Use the date and time the sign was posted in your room as the split between week 1 and week 2)

During Week 1 ________________

During Week 2 ________________

7) When you leave the room do you turn the lights off?

- Always

- Usually
- Occasionally
- Seldom
- Never

8a) Do you use additional lights, not supplied by Cornell, in your room?

- Yes (move to question 8b)
- No (skip to question 9)

8b) Why do you have additional lights? (select all that apply)

- Cornell lights are too bright
- Cornell lights are not bright enough
- Cornell light levels are not adjustable enough
- Reason not listed above. Explain ___________________________________

9a) What building did you indicate as your first choice? (specify which building you picked on your application to Campus Life for your residence during the year 2007-2008 school year)

- Alice Cook House (answer questions 9b and 9c)
- Hans Beth House (skip to part B)
- Other (skip to part B)

9b) Did you chose Alice Cook because it is a LEED building?

- Yes
- No
- I don't know about LEED

9c) Did you chose this dormitory because it is a "green" building?

- Yes
- No
- I don't know about "green" buildings

Lighting Study Survey Part B – Carbon Footprint

10) Where do you call "home" when NOT living at Cornell?

Primary Residence

City _________________State________________Country______________

Secondary Residence (if applicable)

City _________________State________________Country______________

11) Do you ever separate your garbage? (ex. Recyclable vs. non-recyclable)

- o Yes
- o No

12) Recycling Frequency when living at Cornell University? (Check the best answer for each category (examples of paper include cardboard; pizza boxes; drink containers; etc.) (examples of containers include plastic, glass, and metal containers))

Daily Recycling Habits

	Always	Usually	Occasionally	Seldom	Never
Paper?	○	○	○	○	○
Containers?	○	○	○	○	○
Compost?	○	○	○	○	○

13a) Do your recycling habits differ when you are away from Cornell?

- o Yes (move to question 13b)
- o No (skip to question 14)

13b) Recycling Frequency when NOT living at Cornell University? (Check the best answer for each category (examples of paper include cardboard; pizza boxes; drink containers; etc.) (examples of containers include plastic, glass, and metal containers))

Daily Recycling Habits

	Always	Usually	Occasionally	Seldom	Never
Paper?	○	○	○	○	○
Containers?	○	○	○	○	○

Compost?	○	○	○	○	○

14a) Did you drive any vehicles on a regular basis during in 2007?

- o Yes (move to question 14a)
- o No (skip to question 15)

14b) Driving frequency when at Cornell in 2007? (on average)

- o At least once a day
- o At least once a week, but not daily
- o At least once a month, but not weekly
- o At least once a year, but not monthly
- o Never

14c) Driving frequency when NOT at Cornell in 2007. (on average)

- o At least once a day
- o At least once a week, but not daily
- o At least once a month, but not weekly
- o At least once a year, but not monthly
- o Never

14d) Describe all the vehicles you repeatedly used in 2007.* (This includes your car, a family member's car, a friend's car, and motorcycles. If you are unsure of all the details surrounding the vehicle, please fill in as much data as you can)

	Model Year	Make	Model	Cylinders	Drive train	Transmiss ion	Total mileage contributed by you in 2007
Vehicle 1							

**Important note about question 14d: Participants were given enough space to record 5 vehicles. Additionally, in the electronic survey the participants were forced to select certain options under the headings: cylinders, drive train, transmission, and mileage. Below are the following categories:*

Cylinders: 4, 6, 8, or unknown

Drive train: 2-wheel drive, 4-wheel drive, all-wheel drive, and unknown

Transmission: standard/stick, automatic, combination of both

Mileage: < 1,000 miles, 1,001-5,000 miles, 5,001-10,000 miles, 10,001-15,000 miles, 15,001-20,000 miles, > 20,001 miles

15a) Did you take any airplane trips in 2007?

- o Yes (move to question 15b)
- o No (skip to question 16)

15b) Describe the airplane trips you took in 2007.*

	Departure City	Departure State or Country	Arrival City	Arrival State or Country	Type of Trip	Frequency of Trip	Type of plane(s)
Trip 1							

**Important note about question 15b: Participants were given enough space to record 10 trips. Additionally, in the electronic survey the participants were forced to select certain options under the headings: type of trip, frequency of trip and type of plane. Below are the following categories:*

Type of Trip: Round-trip and One-way

Frequency of Trip: 1 to 10

Types of Plane(s): (check all that apply) Prop/Regional Jet, and Large/Jumbo Jet

16a) Did you take any train trips in 2007?

- o Yes (move to question 16b)
- o No (skip to question 17)

16b) Describe the train trips you took in 2007.*

	Departure City	Departure State or Country	Arrival City	Arrival State or Country	Type of Trip	Frequency of Trip
Trip 1						

**Important note about question 16a: Participants were given enough space to record 10 trips. Additionally, in the electronic survey the participants were forced to select certain options under the headings: type of trip and frequency of trip. Below are the following categories:*

Type of Trip: Round-trip and One-way

Frequency of Trip: 1 to 10

17a) Did you take any long-distance bus trips in 2007?

- Yes (move to question 17b)
- No (skip to question 18)

17b) Describe the long distance bus trips you took in 2007.*

	Departure City	Departure State or Country	Arrival City	Arrival State or Country	Type of Trip	Frequency of Trip
Trip 1						

**Important note about question 17b: Participants were given enough space to record 10 trips. Additionally, in the electronic survey the participants were forced to select certain options under the headings: type of trip and frequency of trip. Below are the following categories:*

Type of Trip: Round-trip and One-way

Frequency of Trip: 1 to 10

18a) Did you use TCAT buses during the fall semester of 2007?

- Yes (move to question 18b)
- No (skip to question 19)

18b) Describe your typical weekly TCAT usage for the fall semester.*

	Bus Line #	Pick-up at…	Drop-off at…	Weekly Frequency
Trip 1				

**Important note about question 18b: Participants were given enough space to record 20 trips. Additionally, in the electronic survey the participants were forced to select certain options under the heading: weekly frequency. Below are the following categories:*

Weekly Frequency: 1 to 30

19) Environmental Involvement (Please indicate if you were/are involved in or attended any of the following events addressing Environmental Sustainability, Energy Conservation, Global Warming, or Climate Change)

- One or more environmental lectures or seminars
- One or more environmental courses
- One or more environmental conferences or symposiums
- One or more non-profit environmental organization
- Environmental efforts with the Local, State, or National Government
- Not involved in any environmental activities
- Other type of environmental event _______________________

20) Would you like to receive a copy of your carbon footprint results?

- Yes
- No