Building User Audit:

Capturing Behavior, Energy, and Culture

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Abstract

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Building construction is a major sector of energy consumption and greenhouse gas emissions production in United States. During the last decade many sustainability strategies were provided and performed by top designers, constructors, and decision makers in the building market in order to reduce energy use, minimize environmental impacts, and improve buildings

performance. Implementing the sustainability strategies and energy efficiency programs in educational buildings (e.g. classroom and office buildings on university campuses) is specifically important because of the large amount of energy used by this type of buildings, their unique potential for testing new technologies and innovative sustainability solutions, and high instructive values of these programs for students,. Despite of valuable efforts made towards sustainable development in the building industry, a considerable discrepancy exists between predicted and actual building performance and energy use mainly because of neglecting the occupant's behavior impacts.

This research aimed to address the current gap in analysis of user-influenced energy use in educational buildings by developing and piloting a Building User Audit Procedure (BUAP) that determines how buildings are actually being used and how user behaviors affect energy use in campus buildings.

The research methodology consists of using three case studies (educational buildings on a university campus) and conducting a survey in order to collecting both perceived and actual energy related user behaviors. The building user audit indicated that building users have a considerable effect on energy use particularly on electrical lighting and miscellaneous electrical loads. Also, the data analysis reveals a difference between the occupants expected behaviors/actions and their actual behaviors/actions in terms of space and energy use. For instance, the building occupants are using natural lighting and ventilation much less than what is expected and what they report. In addition, according to the survey over 40% of respondents believe in pro-environmental behaviors yet less than one third believe they can have a positive impact on climate change. All these facts show a significant potential opportunity for fostering the pro-environmental behaviors among the educational building users.

Implementation of the BUAP help the stakeholders to gain a better understanding of their building's performance which enable them to utilize the most effective techniques and technologies and design a training program based on the unique behaviors of their occupants to improve the level of sustainability in their facilities.

Supplemental Files: Two Smart Excel sheets (Manual Observation and Automated Monitoring) are attached to this document. Please refer to chapter 3 to read more about the smart excel sheets.

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List of Abbreviations

ASHRAE	American Society of Heating, Refrigerating, and Air-conditioning Engineers
BAS	Building Automation System
BPS	Building Performance Simulation
BUAP	Building User Audit Procedure
CAP	Climate Action Plan
CBECS	Commercial Buildings Energy Consumption Survey
CPO	(UW) Capital Projects Office
EEM	Energy Efficiency Measures
EIA	(US) Energy Information Administration
EPA	(US) Environmental Protection Agency
EUI	Energy Utilization Index
FS	(UW) Facility Services
GHG	Greenhouse Gas
GSF	Gross Square Footage
HVAC	Heating, Ventilation, and Air Conditioning
IEQ	Indoor Environmental Quality
LEED	Leadership in Energy and Environmental Design
LPD	Lighting Power Density
M&V	Measurements and Verifications
MELs	Miscellaneous Electric Loads
O&M	Operation and Maintenance
PEA	Preliminary Energy Audit

PEB	Pro-Environmental Behavior
POE	Post Occupancy Evaluation
US	United States of America
UW	University of Washington

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1. Introduction

1.1. Sustainability and Energy Efficiency

The concept of "Sustainable Development" has been taken into account since the early 90s and was in the focus of attention among researchers, developers, and policy makers. Investigating this concept reveals that there is a strong connection between sustainability and energy efficiency because of the significant impact the energy issues have on all three aspects of sustainability (environmental, economic, and social). The current economic challenges of energy supply and energy cost as well as environmental impacts like climate change, greenhouse gas (GHG) emissions effects, and air pollution are just few examples. As a result, various sustainability strategies has been set by developed countries during the last decade to make tangible changes in the major sectors of energy consumption and GHG emissions production.

In United States, more than 40% of all energy is consumed by building sector compared to 28% of energy use in transportation and about 25% in industry (US EIA 2012). Fortunately, sustainability has been well developed in the US building construction market. Preserving the built environment, designing high-performance building, and building green are the main values in the leading design and construction companies. However, identifying proper energy efficiency strategies in construction projects is a challenging task. Because, it highly depends on many different factors such as building size, location, structure, type, and other unique characteristics of a building. Despite of the challenges, both public and private sectors make an effort to reduce energy consumption and environmental impacts of building construction.

Among different types of buildings (residential, commercial, industrial, etc.) education buildings have a great importance when it comes to evaluation of energy efficiency. Education building mainly includes k-12 schools, colleges, and buildings on university campuses. According to the U.S. Environmental Protection Agency (EPA) 25% of energy use in schools is wasted. In higher education level, there are more than 20 million students attending hundreds of universities across the United States (NCES 2012). The amount of energy consumed in some university campuses can be higher than the sum of energy consumed by several neighborhoods. A research study in UK shows that electricity used in university campuses can be 85% higher than what expected (Menezes et al. 2012). Besides of the huge amounts of energy consumed and GHG emissions produced by

educational buildings they can be the best option for testing sustainability new technologies and best practices (cf. Lynn et al. 2011). Also, implementing sustainability programs in schools and universities has a great instructive value since the current students are the future leaders and policy makers. It is concluded that pursuing sustainability and energy efficiency practices in educational buildings have significant economic, environmental, and social benefits.

Several attempts have been made from regional to national levels for sustainable development of education buildings. Gaining LEED certification, providing energy efficient office equipment, and using renewable energies are just few examples. However, the discrepancies between designed and actual performance of buildings demonstrate a need for post occupancy evaluation (Menezes et al. 2012) and applying appropriate strategies during the whole life cycle of buildings. For this purpose, performing a building auditing is required which aims to detect operating problems, assesses changes in building use and the condition of existing equipment, and optimize energy use (Alajmi 2012).

1.2. Purpose of Study

Building audit (also known as energy audit) is the first step of the process of measuring and reducing a building's environmental impacts and energy use. Many building auditing protocols and tools (such as ASHRE standards) exist in the market. However, these tools mostly evaluate the building characteristics including building envelop, building structure, and building systems (HVAC, lighting, etc.) and provide suggestions for improvement in operation and maintenance (O&M). While, an energy efficient design approach, technology, and equipment are important criteria, they alone are not driving a building performance. In this case, building occupants play a significant role. However, the current auditing protocols mostly overlook the role of building users and their potential significant influence on energy consumption. In other words, there is a gap in analysis of building user's behavior and its influences on energy consumption.

"Those of us who calls ourselves energy analyst have made a mistake…we have analyzed energy. We should have analyzed human behavior" (Lee Schipper 1991). Some researchers tried to address the role of occupants in energy use mostly in residential and in some cases in office buildings. But these researches study just part of the issue (either technical aspects or social aspects of the subject) and consequently fail to introduce a comprehensive building energy audit tool for understanding

energy related user behaviors and measuring related energy use. Thus, there is still a need for an audit protocol that defines a common language and creates a standard that produces consistent results independently of the auditor (Barley et al 2005).

Therefore, the purpose of this thesis is to fill the current gap by providing a comprehensive building energy audit tool that focuses on building occupants (instead of building itself) and designed specifically for educational buildings.

The anticipated result of this study is a building user audit procedure (named BUAP) that explains the process of auditing step by step and defines all terms clearly. Such procedure may help building managers, facility management staffs, and other decision makers to:

- Understand how people are using energy in educational buildings
- Understand how building facilities and miscellaneous equipment are being used
- Establish a baseline for behaviors that effect energy use in buildings
- Create a benchmark for the design of new buildings
- Guide future intervention programs aimed at fostering energy related behavior

Another goal of this study is an appropriate visualization of building/equipment use, effects of people behaviors, and consequent energy use. This is especially important because energy (and electricity in particular) is invisible and its waste cannot be tangibly considered (unlike material or water wastes) particularly in educational facilities that have hundreds of possibilities for energy leaks (cf. Eggink 2007). A graphical presenting of results of the building audit has several advantages including but not limited to:

- Demonstrating the amount of energy consumed/emissions produced and tracking changes
- Appealing building occupants to take actions for energy conservation
- Showing building performance (as is) and opportunities for improvements
- Creating energy awareness among the faculty, staff, and students (Eggink 2007)
- Making a comparison between different buildings/types of users in terms of energy use

1.3. Description of Research Question

The main question of this research is how does building user's behavior impact the building's energy consumption?

This question can be divided to another two questions for detailed investigation: 1. What types of energy (used in buildings) are influenced by user's behavior? This question can be addressed under the concept of "user-influenced energy consumption" and 2. What factors does impact user attitudes and behaviors? and how? This concept can also be further investigated in the context of "pro-environmental behavior". Both of these two concepts will be discussed in the next chapter literature review.

1.4. Research Outline

The current thesis were written based on the research project "Building User Audit: Capturing Behavior, Energy, and Culture" performed at the University of Washington (UW). This one year project were funded by UW Green Seed Fund and the results were presented to the UW Facility Services (FS) and the UW Capital Projects Office (CPO). UW has implemented several programs to meet its greenhouse gas (GHG) emissions reduction targets. This project team recognized that while UW had previously implemented several programs and initiatives to raise awareness of energy use on campus and reduce campus energy consumption, the campus needed a framework to accurately account for the effects of user influenced energy uses in campus buildings. The absence of such a framework would limit the ability of UW to meet its GHG reduction goals. This project sought to develop a tool for understanding how people impact energy use patterns in campus buildings. The tool that was developed is named The Building User Audit Procedure, or BUAP. This project were accomplished by an interdisciplinary team of faculties and students including:

Faculty members: Prof. Heather Burpee (project lead), Prof. Carrie Dossick, Prof. Gina Neff. Student members: Alireze Borhani (student lead and author), Julie Kriegh, Aran Osborn (former team member). Since, the project was anticipated to be a student-driven project faculties worked mainly as project consultants. The project's part "user survey" were mainly performed by PhD candidate Julie kriegh (parts of it are used in this thesis). All other parts of the work provided in the thesis were performed by the thesis author.

2. Literature Review

This research is an example of an interdisciplinary system approach for research programs that emphasizes on synergy of different fields of science and engineering to initiate a sustainable energy solution (National Science Board 2009). Investigating a broad range of topics such as sustainability, energy, building operations, and environmental psychology was needed for the purpose of this project.

This study intends to fill the current gap in analysis of user-influenced energy use in educational buildings by developing a Building User Audit Procedure (BUAP) that helps stakeholders understand how buildings are actually being used and how user behaviors affect energy use in campus buildings. For this purpose, an understanding of framework and process of building auditing is required. In addition, the main question of the research is about how user behaviors impact energy use. To answer this question two components of it namely user-influenced energy and energy related behaviors should be studied using the existing literatures. As a result, the literatures reviewed in this chapter can be categorized into the following three topics:

- Building energy auditing
- User-influenced energy consumption
- Pro-environmental behaviors

2.1. Building Energy Auditing

The demand for understanding actual building performance and energy use as well as the growing tendency for life cycle sustainability assessment highlights the needs for post-occupancy evaluation (POE) in buildings. There are several approaches for planning POE varying from very technical methods using high-technologies to socio-psychological interests using more subjective parameters to evaluate the building performance (Menezes et al. 2012).

Regardless of differences in POE plans conducting building energy audit is a prerequisite for a successful building performance evaluation and transition to a more sustainable facility operation. Because, if the current building's condition cannot be measured in terms of energy efficiency consequently it cannot be managed effectively.

Although, most of existing typical energy audit protocols fail to take user behavior impacts into account learning them still helps to create a standard framework for an optimized building user audit procedure. A typical energy audit can be defined as a tool that determines where, when, why, and how energy is used in a facility and identifies opportunities to improve efficiency (Beachler et al. 2011). The objective of a building energy audit is to provide building's owner/manager and O&M staffs with an action plan that includes energy efficiency retrofits recommendations, opportunities for better adherence to lighting and comfort standards, and low-cost operation and maintenance adjustments leads to operating cost reduction (Beachler et al 2011; ASHRAE 2011). An energy audit can be performed in different levels of details and complexity from basic no-cost recommendations to complicated and costly measurements and verifications plans. Determining the proper level of audit usually depends on building characteristics (e.g. size, structure, envelop, HVAC, lighting system), time and budget limits, and specific goals of facility managers (ASHRAE 2011; Alajmi 2012).

Identifying the process of building auditing is an important task but also is challenging because of numerous number of auditing standards and protocols in the market. Figure 1 shows a flowchart that summarizes the process of the energy audit (Alajmi 2012).

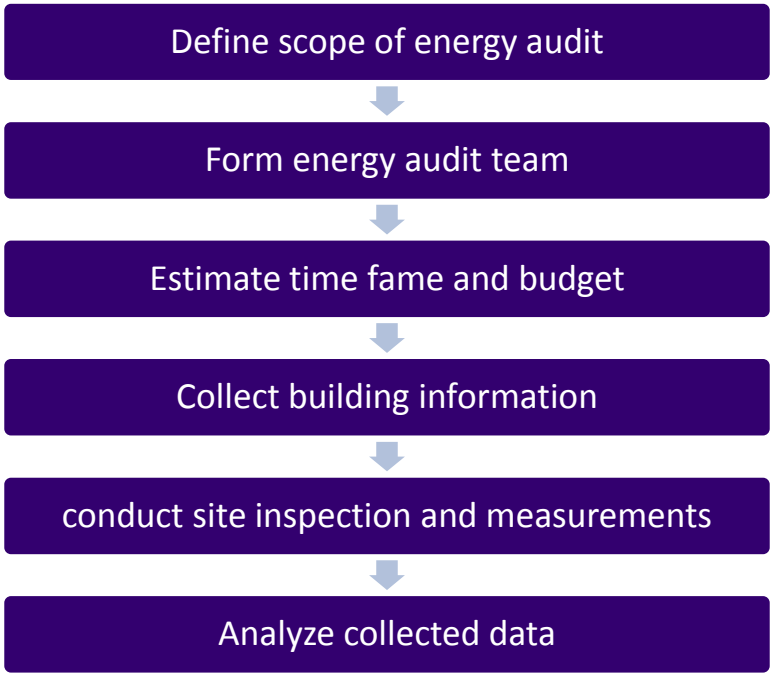

Fig. 1: Energy Audit Flowchart

A report prepared for U.S. department of Energy explains different phases of an energy audit in more details (Beachler et al. 2011). Regardless of the level of audit the first phase starts with a preliminary review of energy use during which facility is benchmarked against similar buildings and base energy load is identified. Needed activities are collecting and analyzing utility data, calculating Energy Use Index (EUI) and comparing to similar facilities, and assessing energy efficiency improvement potential. In the next phase- site assessment- site data is collected and immediate energy savings opportunities is identified. To do this, relevant building staffs should be interviewed and key systems should be visually inspected. The third phase of audit is energy and cost analysis and includes prioritizing energy efficiency measures (EEM defined as adjustments to building systems and controls, or equipment installations that result in lower energy use) and generating savings estimates. For this purpose, utility and site data are evaluated and energy and cost savings are analyzed. In the last phase- completion of audit report- key findings are summarized and an action plan including recommendations is presented.

A comprehensive guideline for building energy auditing has been published by the American Society for Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE). The publication called "Procedures for commercial buildings energy audit" and consists of three levels of audit along with a preliminary step:

- Preliminary Energy Use Analysis
- Level I: Walk-Through Analysis
- Level II: Energy Survey and Analysis
- Level III: Detailed Analysis of Capital Intensive Modifications

Each level of audit varies in the depth of data gathered and extent of analysis. In following each level of audit is explained briefly (ASHRAE 2011; Kelsey et al. 2011):

The first step Preliminary Energy Use Analysis (PEA) is the entry point to the energy audit levels. The primary activity of the PEA is to benchmark the facility within a similar group of buildings (use, size, climate, etc.). During this stage building's current energy and cost efficiency is determined by calculating the energy use and cost per square foot per year (EUI). Also, energy bills are reviewed and other available source of benchmarking data like energy cost index will be used to indicate the potential value of further levels of analysis.

Level I- Walkthrough analysis is the most basic assessment of a building's performance. In this level auditor assesses a building's energy cost and efficiency by analyzing energy bills developed in the PEA, and conducts a brief on-site survey of the building. The goal is to identify low-cost/no-cost energy efficiency measures and provide a listing of potential capital improvements for further study, and provide an initial estimate of potential costs and savings.

Level II- Energy survey and analysis includes a more detailed building survey and energy analysis. An end-use breakdown of the energy consumption within the building is provided. This level of energy analysis will identify and provide the savings and cost analysis of all energy efficiency measures that meet the owner's constraints and economic criteria, along with a discussion of any changes to operation and maintenance procedures. It may also provide a listing of potential capital-intensive improvements that require more thorough data collection and engineering analysis, and a judgment of potential costs and savings. The Level II is an option for obtaining LEED credits in existing buildings.

Level III- Detailed Analysis of Capital Intensive Modifications focuses on potential capital-intensive projects identified during the Level II analysis and involves more detailed field data gathering as well as a more rigorous engineering analysis. It provides detailed project cost and savings calculations with a level of confidence sufficient for major capital investment decisions.

A brief comparison of tasks performed in each level of energy audit is provided in table below:

Table 1: A Comparison of ASHRAE Levels of Energy Audit

	Level I	Level II	Level III
Brief walk-through survey	X	X	X
Summarize utility data	X	X	X
Identify no/low cost recommendations	X	X	X
Identify capital improvements	X	X	X
Compare EUI to similar sites	X	X	X
Detailed end-use breakdown		X	X
Analyze energy efficiency measures		X	X
Review design, condition, and O&M practices		X	X
Estimate capital project costs and savings		X	X
Detailed on-site survey		X	X

	Level I	Level II	Level III
Recommend M&V method		X	X
Detailed system modeling			X
Detailed EEM cost estimates			X

A successful building energy audit cannot be achieved without an effective team communication and collaboration. The audit team consist at a minimum of building owner/manager, the building's Operation and Maintenance (O&M) staffs, and the energy auditor(s). The building owner can set requirements and goals of the project including cost-effectiveness criteria, budget and time limits, an allowable rate of return, and any performance objectives such as obtaining LEED certification. In addition, the O&M staffs are the best source of required information like equipment logs, history of comfort issues, operating patterns, management strategies, and information about building's systems (Kelsey et al 2011).

2.2. User-Influenced Energy Consumption

Numerous techniques and technologies have been provided to the green building market to improve the energy consumption management. During the design phase predicted energy consumption is estimated usually by various building performance simulation (BPS) tools (Hoes et al. 2009). However, current simulation tools do not accurately model the impact of occupants on the energy performance of buildings which is attributed to the use of inadequate assumptions for energy use estimation (Menezes et al. 2012). Therefore, for a better understanding of differences between expected and actual performance of buildings, it is necessary to monitor the energy consumption after occupancy, the behavior of the occupants, and the resulting indoor comfort (Guerra-Santin et al. 2015). The explained discrepancy between predicted and actual building's energy use indicates the importance of occupant's behavior during the whole facility service life.

Considering the context of user behavior in the process of building audit requires a deep understanding of potential impacts of user behavior on energy consumption. Therefore, different types of energy end-uses in a building should be determined and categorized based on intensity of user influence. It is also important to know how those energy drivers can be measured and how they are impacted by user attitudes and behaviors.

In general the factors influencing the building energy consumption can be summarized in six categories (cf. Zhun Yu et al. 2011):

1. Climate (e.g. outdoor air temperature, wind velocity, etc.)
2. Building related characteristics (e.g. type, area, orientation, etc.)
3. User related physical characteristics (e.g. user presence, etc.)
4. Building services systems and operation (e.g. space heating/cooling, hot water supply, etc.)
5. Building occupant's behavior and activities
6. Indoor environmental quality (IEQ) required

Accordingly, two factors clearly refer to role of occupants in building energy use. Also, the indoor environmental quality is not a totally independent factor because it can be controlled by occupants or strongly affected by their behaviors. In a more general perspective even the climate is impacted by human activities. Based on this categorization the occupants impacts is determined by two parameters occupant's presence and occupant's activities (behaviors). Considering these two factors is specifically important in high-load buildings (such as education buildings) where energy use can be highly driven by occupancy presence and actions (Azar et al. 2014).

One study (Guerra-Santin et al. 2015) introduces four characteristics of building users that may influence the building performance:

1. Differences in user behaviors. When the energy consumption in a building is calculated, assumptions are usually made based on the average or standard for all users. While this generalization of user behavior may cause to unexpected high value of actual energy consumption.
2. Users may consume more energy after the implementation of energy savings measure. For example by setting the thermostat higher or turning on the heating for a longer time than before.
3. User-building interaction. User's lack of understanding in the utilization of new technologies and techniques can lead to increase on energy consumption. For example when users set the thermostat much higher than the desired temperature thinking that it would speed the heating of the room.

4. Unexpected building occupancy may cause to miscalculation of energy consumption that may differ significantly from actual use.

The extent of user influence on building's energy use may be varied based on many factors including the building's type (residential, commercial, etc.) and building's systems. For example, in a house, occupants have a complete control of the lighting system, while in an office building (at least in some areas) the occupants may have no access to switches and they are completely controlled by the facility manager. As another example, user impacts in a commercial building that uses natural ventilation (passive system) is much higher compared to a building with fully mechanical air-condition system (Wilson et al. 2006). For the purpose of this research the user-influenced energy in an education building like university campus buildings will be studied.

For an accurate measurement of user-influenced energy the occupant's potential impacts should be discovered first. In an office building an average user impacts can be characterized as follows (Reinhart 2004; Knight et al. 2003):

- Occupancy presence in the room with constant or an irregular pattern.
- Occupants make passive or active use of sun blinds and or lighting.
- Occupants control the internal heating/cooling loads.

Occupancy presence can be measured by several methods. Using movement sensors is an effective option that provides reliable information of occupancy and use of spaces (Guerra-Santin et al. 2015). Such sensors use a bi-directional infrared beam to count people entering or leaving the building (Gul et al. 2015). The pattern of occupancy can be identified by analyzing the total numbers in/out during a certain period of time.

Thermal comfort is another energy consuming issue that is highly impacted by building occupants. There are two main methods for evaluation of thermal comfort including measurements of indoor parameters and application of thermal comfort survey. The indoor parameter data are usually linked to the results of thermal comfort survey for better understanding the level of comfort. The indoor parameters data such as temperature, humidity, and CO_2 concentration can be captured by different sensors found in the market (cf. Guerra-Santin et al. 2015). Average values are used for the purpose of evaluation that are calculated using data recorded in a determined interval basis.

The user-influenced electricity use in education buildings mostly consist of user controlled lighting and unregulated plug loads (cf. Gul et al. 2015). The amount of electricity used for lighting can be widely different depends on user actions. Leaving lights on at nights or in unoccupied rooms, user-acceptance issues related to the proposed low light levels, and using indoor electrical lights instead of natural daylighting are examples of energy increasing issues. Another source of electricity use in buildings is Miscellaneous Electric Loads (MELs) that is totally impacted by building users. MELs is defined as "electricity-consuming loads that do not fall under conventional end uses, such as lighting, HVAC, and refrigeration (Mckenney et al. 2008). Studies show that MELs energy intensity tend to increase while energy demand of conventional end uses is projected to decrease or remain unchanged. Part of reason is that researches on energy efficiency has focused on traditional end uses and despite the MELs market is growing rapidly, energy use reduction strategies for MELs have so far received little attention (Kamilaris et al. 2014). Both lighting and plug loads can be measured by means of sensor devises as well as conduction a building walkthrough (Guerra-Santin et al. 2015).

Figure 2 (source: CBECS 2003) shows different types of energy end uses for a typical education building. Based on information provided, the part of user-influenced end uses can be separated (dash-line) which accounts for more than 25% of total energy use.

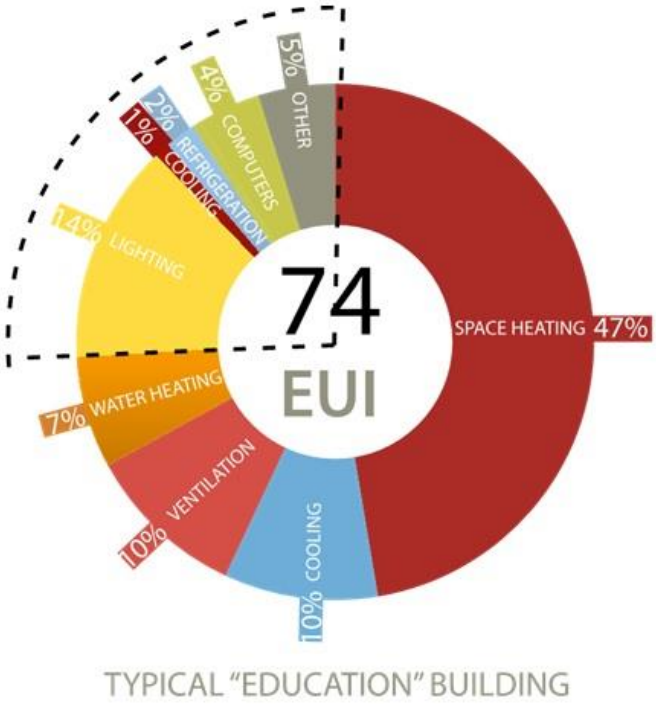

Fig. 2: User-Influenced Energy End-Uses

In general, user-influenced energy data are both subjective and objective. Building walkthrough is an example of objective data collection because the data describes a fact (e.g. windows is open/closed). Also, occupant's survey is an instance of subjective data collection in which the data describe the occupant's qualification of how they feel (cf. Guerra-Santin et al. 2015). Several techniques can be employed for occupant's data collection from more basic methods like sending a questionnaire to more complicated methods like mining data from a Building Automation System (BAS) database.

Many studies refer to the occupant's role as a negative source of unnecessary or unexpected energy use. While, it can also be perceived as an opportunity to better energy efficiency and conservation (Azar et al. 2014). This purpose can be achieved through increasing building user awareness about energy-efficient low-impact technologies and also promoting environmental sustainability behaviors and actions.

2.3. Pro-Environmental Behaviors

The significant influence of building users on energy consumption and the potential impacts of their behavior on energy end uses have been explained so far. In the previous section the physical characteristics of user behaviors and actions were investigated (e.g. the act of using natural ventilation and lighting instead of energy consuming mechanical options). In this section, reasons and motivations behind those behaviors will be studied in a cultural context. Energy related behaviors of building users is an aspect of a more general concept "environmental behavior". As a short definition, it is any action that affects the quality of the environment, in either a positive or negative way. Accordingly, "pro-environmental behavior" can be defined as any action that enhances the quality of the environment (Steg et al. 2014). The pro-environmental behavior (PEB) is a complicated subject that is rooted in various fields of science including psychology, sociology, and built environment.

Two main questions should be answered to gain a better understanding about the concept of PEB: 1.what factors does affect the pro-environmental behavior? And 2.How the pro-environmental can be encouraged in communities?

In general, the pro-environmental behavior is influenced by both internal factors (an individual himself/herself) and external factors (the environment of an individual) (Krajhanzl 2010). As

another categorization, factors influencing PEB can be summarized in the following three groups: (cf. Clayton, ed. 2012; Vicente-Molina et al. 2013; Steg et al. 2009)

- Demographics characteristics, that refers to personal information that may impacts pro-environmental behaviors. Examples are age, gender, religion, education, and socio-economic status.
- Contextual factors, that refers to the environment or specific situation of an individual that may impacts pro-environmental behaviors. Examples are residency (e.g. urban or rural) and nationality (when compared regarding access to environmental structures).
- Individual's values & attitudes, that refers to personal and social values and beliefs that may impact pro-environmental behavior. Examples are social norms, individual morals, and biospheric values.

There are many other classifications provided by researches. Also, some other factors such as individual's political views, emotions, and habits (Vicente-Molina et al. 2013) influence human behavior but cannot be easily included in one category.

For a more systematic study of subject it is important to know how these groups of influencing factors are related to each other and how they lead to a pro-environmental behavior. The demographic characteristics are normally the primary source for shaping the environmental behaviors (cf. Clayton, ed. 2012). However, in a given situation, there is always one dominant environmental behavior. The Goal Framing Theory (Lindenberg & Steg 2007) were introduced to predict such behavior. According to this theory environmental behavior often involves a conflict between three goals a person pursues namely hedonic, gain, and normative goals. Hedonic goals lead individuals to focus on ways to improve their feelings in a particular situation. Gain goals prompt people to be sensitive regarding their personal resources. While, normative goals lead people to focus on the appropriateness of their actions (Steg et al. 2014).

In general, any or all of these three goals may motivate people to engage in pro-environmental behavior. For instance, an individual may show a pro-environmental behavior because it is enjoyable (hedonic goal), saves money (gain goal), and protects the environment (normative goal). However, a conflict occurs in many cases because pro-environmental behavior is less profitable, less pleasurable, or more time consuming compared to an environmentally harmful action (Steg et al. 2014). Therefore, it is vital to know which goal is salient in a given situation. In this case,

environmental attitude plays a significant role. Environmental attitudes describe one's beliefs regarding a specific environmental issue. For example, if someone believes that saving energy is always inconvenient or it is impossible to conserve natural resources it would be very unlikely that his/her goals in a given situation guide him/her to a pro-environmental behavior (cf. Eggink 2007).

The values each person possess in his/her life impacts his/her environmental behaviors in deepest level of cognition. In fact, environmental values are more strongly associated with environmental attitudes than behaviors (Milfont et al. 2010). Thus, it can be concluded that pro-environmental values lead to pro-environmental attitudes that lead to pro-environmental behaviors. In practice, however, contextual factors and social impacts have considerable influence on people actions and behaviors (cf. Steg et al. 2014).

Developing an intervention program for encouraging pro-environmental behavior requires a carful observation of existing people behavior and a detailed assessment of factors influencing environmental behaviors including values, demographic characteristics, contextual factors, and social impacts. One study (Steg & Vlek 2009) provides a framework for promoting behavior change: 1.carefully select the behaviors to be changed to improve environmental quality, 2.examine factors which cause those behaviors, 3.apply proper interventions to change relevant behaviors, and 4.systematically evaluate the effects of those interventions on the behaviors.

Among many different intervention programs three effective strategies are introduced below.

1. Considering the goal framing theory, the perceived costs (e.g. time, convenience, effort, money, and comfort) of pro-environmental behavior can be reduced, while its perceived benefits are increased. Implementing information campaign and pricing policies are a few examples (Steg et al. 2014).
2. Pro-environmental values and attitudes should be strengthen through the community. This may have positive impacts on environmental behavior directly and indirectly (cf. Steg & Vlek 2009; Steg et al. 2014).
3. The contextual factors should be changed to offer more pro-environmental behavior alternatives. This strategy is especially effective when acting pro-environmentally is rather costly or difficult because of external barriers (cf. Steg & Vlek 2009).

3. Methodology

The aim of this study is to create a building audit tool (called BUAP) particularly for university campus buildings that focuses on occupant's impacts on energy consumption. This research were made in the form of a one year project at University of Washington during which the BUAP were developed and tested in three buildings on UW campus. This section studies the content of BUAP and the process of its development.

3.1. Methods of Data Collection

It was explained during the literature review that a wide range of building user variables exist that underscoring pro-environmental behavior including: values, beliefs and attitudes, awareness of issues and consequences, personal and social norms, perceived control over outcomes, behavioral intention and motivations leading to actions in the context of a specific place or environment. As such, including an analysis of the interplay between individuals and their built environments is necessary to understanding the impact of users on energy consumption. Therefore, the proposed audit tool includes two distinct components. The first component is the development of a User Energy Behavior baseline recording the physical characteristics of user's behavior. The second component is a User Cultural Context baseline recording the social context of the building's users. To cover both these components of the audit tool, two methods of research were used including identifying some case studies for performing building audit and developing a user survey. The first method was anticipated to collect actual behaviors of building users, while the second method should capture their perceived behaviors.

The overall process of the research is indicated in figure 3. An iterative process were designed for this project in order to revise and complete the BUAP based on the results of two rounds of audit (for more details refer to section 3.2).

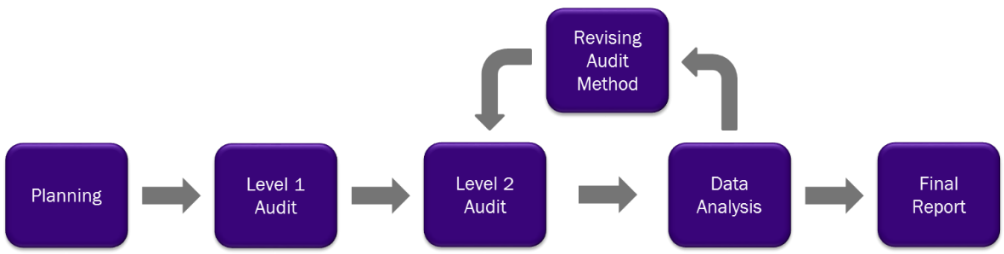

Fig.3: Project Process

The Audit tool (BUAP) used the ASHRAE publication "Procedures for Commercial Building Energy Audits" as a basis for the procedure. The BUAP consists of three levels of analysis emulating the ASHRAE Level One and Two Audit procedures:

1. Level 1 Preliminary Analysis.
2. Level 2 Building Walkthrough Analysis.
3. Level 3 Energy Survey and Engineering Analysis.

3.1.1. Level 1: Preliminary Analysis

The preliminary analysis is the first level of a three level building use audit. The goals of the audit should be defined in this early phase. Accordingly, the analyst will select the target building(s) for the audit. In addition, basic information regarding the energy consumption and building use should be gathered and investigated.

Criteria for Building Selection

Some pre-defined criteria were used to determine the types of buildings to be audited in order to ensure that the selected buildings are appropriate and that gathered data are comparable.

Table 2 shows a list of criteria used for the building selection. In general, the selection was made based on primary building program, building vintage (original construction), renovations, building category (historic, historic renovated, modern, and new), overall energy use, energy consumption patterns, and energy mix (i.e. all electric, mixed electric and natural gas, etc.).

The BAUP was specifically developed for the education buildings that primarily contain classrooms and administrative offices. However, the list of criteria can be adjusted for other types of buildings based on the goals and objectives of the audit.

Several buildings on UW campus were considered and a list of 5 buildings were created. After further investigation three buildings were chosen for the audit. The information of these three buildings is summarized in table 2.

Table 2: Criteria for initial building selection

	Gould Hall	Savery Hall	Paccar Hall
Major Departments	Built Environment	Sociology, Philosophy ,Economics	Business
Year Constructed	1972	1917	2010
Year Renovated	N.A.	2009	N.A.
Building Category	Modern	Historic Renovated	New
Gross Square Footage	105,577	84,698	115,103
% Classrooms (of GSF)	10.0%	14.9%	20.7%
% Offices (of GSF)	8.0%	26.6%	14.5%
Energy Use Type	Steam / Electric	Electric	Steam / Electric
Electric EUI (KBtu/ft2)	27.09	45.02	36.16

Databases for the Building Audit & Energy Analysis

The BAUP used several resources/databases provided by the UW. First, the UW energy dashboard was used to identify the total amount of energy (i.e. electricity and chilled water) used in a building. This value was necessary for many purposes such as calculating the whole building Energy Use Index (EUI) for the selected buildings as well as calculating the share of user-influenced energy use in the phase of in-depth data analysis. Also, the energy dashboard indicates the pattern of energy use on a monthly basis which can be employed for a comparison between the buildings initially selected for the audit. The webpage of UW energy dashboard can be seen in Figure 4.

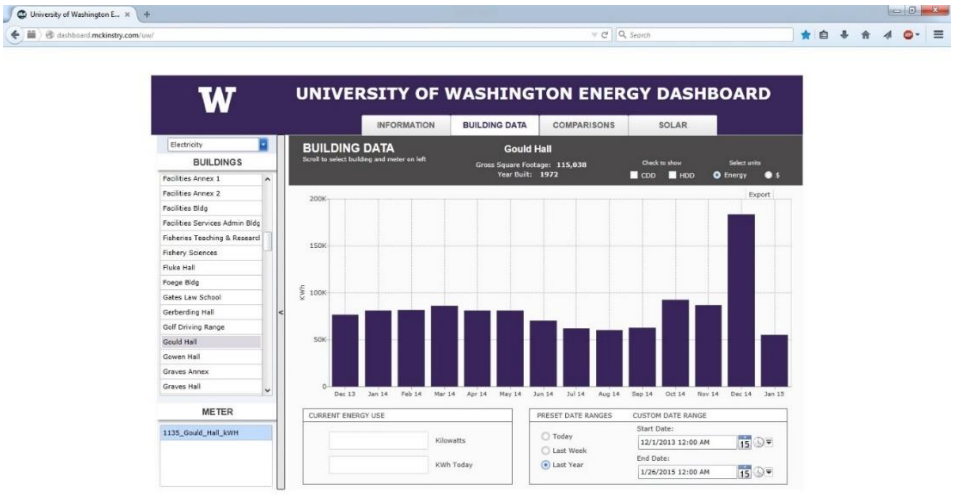

Fig. 4: UW Energy Dashboard Website

Another resource used in the BAUP is the "GeoSIMS database" developed by UW Office of Planning & Budgeting. The basic information for buildings (e.g. year of construction, Gross Square Footage (GSF) of the building, percentages of building's GSF of classrooms and offices, and building floor plans) was collected from this database. This information was used in both the preliminary analysis and the whole building energy analysis.

Finally, the BUAP used the "room schedule finder" database (provided by UW Office of registrar) for the purpose of identifying unexpected uses of buildings (refer to the section 4.4 for more details).

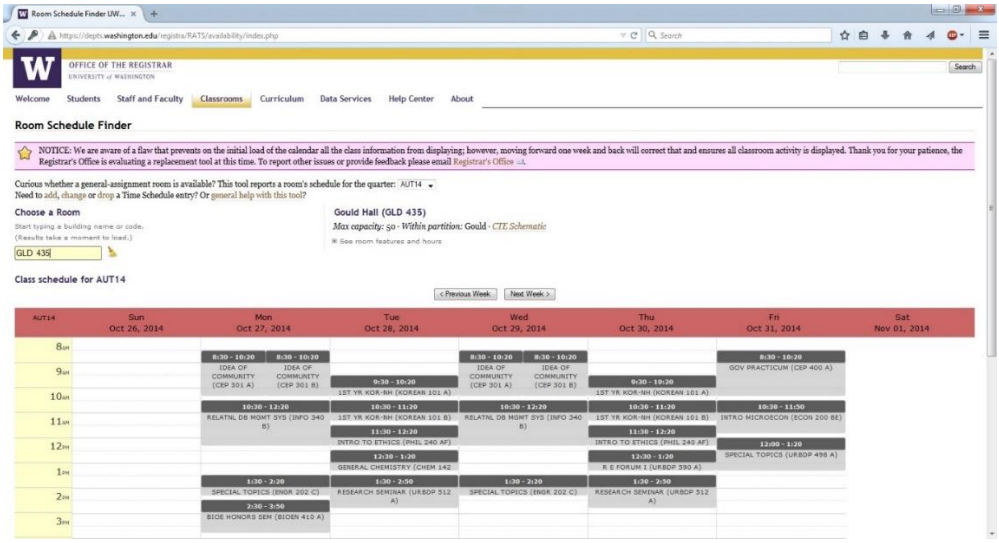

Fig. 5: Room Schedule Finder Database

3.1.2. Level 2: Building Walkthrough Analysis

The second level of building user audit begun after finalizing a preliminary list of buildings to analyze. In brief, the purpose of level 2 was to gain a better understanding of the use, condition, and operation of the buildings as well as to recognize the prerequisites for conducting a smooth building audit. Level 2 of the audit contains two steps - a questionnaire and a building walkthrough.

Building Audit Questionnaire

A set of meetings were conducted with building representatives including building manager/coordinator, facility operation and maintenance (O&M) staff, and possibly the academic head of the department(s) that primarily occupies the building. The goal of these meetings was to learn about the building operation and any related issues which may affect user behavior and

consequently energy consumption. Also, these meetings gave the energy analyst the chance to talk about the audit's goals and process and discuss any issues or expectations from both parties.

An effective collaboration and communication between the building manager and the analyst before and during the audit was necessary for the success of the audit project. In particular, the building manager played an instrumental support role facilitating the following activities:

- Facilitating access to the building for observation/auditing (building access permit(s)
- Informing building occupants of the presence of the research team (auditors)
- Recruiting faculty & staff volunteers for automated monitoring portion of the audit (installing data loggers in the selected offices)
- Facilitating access to selected rooms (faculty/staff/graduate student offices, classrooms, computer labs) for installing the energy monitoring equipment
- Sending invitations (email) to the building occupants requesting volunteer participation in the survey.

In addition, a short interview (using a questionnaire) were made with the building manager. This helped identify the types and number of building occupants (undergraduate/graduate students, staff, faculty, and irregular building users) and the pattern of building and equipment energy use. It is important to note that the building manager did not know all of the answers to these questions, so the questionnaire was intended as a conversation starter to find out perceived building uses and known idiosyncrasies of the building use and occupants.

The following questionnaire was used for the purpose of interviewing the building manager:

Building Name:

Date:

1. CONTACT(S)

a. Interviewee Name:

b. How often are you in the building?

c. Suggestions for other personnel whom we might contact (i.e. cleaning/maintenance)?

2. GENERAL BUILDING INFO

a. Space use

i. Verify general breakdown of function (as compared to maps)

ii. Is this in line with original function of the space?

iii. Is the population mainly fixed or transient?

iv. How often are there special functions in the building outside of normal scheduled events?

b. Occupancy

i. Typical occupancy hours

ii. Peak occupancy periods

iii. Weekday vs. weekend occupancy

c. Mechanical Systems

i. Operation and setback hours

ii. Efficiency and capacity

iii. Special controls?

d. Lighting Systems

i. Controls accessible to occupants?

ii. Special controls?

3. OBSERVED USER BEHAVIOR

a. Hot spots of building use (i.e. public gathering spaces, cafes, etc.)

b. Most typically used entrance doors (mark on map)

c. Are faculty/staff/administrative personnel in offices on a regular basis?

d. Are lights often left on at night?

i. Is this on purpose (for security)?

ii. Does maintenance staff regularly turn lights off?

e. Are there personal heaters or fans?

f. Is there a building policy on leaving computers and other equipment on?

g. Are there occupant on/off plug strips available for use?

h. Are windows operable?

i. Do users frequently open them?

ii. Are they often left open in vacant rooms?

4. FEEDBACK FROM USERS

A Brief Walk-through Audit

After meeting with building representatives, an initial walk-through of the building were conducted to accomplish the following tasks:

1. Become familiar with building's construction, operation, and equipment.
2. Compare building's floor plan and expected space functions (e.g. instruction area, study facility, office, etc.) collected from the GeoSIMS database with the current actual programming/use.
3. Identify potential locations for installing sensors including building entrances, computer labs, as well as sample faculty, staff, and student offices.
4. Address any issues/problems for performing audit including difficulties gaining access to offices for installing devices, disturbances in building walkthrough because of closed doors, frosted glass on doors, and temporary blocked areas, any concern or limitations building occupants or building managers may have.
5. Create a building overview using building floor plans to record: number of offices, classrooms, computer labs, and rooms with operable windows.
6. Identify areas that should be excluded from the building audit. Areas excluded from the audit include, but are not limited to: parts of buildings managed/operated by a different department not participating in the auditing project; restrooms, and specialty areas (in them occupants have no access to thermal controls and lighting switches) such as cafes, and libraries.

3.1.3. Level 3: Energy Survey and Engineering Analysis

The third level of the building user audit introduces three methods of audit including "Manual Observation", "Automated Monitoring", and "User Survey". The Level 3 implementation process for each of these three methods can be explained based on the six steps depicted in Figure 6.

Fig. 6: An Overview of this Research Process

The purpose of using three different methods of data gathering was to triangulate user behavior (physical and cultural characteristics) and its influences on energy use. Although each method of audit captures different types of data, the results of separate analyses can be compared and correlated for a more comprehensive understanding of the building performance and energy use affected by user behavior.

Manual Observation Definition

During the manual observation, auditors captured the actual use of the building spaces, which can often differ from planned or expected use. The manual observation 1) identifies energized equipment such as lighting and desktops, 2) identifies the nature of miscellaneous electric loads (MEL's) that are brought into buildings (such as laptops, cellphones, and other devices that plug in), 3) evaluates use of windows and blinds, and 4) allows a visual inspection of building occupancy.

Manual Observation Data Collection Procedure

The procedure of data collection consists of performing a building walkthrough, observing the building spaces directly, and filling out data sheets. The whole process of audit for each building took six days from Monday to Saturday and the buildings were audited at six pre-scheduled times (8am, 10am, 12pm, 3pm, 6pm, 9pm) per day. Below is a list of all types of data that are gathered during manual observation periods:

Occupancy (number of people in room) - Number of desktops in use

Lights use (on/off) - Number of TV, Projector in use

Windows open/closed - Blinds or drapes open/closed

Number of laptops - Number of laptops plugged in

Number of desk/floor lamps in use - Number of personal fan/heater in use

Number of other plug loads (cell phone, tablets, etc.)

Six students were hired and trained to perform the manual observation. Figure 7 shows a data check-sheet that auditors used to capture data. It should be mentioned that Microsoft Excel was used for recording data as well as data summarization and analysis (however, some auditors used hardcopy of data sheet at the time of walkthrough and then transferred data to the Excel sheets).

Building: **Date:** **Time:** **Observer Name:**

Floor:

Area	(reference room # on map):														
	Room Conditions														
	Number of people present:														
	Lights on? (yes/no)														
	Windows open? (yes/no)														
	Blinds/drapes open? (yes/no)														
	Temperature (from thermostat)														
	Desktops														
	Number of desktops on (not idle):														
	Laptops														
	Number of laptops:														
	Number of laptops plugged in:														
	Projectors														
	Number of projectors in use:														
	Televisions:														
	Number of TVs in use:														
	Other plug loads:														
	Number of desk/floor lamps in use														
	Number of personal fans in use														
	Number of personal heaters in use														
	Number of cell phones/tablets plugged in:														
	Other:														

People Counters	1	2	3	4	5	6	7	8	9	10
Number (in)										
Number (out)										

Fig. 7: The manual observation data sheet

An "analyst building walkthrough" were performed on the first day of each building audit to identify the total number and types of MEL's (energy-using equipment) in the building and the total number of vacant rooms in the building as well as to respond to any issues that could occur on the first day of the audit.

Building Auditor Instructions

Several students worked as auditors during the project. Although, doing a building walkthrough and filling out a check sheet may seem to be an easy work task, it could be a challenging task in practice and raise some issues in the phase of data retrieval and analysis. Therefore, instructing the auditors was an important part of the audit. An orientation session was held before starting the audit to instruct the auditors and address questions that could arise. The session included the following points:

As the first step, auditors were informed about the goals, procedure, and process of audit. Considering the fact that each room in the building (including faculty and staff offices) was audited six times per day necessitating consistency in methodology during the audit which could be a

challenge during manual auditing. The auditors were instructed to have minimum interruption for the building occupants (e.g. not entering the office if its door is closed). Still, the auditors had to be well prepared to inform occupants about their work and appropriately deal with different reactions.

Standardization of check sheets was probably the most important point and was needed to be discussed with the auditors. Because, a standardized format for filing out the check sheets eliminates potential errors in the Excel summary sheets and may significantly shorten the process of data retrieval and analysis. To standardize data collection, the recommendations for shorthand notation indicated in Table 3 had to be followed carefully.

Table 3: Standard form of data collection

Character	Meaning	Example
y	Yes	For the questions "is light on?" and "is window open?"
n	No	Same as above
h	Half	Half of the ceiling lights are on or drapes/blinds are open in half
NA	Not applicable	The device (e.g. projector) does not exist in room.
L	Locked	The door of room is closed/locked
(empty)		If the value of cell is zero the auditor can write 0 or leave the cell empty
For most cells in the sheets a number (people and devices) should be written. If an accurate counting is not possible (e.g. in a class rooms or conference rooms with a huge number of occupants) the best estimated number should be written.		

The auditors were asked to only count the equipment if it is in use. In this case, a computer, for example, was considered as "in use" if the monitor is on and is not idle. A TV and/or projector was considered "in use" if they are on (even if the user is not actively engaged with them). It should be mentioned that devices such as printers, copiers, scanners, refrigerators, microwaves, and coffee makers should not be counted during the daily audits. Because they were counted during the one time analyst walkthrough audit. These devices were considered as "in use" if they were plugged in and on. In addition, no cell in the excel sheet should be left empty unless the only condition explained in Table 3 applies. Because an empty sheet or cell could be interpreted in different ways

(such as the data was not recorded, the room was not accessible, or if the values of data were zero), which was confusing for the analyst and decreases the data accuracy.

Finally, the submitted data sheets were checked in a daily basis to ensure recorded data were completed and accurate. For this purpose the data of submitted Excel documents were transferred to the smart Excel sheets.

Automated Monitoring Definition

Automated data loggers were used to capture detailed data about the building and occupant's behavior. The data collected were then categorized into two groups: 1) energy (electricity) use and 2) indoor environmental quality (temperature, humidity, and lighting). The first group is useful to determine the amount of user-influenced energy consumed. The data in the second group helps to understand the motivations that may trigger a building user's behavior and may help explain fluctuations or changes in the recorded data.

Automated Monitoring Data Collection Procedure

The different types of automated devices and types of data they collect are introduced in this section:

1. HOBOs: Two types of hobos were used in the audit (Figure 9). They capture the following data:
    - HOBO, UX90 records room occupancy (time room is occupied in seconds) and light use (time light is on in seconds).
    - HOBO, UX100 captures average room temperature (°F) and relative humidity (%).
    - Both devices should be programmed to record data in 15 minute intervals for 24 hours per day throughout the period of audit.

Fig. 8: HOBO data loggers, UX90 (left) and UX100 (right) (Source: www.onetemp.com)

2. Watts UP meter: this device monitors the plug loads of MEL's (miscellaneous electric load equipment) (Figure 9). The meter is plugged into a wall outlet, and the MEL's (equipment) to be monitored are plugged into the meter. The Watts Up meter captures power (kW) and energy (kWh) usage at 15 minute intervals for the duration of the time the meter is plugged in. Since the goal of the audit was to identify the amount of electricity used by the room occupants any electrical equipment (MEL) present in the room were plugged into the meter (an extension cord should be used if needed). However, no lighting devices such as desk lamps could be plugged in because the amount of energy consumed for lighting was determined separately (using HOBOs). Also, it was assumed that each room selected for audit had only one occupant.

Fig. 9: Watts-UP Meter (Source: www.upsforless.com)

3. People counter: This device was used to record the number of people who enter and exit the building. For this purpose, counters were installed in all entrances of the building. The number of people in/out could be seen on a small screen on the device. However, the numbers should also be read manually which could be done by the building auditors at the time of building walkthrough. It should be noted that in addition to automated people counters the number of occupants was manually recorded at regular intervals by building auditors during the building walk-throughs.

Fig. 10: People counter (Source: www.all-tag.com)

The automated monitoring occurred over the same time period as the manual monitoring method. In other words, the time of automated data collection begun at the same time as the manual observation started on Monday and ended at the same time on Saturday. Table 5 shows the number of devices and the number of rooms were planned to be audited in each building. The energy analyst tried to select the rooms from different parts of the building so that the results of analysis could be generalized to all other rooms in the building with the same type of occupancy. For example, in the case of selecting faculty offices it was attempted to select them from different floors and with various orientations to sun and wind as well as access to operable windows.

Table 4: Number of selected rooms and types of devices installed in

	2 Classrooms	3 Faculty/Grad Student Offices	3 Staff Offices	2 Computer Labs
HOBO, UX90	Y	Y	Y	NA
HOBO, UX100	Y	Y	Y	NA
Watts UP	NA	Y	Y	Y

Table 5 outlines installing eight HOBO devices of each type and eight Watts Up meters for the purpose of this audit. The number of people counters depends on the number of building entrances varied from six to eight.

User Survey Definition

The survey explores the link between building occupants' perceptions of energy use (survey) and actual energy consumption affected by occupant behavior (manual and automated energy use audits). Also, the survey variables aim to capture: values, beliefs and attitudes of building user that may encourage or discourage them to behave pro-environmentally. Another purpose is to develop a behavioral baseline capturing the interplay between individuals and their built environment (cultural context) that is necessary to understand the impact of users on energy consumption. The user survey consists of the following eight categories and includes twenty questions to address both physical and cultural characteristics of user behaviors:

- Building Use (questions 1 to 4)
- Miscellaneous Electric Loads (MELs) Equipment Inventory: (question 5)
- Energy Related Intentions and Behaviors (questions 6 to 9)
- Occupant Comfort (questions 10 and 11)

- Climate Action Plan (CAP) related items (questions 7, 8, 13, and 14)
- Inherent Value Orientations (question 12)
- Climate Change Beliefs (question 15)
- Socio-demographic measures (questions 16 to 20)

User Survey Data Collection Procedure

The survey was developed using the web-based UW Catalyst site. Audited buildings occupants including faculty, staff, graduate students and undergraduate students were invited by email to participate in the study. Invitations were distributed through the respective building managers. After activating the web-based survey each building community were given one month to complete the anonymous survey. Meanwhile, reminder emails were sent out one week prior to the close of the survey, a few days before the close, and to increase participation, the day before the close.

The formatted copy of user survey as well as brief descriptions of survey questions are provided as follows:

In general questions 1-4 captures data regarding the pattern of building use. Questions 5-11 collect physical characteristics of user behaviors (e.g. miscellaneous electric loads, lighting, thermal comfort, etc.). While, question 12 asks about user values that may impact their environmental behaviors. Questions 13 and 14 were asked to know user opinions about UW initiatives (particularly UW climate action plan*) and their effectiveness to reduce carbon reductions. Question 15 captures user's pro-environmental values and beliefs. Finally, questions 16-20 collect building user's demographics information.

* UW Climate Action Plan (CAP) describes commitments of UW to meet its obligation for greenhouse gas (GHG) emissions reduction. A survey were designed by UW CAP communication team and sent out to UW community to measure awareness, attitudes and behaviors regarding reducing energy use and carbon emissions on campus. (Source: www.green.uw.edu/cap/survey)

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The University of Washington Green Seed Fund Research Team is developing an energy use audit tool to analyze people's understanding of energy and how their actions affect its use in campus offices, classrooms, and buildings. In the spring of 2014, you were invited to participate in this audit because you were a regular building user in one of the three buildings of interest to the study. In the fall of 2014, the team will be conducting a second round of the survey and the monitoring sessions to fine-tune the audit tool. As in round one, there are two parts to the audit in round two and we hope that you will continue your support of the project and participate in the second and final round.

Question 1.
This survey is being sent out to regular building users as part of a University of Washington research study to make building use greener. Which building do you use on a regular basis:

- ○ Gould Hall
- ○ Savery Hall
- ○ Dempsey Hall
- ○ I do not regularly use any of these buildings
- ○ Other: _____

Question 2.
Keeping in mind the building you listed above, on average, how many hours a WEEK do you use this building:

- ○ Less than 5 hours per week
- ○ 6-20 hours per week
- ○ 21-40 hours per week
- ○ More than 40 hours per week

Question 3.
In general, what times of day do you use this building (choose a maximum of 4 responses):

Limit response to four answers.

- ☐ Morning
- ☐ Afternoon
- ☐ Evening before 10:30 pm
- ☐ Evening after 10:30 pm
- ☐ Weekday
- ☐ Weekend

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Question 4.

Which of the following best describes your use of this building on campus (choose a maximum of 4 responses):

Limit response to four answers.

- ☐ General Classroom
- ☐ Office
- ☐ Computer Lab
- ☐ Lecture Hall
- ☐ Study or social area
- ☐ Other: _____

Question 5.

Which pieces of equipment do you keep at your desk, workstation, or office and how freqently do you use each of them? (Choose all that apply):

	Less than 5 hours per week	6-20 hours per week	21-40 hours per week	More than 40 hours per week
Computer	☐	☐	☐	☐
Monitor	☐	☐	☐	☐
Laptop	☐	☐	☐	☐
Projector	☐	☐	☐	☐
Printer/copier	☐	☐	☐	☐
Scanner/copier	☐	☐	☐	☐
Tablet/cell phone (charging)	☐	☐	☐	☐
Desk lamp	☐	☐	☐	☐
Microwave	☐	☐	☐	☐
Refrigerator	☐	☐	☐	☐
Tea or coffee pot	☐	☐	☐	☐
Personal heater	☐	☐	☐	☐
Personal fan	☐	☐	☐	☐
TV	☐	☐	☐	☐
Radio	☐	☐	☐	☐
Music CD Player	☐	☐	☐	☐
VCR	☐	☐	☐	☐

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Question 6.
Is there another piece of equipment that you use at your desk, workstation, or office that was not listed above? Please list other equipment in the space provided below.

For each piece of additional equipment, please tell us the frequency of use:

- Less than 5 hours per week
- 6-20 hours per week
- 21-40 hours per week
- More than 40 than hours per week

Question 7.
On LEAVING your office, classroom, and/or building named above, which actions do you do:

	Almost Always	Sometimes	Never	Don't have control over this	Don't have this item
Turn off and unplug your computer and / or laptop	☐	☐	☐	☐	☐
Turn off and unplug your monitor	☐	☐	☐	☐	☐
Turn off and unplug cell phone or tablet charger	☐	☐	☐	☐	☐
Turn off and unplug small equipment: projector, printer, copier	☐	☐	☐	☐	☐
Set room thermostat cooler in the winter and/or warmer in the summer summer	☐	☐	☐	☐	☐
Turn off and unplug personal heater or fan	☐	☐	☐	☐	☐
Close windows	☐	☐	☐	☐	☐
Close shades, blinds, or shutters	☐	☐	☐	☐	☐
Turn off desk lamp	☐	☐	☐	☐	☐
Turn off lights	☐	☐	☐	☐	☐
I unplug my equipment individually or turn off a plug strip designed to reduce standby loads (computers, monitors, copier, etc.)	☐	☐	☐	☐	☐

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Question 8.
Which ACTIONS do you incorporate into your daily routine (choose all that apply):

- ☐ Turn off power to my computer and monitor
- ☐ Turn off plug strip designed to reduce standby loads (computers, monitors, copier, etc.)
- ☐ Adjust the room thermostat
- ☐ Turn off my personal heater or fan
- ☐ Make sure windows are closed
- ☐ Close window shades or blinds
- ☐ Turn off desk lamp
- ☐ Turn off lights
- ☐ Make sure water is turned off in kitchens, bathrooms, and washrooms
- ☐ Turn off power to small appliances (fan, heater, coffee pot, tea pot, radio, etc.)
- ☐ Other: _____

Question 9.
Which ACTIONS do you expect to be automated and so you do NOT incorporate them into your daily routine (choose all that apply):

- ☐ Control over lighting levels
- ☐ Window blind / shade controls
- ☐ Window operation controls (open / close)
- ☐ Fresh air supply
- ☐ Temperature controls
- ☐ Water supply at sink fixtures
- ☐ Toilet flushing
- ☐ Other: _____

Question 10.
In general, are you comfortable in this building on the:

	Almost Always	Sometimes	Almost Never	Never
Hottest days in the summer	○	○	○	○
Coldest days in the winter	○	○	○	○
Mornings	○	○	○	○
Afternoons	○	○	○	○
Evenings before 10:30 pm	○	○	○	○
Evenings after 10:30 pm	○	○	○	○
Weekdays	○	○	○	○
Weekends	○	○	○	○

Question 11.
To adjust your comfort level in this building, which strategies do you use the most (choose a maximum of 4 responses):

- ☐ Open or close windows
- ☐ Adjust clothing layers, for example put on a sweater
- ☐ Open or close window shades or blinds
- ☐ Call facilities maintenance to have temperature adjusted
- ☐ Turn on or off your personal fan or heater
- ☐ Other: _____

Question 12.
Below you will find 16 VALUES. Behind each value there is a short explanation concerning the meaning of the value. Please rate how important each value is for you AS A GUIDING PRINCIPLE IN YOUR LIFE?

The rating scale is as follows:

- **-1** means the value is *opposed* to the principles that guide you
- **0** means the value is *not important at all;* it is not relevant as a guiding principle in your life
- **1,2,3,4,5** means the value is increasingly *important*
- **6** means the value is *very important*
- **7** means the value is of *supreme importance* as a guiding principle in your life; ordinarily there are no more than two such values

Your scores can vary from -1 up to 7. The higher the number (-1, 0, 1, 2, 3, 4, 5, 6, 7), the more important the value is as a guiding principle in YOUR life. Try to distinguish as much as possible between your ratings of the values by using different numbers.

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	-1	0	1	2	3	4	5	6	7
EQUALITY: equal opportunity for all	☐	☐	☐	☐	☐	☐	☐	☐	☐
RESPECTING THE EARTH: harmony with other species	☐	☐	☐	☐	☐	☐	☐	☐	☐
SOCIAL POWER: control over others, dominance	☐	☐	☐	☐	☐	☐	☐	☐	☐
PLEASURE: joy, gratification of desires	☐	☐	☐	☐	☐	☐	☐	☐	☐
UNITY WITH NATURE: fitting into nature	☐	☐	☐	☐	☐	☐	☐	☐	☐
A WORLD AT PEACE: free of war and conflict	☐	☐	☐	☐	☐	☐	☐	☐	☐
WEALTH: material possessions, money	☐	☐	☐	☐	☐	☐	☐	☐	☐
AUTHORITY: the right to lead or command	☐	☐	☐	☐	☐	☐	☐	☐	☐
SOCIAL JUSTICE: correcting injustice, care for the weak	☐	☐	☐	☐	☐	☐	☐	☐	☐
ENJOYING LIFE: enjoying food, leisure, etc.	☐	☐	☐	☐	☐	☐	☐	☐	☐
PROTECTING THE ENVIRONMENT: preserving nature	☐	☐	☐	☐	☐	☐	☐	☐	☐
INFLUENTIAL: having an impact on people and events	☐	☐	☐	☐	☐	☐	☐	☐	☐
HELPFUL: working for the welfare of others	☐	☐	☐	☐	☐	☐	☐	☐	☐
PREVENTING POLLUTION: protecting natural resources	☐	☐	☐	☐	☐	☐	☐	☐	☐
SELF-INDULGENT: doing pleasant things	☐	☐	☐	☐	☐	☐	☐	☐	☐
AMBITIOUS: hard-working, aspiring	☐	☐	☐	☐	☐	☐	☐	☐	☐

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Question 13.
The UW has many initiatives to reduce its carbon emissions. How aware are you of the following on-going initiatives at the UW:

	Very aware	Somewhat aware	Not aware	Don't know what this is
Developing a regional Smart Grid network.	○	○	○	○
Operating free shuttle services around campus.	○	○	○	○
Monitoring all of its campus buildings' energy consumption.	○	○	○	○
Offering bike lockers, bike racks, and secure indoor "bike rooms" throughout campus.	○	○	○	○
Purchasing only Energy Star rated appliances.	○	○	○	○
Monitoring all of its campus buildings' water consumption.	○	○	○	○
Offering telecommuting options for staff.	○	○	○	○
Funding for students and [illegible] projects and research.				
Committing to a Climate Action Plan to reduce its campus emissions.	○	○	○	○

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Question 14.
Of the following ongoing UW initiatives, please estimate what you believe to be the impact of each on the University's reduction of carbon emissions:

	High Impact	Medium Impact	Low Impact	No Impact
Decreasing water consumption.	○	○	○	○
Decreasing paper purchasing.	○	○	○	○
Increasing purchases of recycled products	○	○	○	○
Increasing purchasing of locally processed food.	○	○	○	○
Decreasing the number of UW community members who drive alone to campus	○	○	○	○
Maintaining campus energy consumption at current levels despite increases in buildings and population.	○	○	○	○
Increasing number of LEED certified buildings on campus.	○	○	○	○
Decreasing amount of waste sent to landfills.	○	○	○	○

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Question 15.
To what extent do you agree with the following statements:

	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree
Acting environmentally-friendly is an important part of who I am	○	○	○	○	○
We do NOT need to worry about global warming or climate change	○	○	○	○	○
I am the type of person who acts environmentally friendly	○	○	○	○	○
Government regulations are the best way to solve environmental problems	○	○	○	○	○
There is something that I can do to help stop climate change	○	○	○	○	○
The free market is the best way to solve environmental problems	○	○	○	○	○
I see myself as environmentally-friendly person	○	○	○	○	○

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Question 16.
Which of the following best describes your role on the UW campus:

- ○ Undergraduate
- ○ Graduate or Professional Student
- ○ Staff Member
- ○ Faculty Member
- ○ Other: [ ]

Question 17.
What college, department, or major do you most identify with?

Limit response to 30 characters.

[ ]

Question 18.
What is your age in years?

- ○ 18-25
- ○ 26-45
- ○ 46-65
- ○ Over 65

Question 19.
What is your income per year in US dollars?

- ○ 25,000 or less
- ○ 25,001- 50,000
- ○ 51,000-100,000
- ○ 100,001 or more

Question 20.
What is your highest level of education completed?

- ○ High School or GED
- ○ Some trade school or two year community college
- ○ Trade school or two year community college degree
- ○ Some college
- ○ Four or five year college degree
- ○ Some masters graduate level work
- ○ Masters degree
- ○ Some doctoral graduate level work
- ○ Doctoral degree

Question 21.
Is there any other feedback you would like to share with regard to energy use, behavior, and awareness?

Thank you from the University of Washington Green Seed Research Team!

3.2. Project Timeline and Main Activities

Timeline: The duration of this project was one year, starting in February 2014. Two rounds of building audits occurred during the project with kick-off, mid-year, and final presentations to the University of Washington Capital Projects Office (CPO) and Facility Services (FS). After a Spring kick-off meeting and building selection, the first round of audits (manual observations, automated monitoring, and user survey) were completed in May 2014. During the summer of 2014, the project team conducted data retrieval & analysis. Subsequently, the audit procedure were revised based on the results of first round of audit. After audit procedure refinements a second round of audits was conducted in fall 2014 with analysis and final reporting including final presentation to FS and CPO in winter 2015.

Audit Refinements: Based on the experience gained from the first round of auditing, the project team refined the audit procedures. For instance, the manual observation protocol was standardized, automated data collection methods were revised for ease of implementation, and data interpretation and visualization was improved. Also, the time period of manual and automated data gathering were increased to six days (previously four) for the purpose of improving data accuracy and having a pattern of building uses for a typical week/weekend. Standardization of manual observation instructions and a new check-sheet were provided to building auditors during a training session. This helped the auditors to do the building walk-through and fill out the check sheet much faster and also decreased the time of data processing significantly.

In October and November 2014 the second round of audits were initiated and invitations were sent to the building managers of the three buildings that participated in the first round audits (Gould, Savery, and Paccar). Paccar Hall did not confirm its participation in the second round audit. Thus, the project team identified alternative buildings (in the same “new buildings” group) on campus to find a replacement for Paccar Hall. The team found that Dempsey Hall was an appropriate replacement for the second round audit. Dempsey Hall is another building of the UW Foster School of Business, is adjacent to Paccar Hall, and is similar in many aspects. One difference is that Dempsey Hall does not have a computer lab or faculty offices, which are part of the automated monitoring protocol. Despite Dempsey Hall's lack of these program elements, the building auditors were still able to capture valuable data. The auditing process description handed out to the building managers as well as flyers sent to the building users are found in Appendices.

As part of the automated monitoring method, for the first round of audits, the team intended to use an automated people counting system. Though the team made a good effort to install and run the system, the equipment was not technically capable of performing this task (the signal strength was too weak between sensors and a hub that consolidated data), and thus data could not be recorded correctly. For the second audit, however, the project team overcame this problem by re-evaluating the people counting technology and replacing the previous system with another people counting technology. The new system had an internally dedicated data storage capability in place of a consolidated data hub. The number of people that entered and exited the building was recorded in an incremental manner and showed on a small screen on the device. This allowed the auditors to read and record the number of people in/out at the pre-scheduled times of audit every day.

In the case of implementing user survey, the project team made some changes to the questions of survey based on the results of data analysis. Another major change in implementing the survey for second round of auditing was that the project team got a new approval from IRB to include undergraduate students in the study. This was particularly important because this is the largest group of building occupants and they may have the greatest impact on energy use in the buildings.

3.3. Summary

The building user audit procedure (BUAP) is an audit tool that analyzes physical and cultural aspects of building user behaviors and their impacts on energy consumption. Three methods of data collection manual observation, automated monitoring, and user survey were used to capture both perceived and actual user behaviors.

Below is a summary of key activities should be done for a successful conduction of BUAP.

1. Preliminary Analysis
    - Building Selection
    - Access to Databases: gaining access to the UW Energy Dashboard, GeoSIMS, and UW Room Schedule Finder databases and obtain required documents and information for the audited building (e.g. floor plans, building general information, and contact information of key members).

2. Walk-through Analysis
    - Interview with Building Manager to gain the basic information about the building's occupants and also to coordinate with him/her to conduct the building audit.
    - Basic Building Walkthrough to gain familiarity with the building and to identify any issues that may affect the building audit.
3. Energy Survey & Engineering Analysis
    - Manual Observation:
        - Perform an analyst building walkthrough (preferably, on the first day of the regular building walkthrough) to conduct a comprehensive equipment assessment and to help identify potential issues that auditors may face.
        - Regular Building Walkthrough: Performing the daily building walkthrough (by auditors) to capture needed data by fill out the data sheets.
    - Automated Monitoring: Install data loggers in selected rooms and people counters in building entrances to capture energy and occupancy data.
    - User Survey: Send a web-based survey to the building users (faculty, staff, and students) to evaluate their energy behaviors in a cultural context.

Figure 11 shows the three levels of building audit implementation.

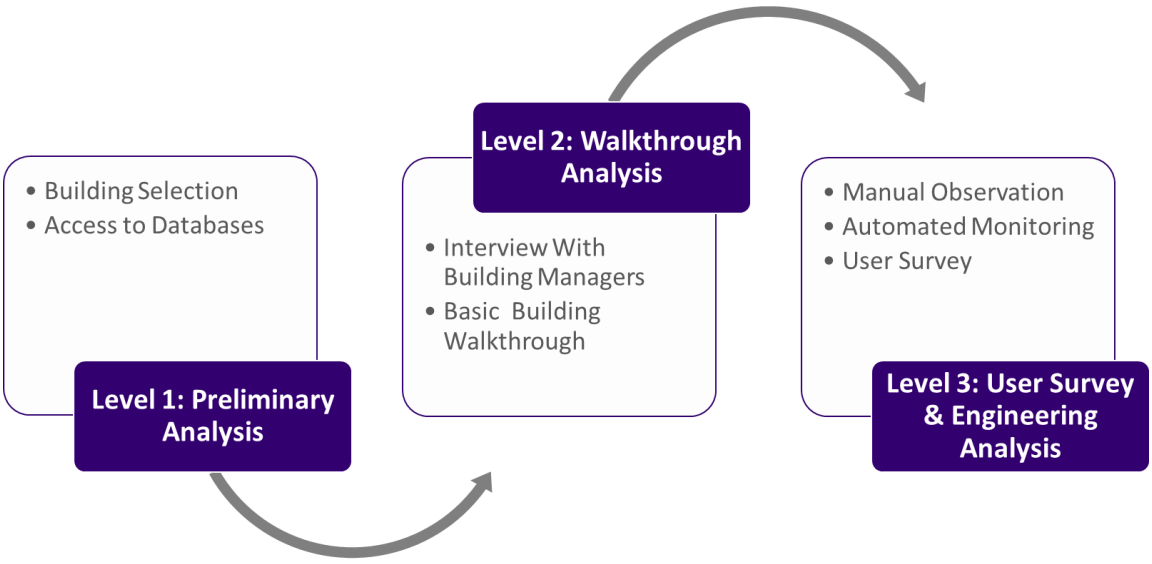


Fig. 11: BUAP Process of Implementation

4. Analysis

Three different data collection methods were used to capture selected types of data related to energy-influencing occupant's behavior: manual observation, automated monitoring, and a user survey. This Chapter explains the proper form of data visualization for each method and represents the results of data analysis for the audit. It should be mentioned that this section does not provide all of the tables and graphs created for the data analysis and visualization. The complete profiles of the selected buildings (Gould Hall, Savery Hall and Dempsey Hall) can be found in the Appendices.

4.1. Manual Observation

To implement the manual observation portion of the audits, building walkthroughs were conducted at prescheduled times of the day and building auditors filled out data sheets to capture the actual use of the building spaces (classrooms and offices) and equipment using miscellaneous electric loads (MELs). Two primary forms of data analysis and visualization were provided to extract most useful information about building performance and user behavior:

Manual observation summary sheets: The summary sheets are the tables that summarize the data collected during the whole period of audit. A total of 36 data sheets were submitted for each building; sorted by different days of the week and by different pre scheduled hours of the day. These data sheets will be used to create a building factsheet demonstrating tangible findings of the whole audit (different sources should be investigated to create the factsheet including data summary sheets, results of preliminary analysis, automated monitoring, and the analyst building walkthrough. However, the content of the factsheet may vary based on the building that is audited (the building fact sheets are attached to appendices).

Weekly profiles of occupancy and energy use: Based on the data sheets, graphs can be created to show the profile of building occupancy and energy use. In this regard, the graphs indicate the pattern of occupancy, use of desktops/laptops, and use of lights. In these weekly profiles, the pattern of building & equipment use can be compared between different days and the weekend. Also, the peak times of use can be identified and the number of equipment or devices in use can be compared with the total number of devices.

Table 5 is a sample manual observation summary sheet. The tables show a weekly and daily profile of building/equipment use respectively.

Table 5: The Manual Observation Summary Sheets (data are sorted base on different days of the week and different hours of the day)

Type of Data	Mon.						Tue.						Wed.						Thu.						Fri.						Sat.					
	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM
Total number of people present	197	307	322	281	228	113	48	309	333	321	190	113	46	330	422	410	190	84	81	364	393	346	131	33	85	231	232	240	38	21	13	52	88	79	38	16
Total number of room with light on	36	86	28	92	24	18	32	97	30	89	28	18	22	87	27	85	24	15	35	102	26	84	22	12	32	67	30	72	16	14	6	14	4	16	20	2
Total number of rooms with opened windows	0	7	0	0	1	0	1	6	0	0	1	0	14	7	0	0	3	0	4	8	0	4	4	0	3	4	0	0	2	0	4	5	0	0	3	0
Total number of rooms with opened blinds/drapes	28	34	0	40	10	5	22	37	16	41	17	5	15	42	17	41	16	11	23	41	17	31	10	4	20	32	16	36	11	0	10	15	0	15	12	0
Average rooms temperature	72	71	NA	73	69	NA	72	72	NA	73	NA	NA	73	72	NA	73	72	NA	71	72	NA	73	70	NA	71	71	NA	73	69	NA	70	70	NA	NA	70	NA
Total number of desktops on	19	106	31	48	9	2	47	74	26	47	12	2	12	45	23	58	10	6	79	74	28	49	48	1	33	43	19	29	1	2	0	3	0	1	2	0
Total number of laptops present	11	38	0	94	53	54	8	47	26	91	43	54	0	44	33	106	51	62	10	50	30	95	25	14	9	29	26	44	11	0	1	8	0	27	25	0
Total number of laptops plugged in	2	23	0	83	19	23	1	18	10	77	7	23	1	31	14	84	16	30	3	27	13	90	9	8	0	12	10	41	7	0	0	3	0	27	14	0
Total number of projectors in use	3	2	0	6	2	2	1	4	3	5	7	2	1	2	9	5	5	5	0	9	8	5	8	1	2	4	3	7	2	0	0	0	0	1	3	0
Total number of TV's in use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of desk/floor lamps	2	6	0	1	0	0	5	4	1	1	2	0	2	10	0	1	0	0	7	11	4	3	0	0	0	5	1	2	0	0	0	0	0	0	0	0
Total number of personal fans	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Total number of personal heaters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of cell phones plugged in	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
Total number of tablets plugged in	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	2	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0

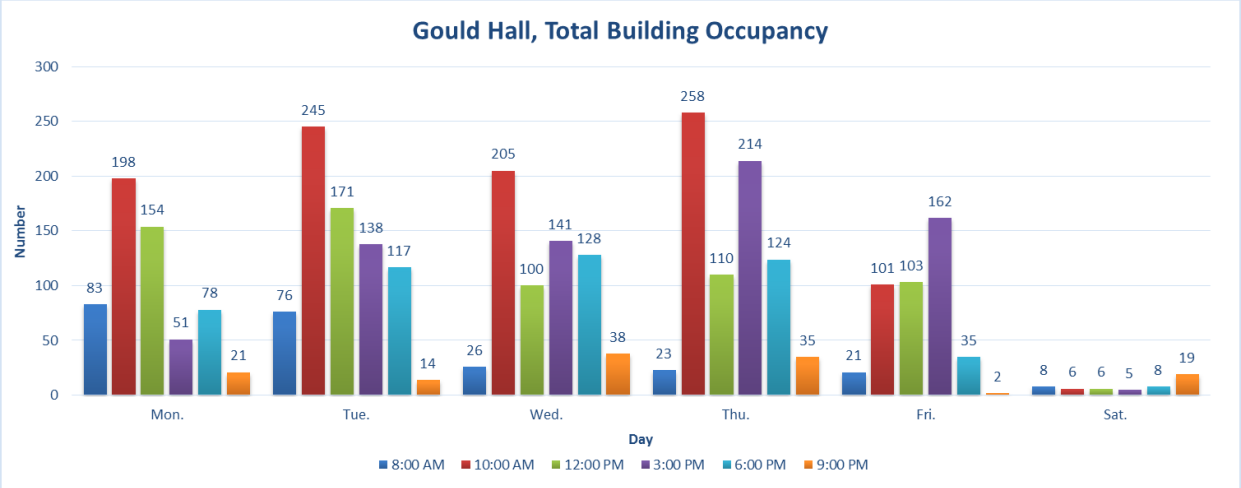
Type of Data	8 AM						10 AM						12 PM						3 PM						6 PM						9 PM					
	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
Total number of people present	83	76	26	23	21	8	198	245	205	258	101	6	154	171	100	110	103	6	51	138	141	214	162	5	78	117	128	124	35	8	21	14	38	35	2	19
Total number of room with light on	15	18	12	11	12	3	32	29	34	32	29	6	17	21	18	11	12	1	26	28	20	26	22	4	24	24	17	20	13	14	9	6	6	5	1	2
Total number of rooms with opened windows	0	0	0	0	0	1	4	2	2	1	2	3	2	0	0	1	1	0	0	0	0	0	0	0	3	0	2	1	1	2	0	0	0	0	0	0
Total number of rooms with opened blinds/drapes	14	21	17	15	13	10	6	15	16	17	19	10	11	8	13	3	3	1	23	18	14	20	13	3	0	2	5	1	4	2	0	0	2	0	0	1
Average rooms temperature	62	61	62	69	61	70	65	66	65	69	71	71	64	62	67	70	NA	NA	65	64	67	65	67	NA	64	63	NA	NA	70	71	NA	NA	NA	NA	NA	NA
Total number of desktops on	19	23	11	6	4	0	63	45	71	69	40	4	33	61	51	25	32	2	27	46	44	49	35	4	30	19	25	14	6	8	15	2	13	33	1	5
Total number of laptops present	13	18	6	7	6	0	39	30	48	44	49	1	34	27	13	16	20	3	15	17	39	27	16	0	15	35	30	19	0	1	6	4	4	5	1	1
Total number of laptops plugged in	3	10	3	5	1	0	6	20	18	16	24	1	15	18	8	7	8	1	14	11	25	18	16	0	3	8	11	2	0	0	5	3	1	5	1	0
Total number of projectors in use	0	1	0	0	0	0	1	1	3	1	5	2	2	4	1	1	1	0	1	4	4	4	1	0	3	5	0	2	0	0	0	0	0	0	0	0
Total number of TV's in use	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
Total number of desk/floor lamps	5	14	8	6	2	0	0	9	7	11	12	1	0	8	10	7	7	0	2	9	10	6	6	0	0	1	4	2	8	1	0	0	0	0	0	0
Total number of personal fans	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of personal heaters	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of cell phones plugged in	0	2	1	0	0	0	0	0	0	0	0	0	4	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Total number of tablets plugged in	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

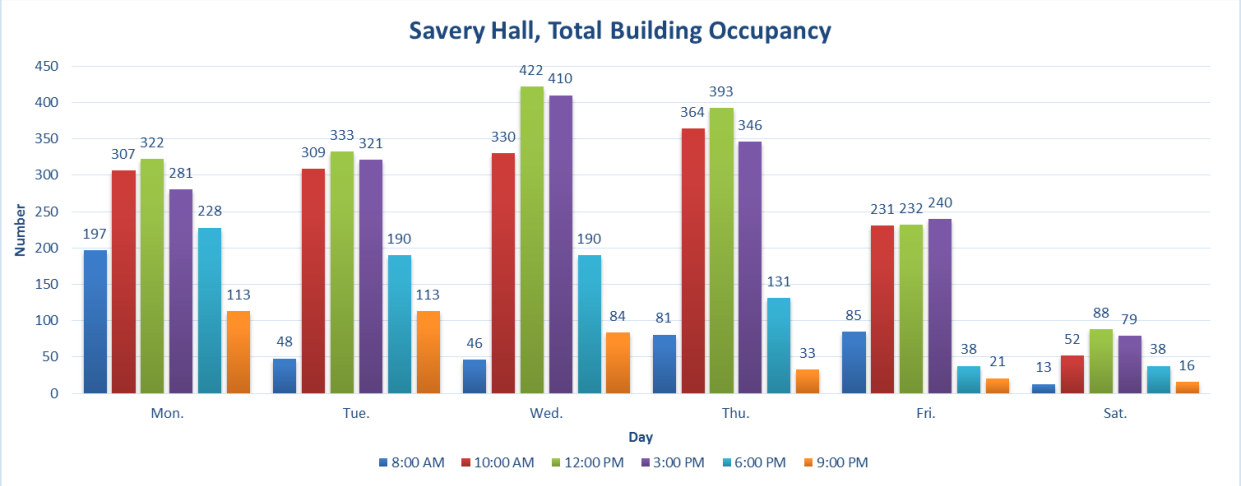
Figure 12 indicates the pattern of building occupancy and the total number of people present in the building. According to these graphs, the peak hours of building use and the maximum number of people can be determined. The peak hours of occupancy are 10 am and 3 pm with about 225 people present in Gould Hall, 12pm with about 350 people present in Savery Hall, and 8 am & 3 pm with about 170 people present in Dempsey Hall. Additionally, it can be seen that the number of people significantly decreases after the working hours (6pm) and on the weekends in all three buildings. The general occupancy on Fridays is considerably less than other business days of the week (specifically in Savery Hall and Dempsey Hall). However, it is still hard to specify a certain daily pattern of occupancy for any of these buildings.

The number of desktops in use for each of the selected buildings is indicated in Figure 13. Based on this data, 10am is the peak hour of desktop use. At the peak hour almost 60% of desktops are in use in Gould Hall compared to 61% in Savery Hall, and 88% in Dempsey Hall. Similar to building occupancy data, the number of desktops in use significantly decreased after business hours and also on the weekends in all the three buildings.

The Figure 14 shows the number of rooms with electric lights on and the pattern of light use. Based on these data, 10am and 3pm are clearly the peak hours of lighting use in all buildings. Regarding the duration of lighting use the difference between peak hours and other (normal) times is much higher in Savery and Dempsey Halls than in Gould Hall. In addition, fluctuations in the number of rooms (with lights on) follows a more certain pattern in Savery and Dempsey Halls.

Finally, Figure 15 shows the average number of laptops brought into the building and the number that were plugged in. In Gould Hall approximately 19% of the users bring their own laptops into the building compared to 25% in Savery Hall and 27% in Dempsey Hall. Also, about 51% of the laptops are plugged in in Gould Hall. While, this value is about 50% in Savery Hall and 39% in Dempsey Hall.





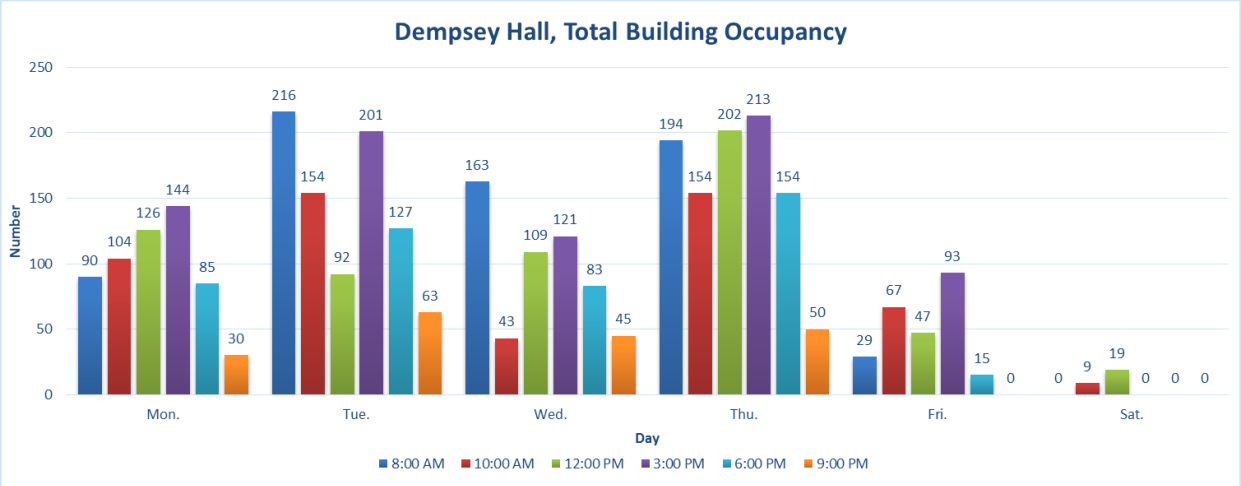
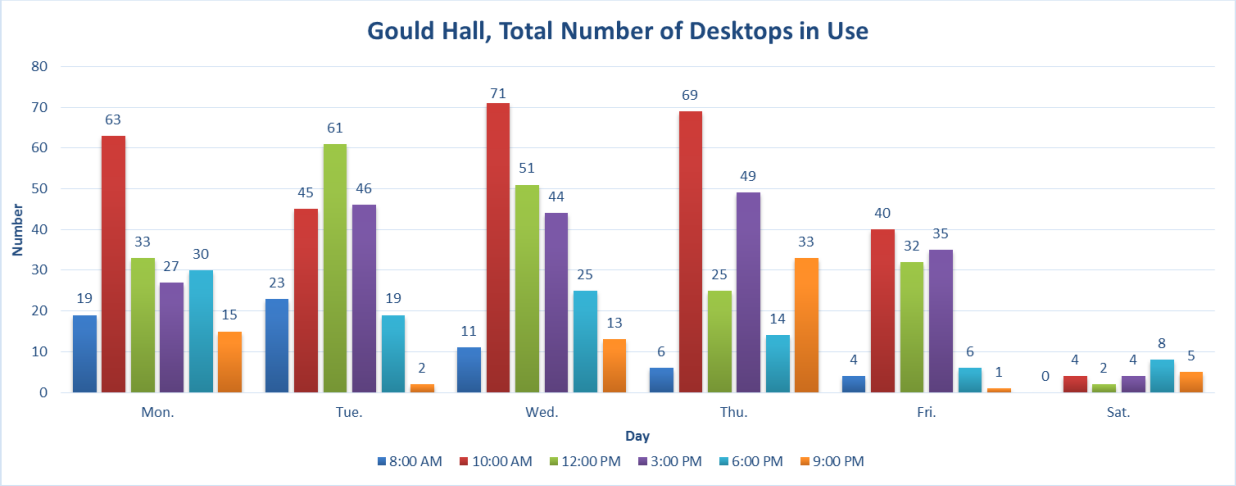
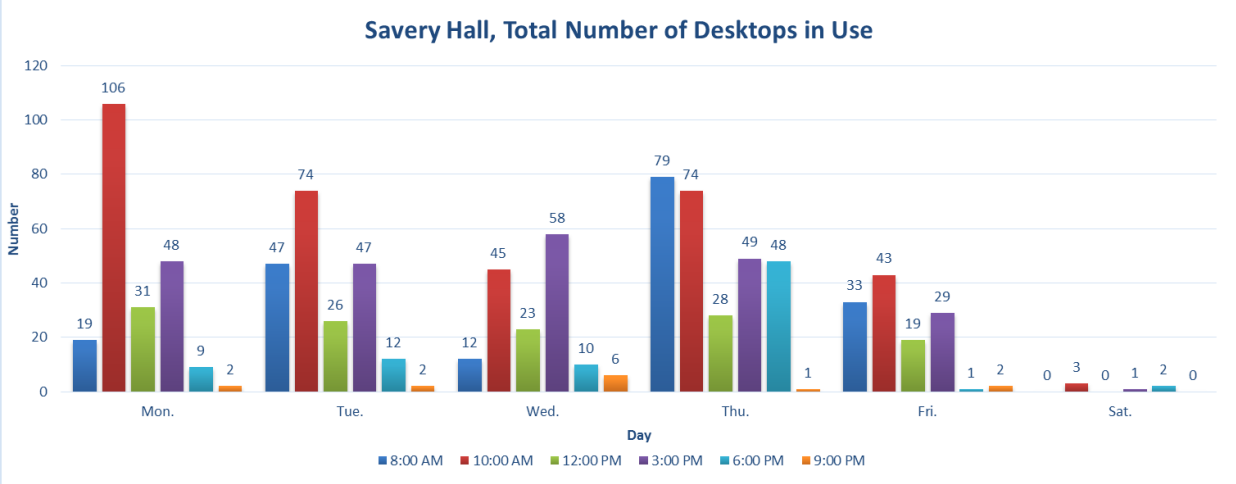


Fig. 12: Profile of Building Occupancy





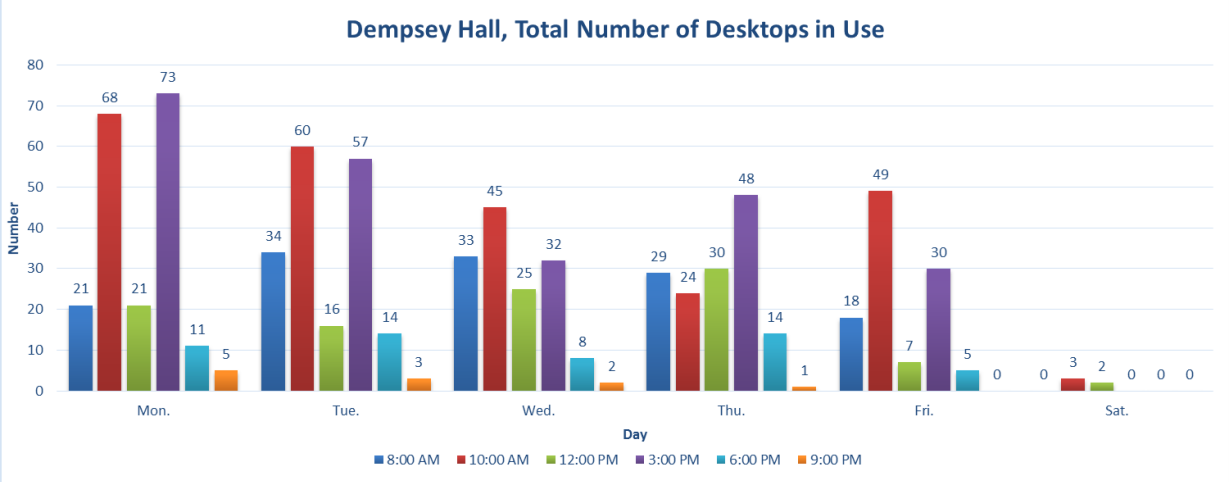
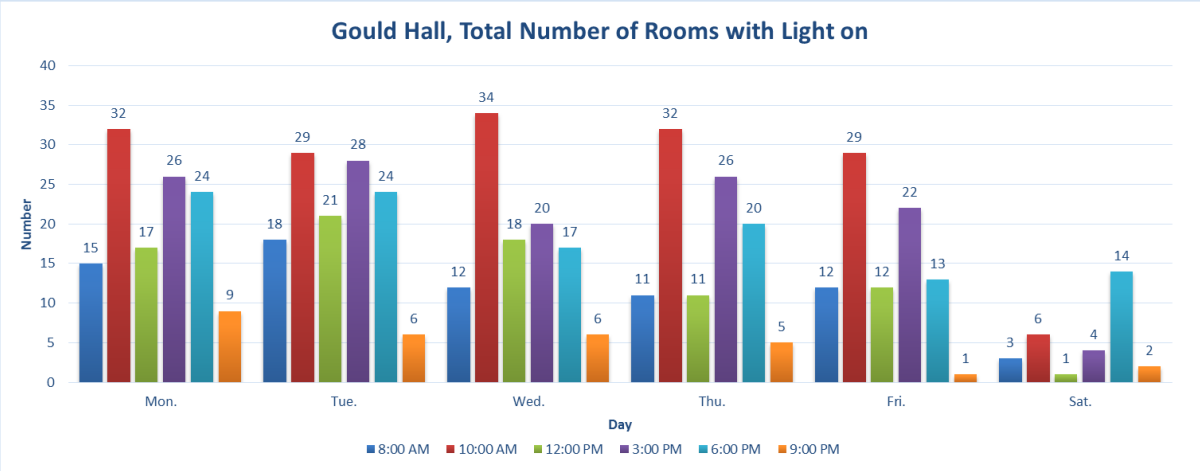
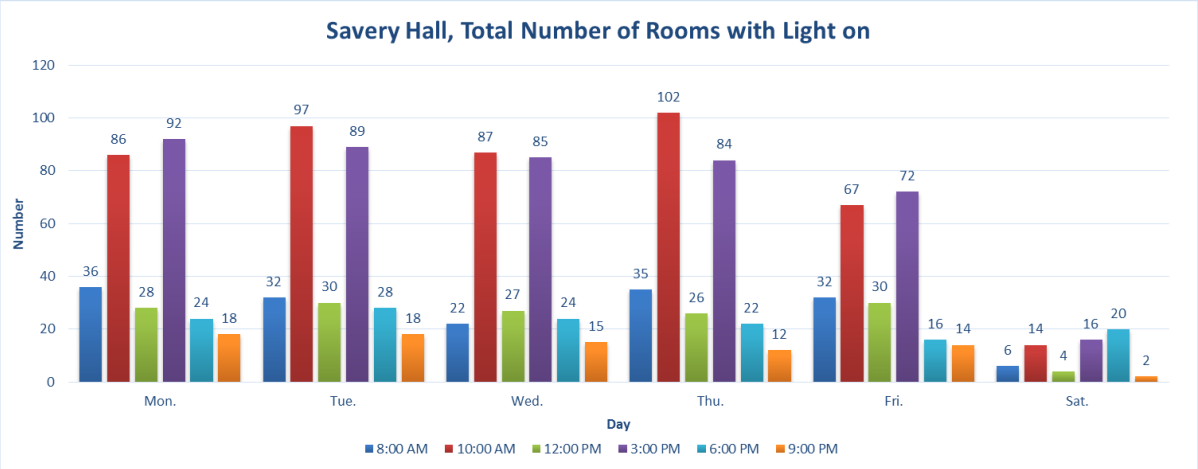


Fig. 13: Profile of Desktops Use





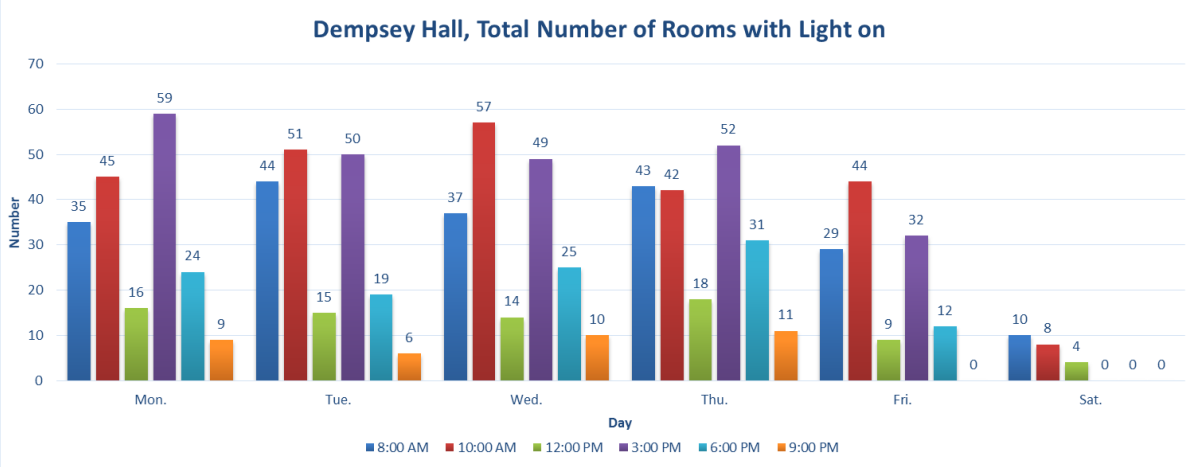


Fig. 14: Profile of Lights Use

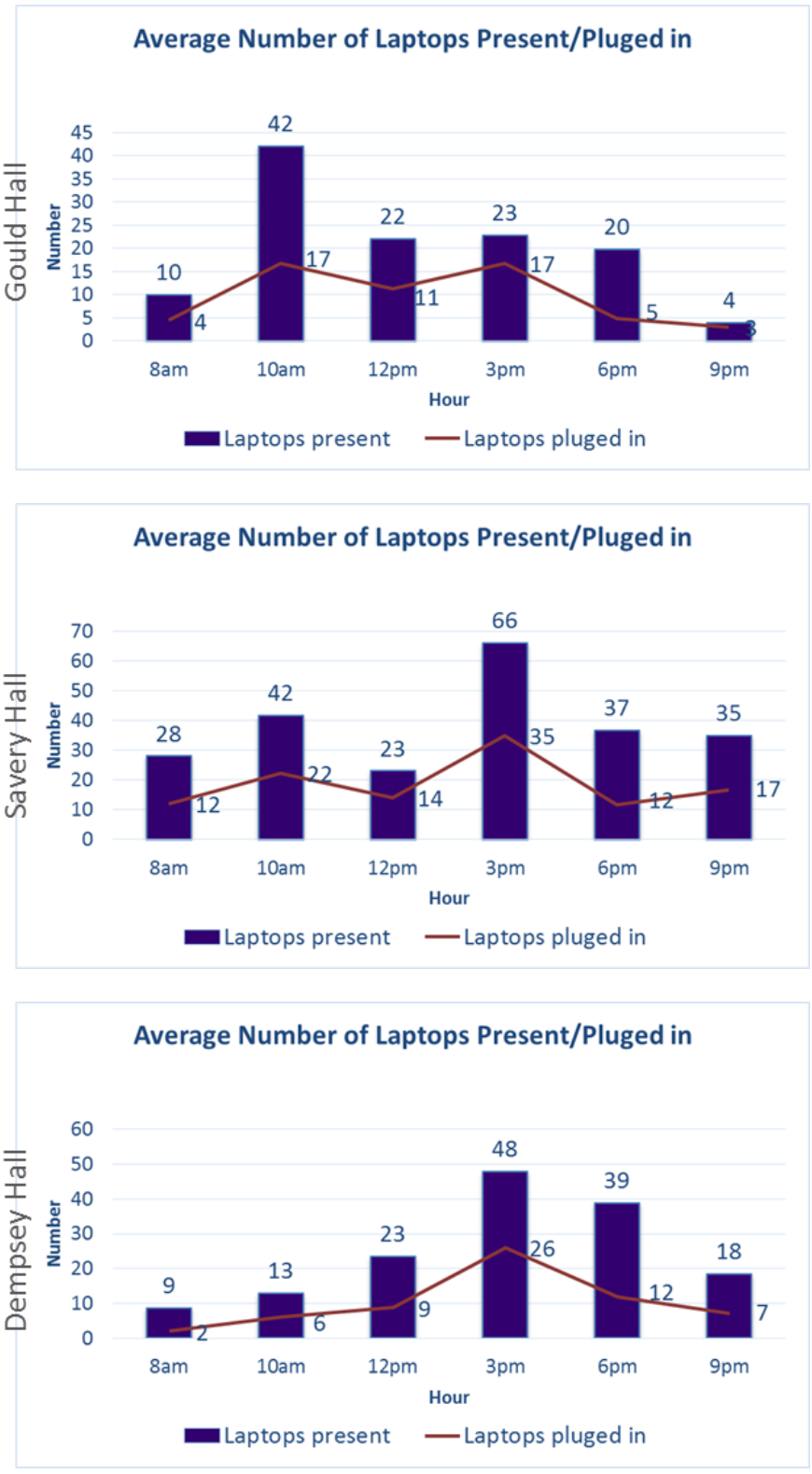


Fig. 15: Daily Profile of Laptops Present/Plugged In

Based on data collected in the manual observations, less than half of occupants had their blinds open during daylight hours (35% in Gould Hall, 26% in Savery Hall, and 22% in Dempsey Hall). With blinds closed, glare may be obstructed during limited hours, but daylighting is greatly reduced. To better understand the thermal comfort level in buildings as well as other energy related factors, the data collected through the manual observation should be compared with other two methods of audit.

4.2. Automated Monitoring

Automated monitoring is the second method of audit and includes installing several devices in selected rooms to collect data related to electricity use (including lighting and plug loads), indoor environmental quality (including temperature and humidity), and building occupancy. The result of data analysis for each group of data is presented below.

Temperature and Relative Humidity

Table 6 is a summary sheet of indoor temperature and humidity for a sample office. The daily averages of these two factors are presented in the last row. Accordingly, two graphs are created for a better graphical representation.

Table 6: Summary Sheet of Room's Temperature and Humidity

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	71	45	71	40	71	54	72	52	72	57	72	47
1:00 AM	71	45	71	40	71	55	72	52	71	56	72	47
2:00 AM	70	45	71	41	71	55	72	51	71	56	71	48
3:00 AM	70	46	71	42	71	55	71	51	71	56	71	48
4:00 AM	70	46	71	43	71	55	71	51	71	56	71	47
5:00 AM	70	46	71	44	71	55	71	51	70	56	72	47
6:00 AM	69	47	70	46	70	57	70	53	70	56	72	47
7:00 AM	70	46	71	47	71	56	71	52	71	55	73	46
8:00 AM	71	45	72	48	71	56	72	52	72	54	73	46
9:00 AM	72	44	72	49	72	55	72	52	72	54	73	46
10:00 AM	72	45	72	50	72	55	72	54	72	54	72	49
11:00 AM	72	45	72	51	72	55	72	56	72	53	72	51
12:00 PM	72	45	72	52	72	55	72	58	72	51	72	52
1:00 PM	72	43	72	54	72	54	72	58	72	46	71	53
2:00 PM	72	42	72	55	72	53	72	59	72	46	71	55
3:00 PM	72	41	72	55	72	53	72	59	72	46	72	56
4:00 PM	72	41	72	56	72	53	72	59	72	47	72	56
5:00 PM	72	42	72	55	72	53	73	59	72	46	72	53
6:00 PM	72	42	71	54	72	54	73	59	72	46	72	53
7:00 PM	72	41	72	53	73	52	73	57	73	45	73	52
8:00 PM	72	42	73	53	73	51	73	58	73	45	73	52
9:00 PM	72	41	72	53	73	51	73	57	72	46	73	50
10:00 PM	72	40	72	53	72	51	72	57	72	46	73	49
11:00 PM	72	40	72	53	72	52	72	57	72	46	73	48
Average	71.3	43.5	71.6	49.5	71.7	53.9	71.9	55.2	71.7	50.9	72.1	49.9

Figure 16 indicates daily profile of temperature and humidity. These graphs clearly show the changes in temperature and humidity during the day and also on different days of the week. Any unusual range of or any considerable changes in temperature and humidity can be tracked with

these graphs, which helps the building manager and O&M members identify potential issues with facility performance. For example, investigating the graphs for the selected rooms in Gould Hall indicates a considerable fluctuation (about 20%) in humidity between days of the week.

Additionally, these data are used to make a comparison of temperature/humidity profiles between different types of building spaces (faculty office, staff office, classroom, etc.), giving an approximate range of temperature and humidity for the whole building.

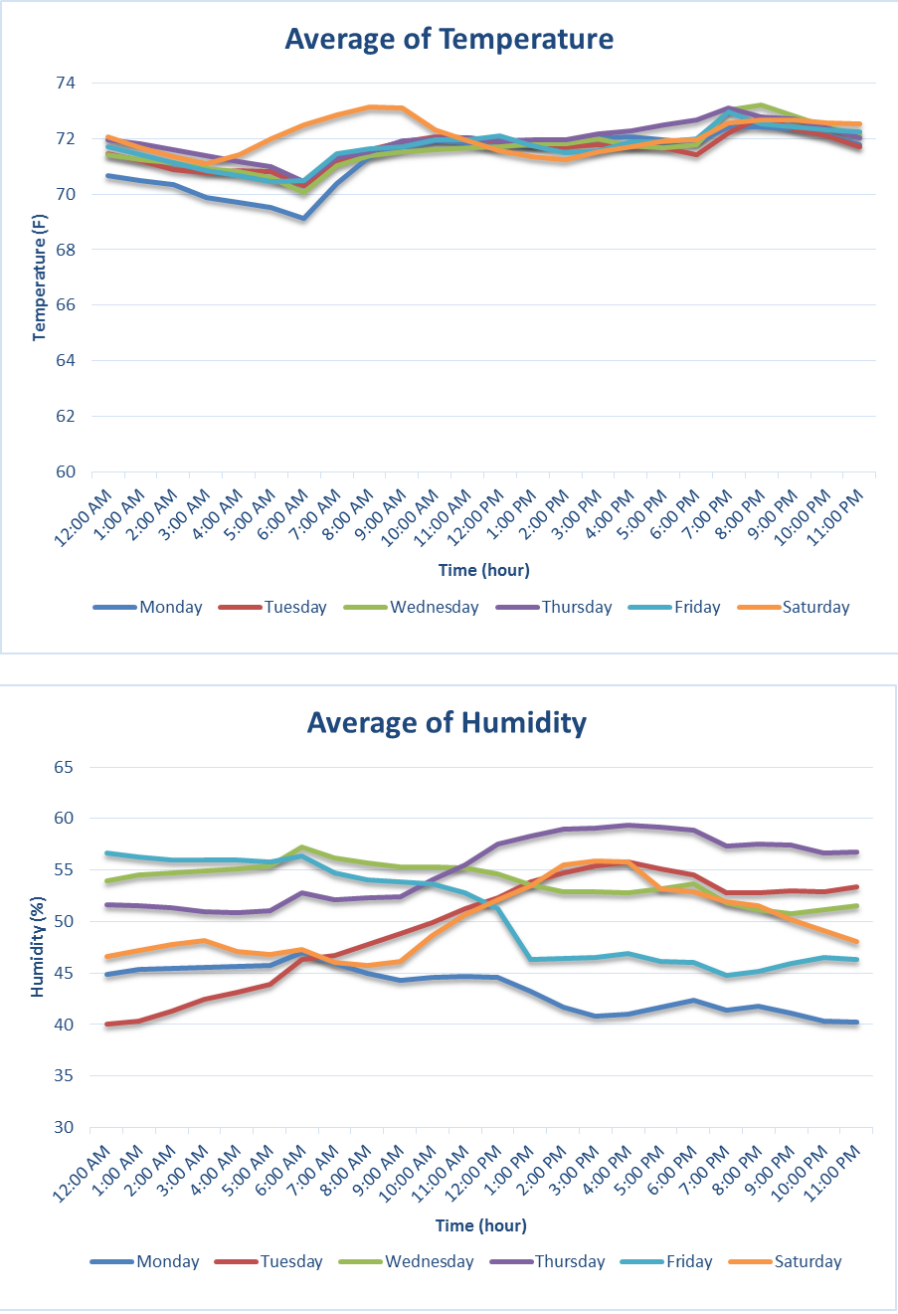


Fig. 16: Profiles of Indoor Average Temperature and Humidity (in a sample office)

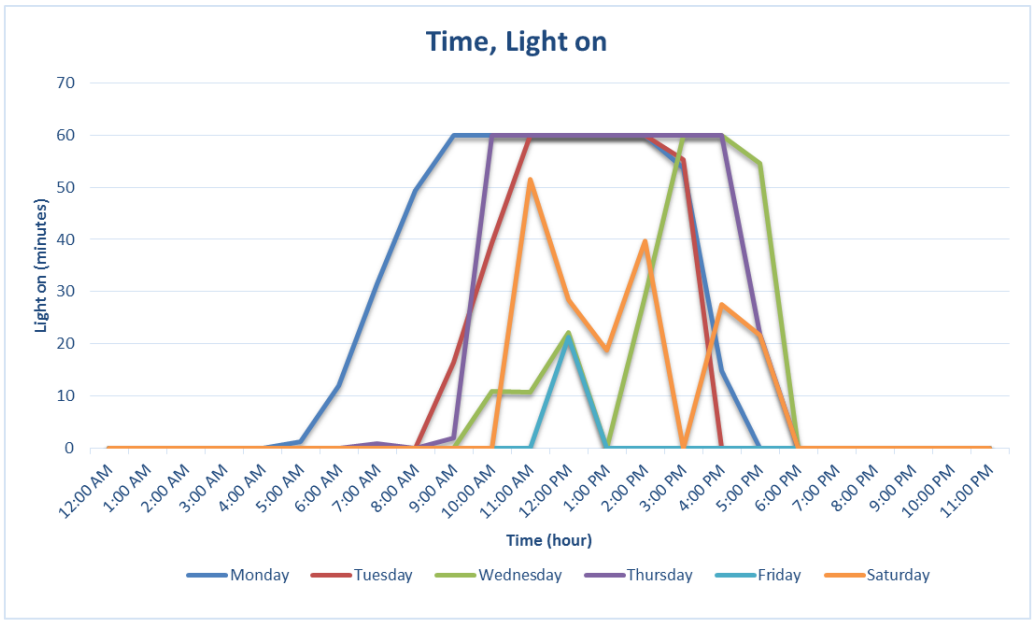
Lighting and Occupancy

Similar tables and graphs are provided to analyze the data. Table 7 summarizes the light and occupancy data recorded by the HOBO devices. The second to last row of the table indicates the total number of hours per day of lighting and occupancy. The last row indicates the average lighting and occupancy for each day of the week in minutes/hour. The last two columns show the total number of hours of lighting and occupancy in the space for each hour of the day during a typical week (the maximum value in these two columns is 6 hours since the total number of days the HOBOS were in use was 6 days and each row represents one hour of each of those days). The tangible use of these data can be seen in Figure 19 depicting behavioral patterns for times of day when lights are left on in vacant rooms.

Table 7: Occupancy and Light Use Summary Sheet

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Average Lighting & Occupancy	
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	4	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	2	0	0	0	0	0	0	0	0
2:00 AM	0	2	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	4	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	2	9	3	5	10	12	0	13	12	17	0	0	0	1
8:00 AM	54	34	54	47	0	0	26	21	32	33	0	2	3	2
9:00 AM	60	41	22	60	0	0	60	60	60	60	0	0	3	4
10:00 AM	60	57	60	60	0	45	60	58	60	60	0	2	4	5
11:00 AM	60	60	60	59	0	60	60	60	60	49	14	8	4	5
12:00 PM	60	60	60	60	0	60	36	50	60	40	60	60	5	5
1:00 PM	39	60	60	60	30	30	60	60	52	51	11	13	4	5
2:00 PM	60	60	60	49	60	59	36	51	38	59	0	0	4	5
3:00 PM	60	47	60	58	60	60	30	46	8	24	0	0	4	4
4:00 PM	60	19	60	60	60	60	45	45	0	0	0	0	4	3
5:00 PM	60	29	60	60	60	60	0	2	0	3	0	0	3	3
6:00 PM	60	4	60	60	55	49	26	29	0	4	0	3	3	2
7:00 PM	60	2	60	60	0	0	47	58	0	4	0	0	3	2
8:00 PM	60	0	13	20	0	0	0	0	0	0	0	0	1	0
9:00 PM	18	2	0	8	0	0	0	0	0	2	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	12.9	8.2	11.5	12.1	5.6	8.3	8.1	9.2	6.3	6.8	1.4	1.5		
Average Use (min/hr)	32.2	20.6	28.8	30.3	14.0	20.7	20.2	23.1	15.9	17.0	3.6	3.7		

Based on the summary sheet, three kinds of graphs are be provided. Figure 17 shows the pattern of room occupancy and light use for a sample staff office. As it can be seen in this graph, and also according to the overall result of data analysis, no replicable pattern of use can be determined. However, these data are useful for understanding peak hours of use, start/end hours of use, and the difference between business days and weekend use patterns.



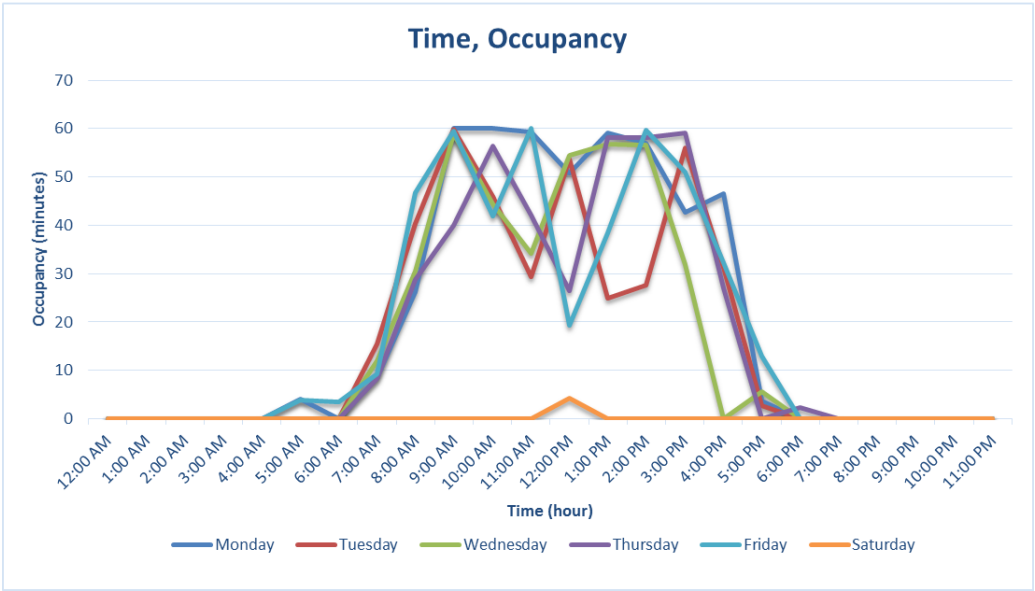


Fig. 17: Pattern of occupancy and light use (in a staff office)

Figure 18 shows the pattern of occupancy and lighting use and its fluctuations for the whole period of the audit.

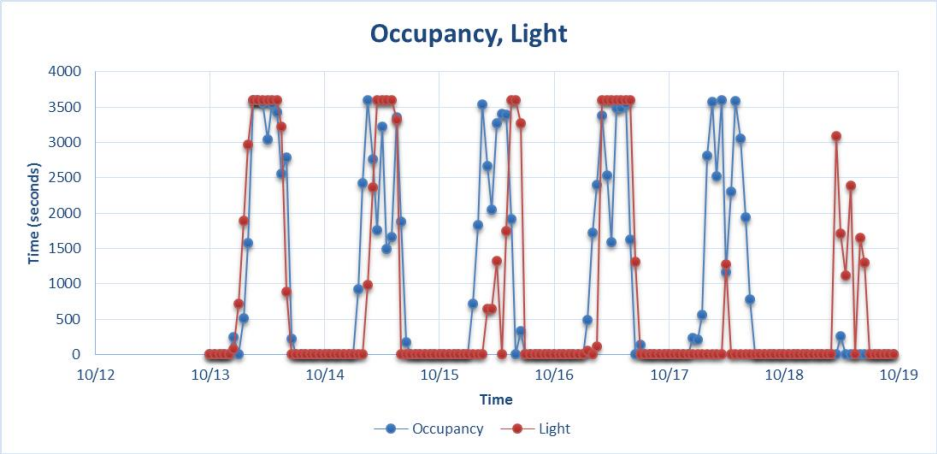


Fig. 18: Fluctuations in Light Use and Occupancy during the Whole Period of Audit

Figure 19 compares the duration of when the light used and the duration of occupancy for the average day in the audit period. In this graph, when the red line is above the blue line the light was on when the room was vacant (using unnecessary energy). When the blue line is above the red line the room is occupied and the electric light is not in use (saving energy). It can also be inferred from this sample graph that 9am and 3pm are the peak hours for room occupancy while 12-1pm and 3pm are peak times of light use.

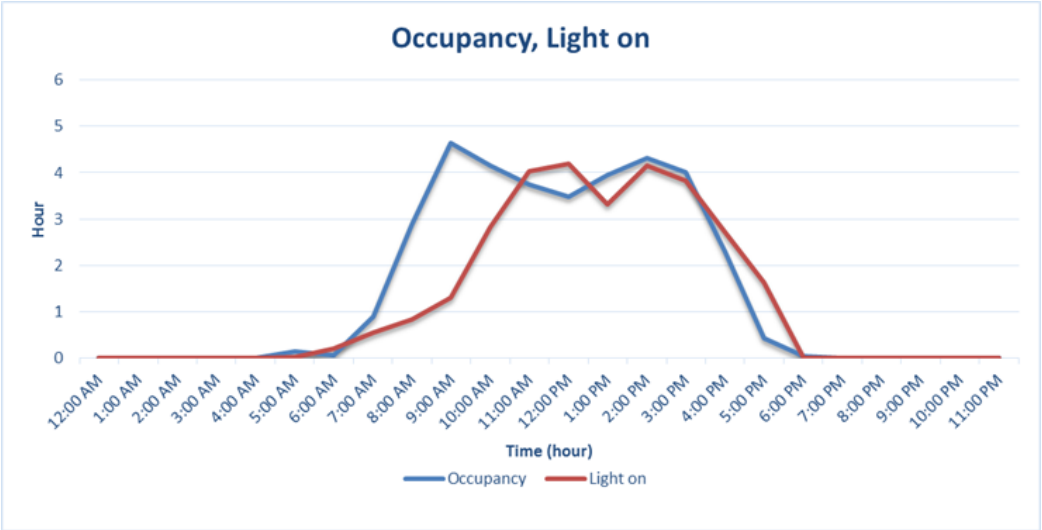
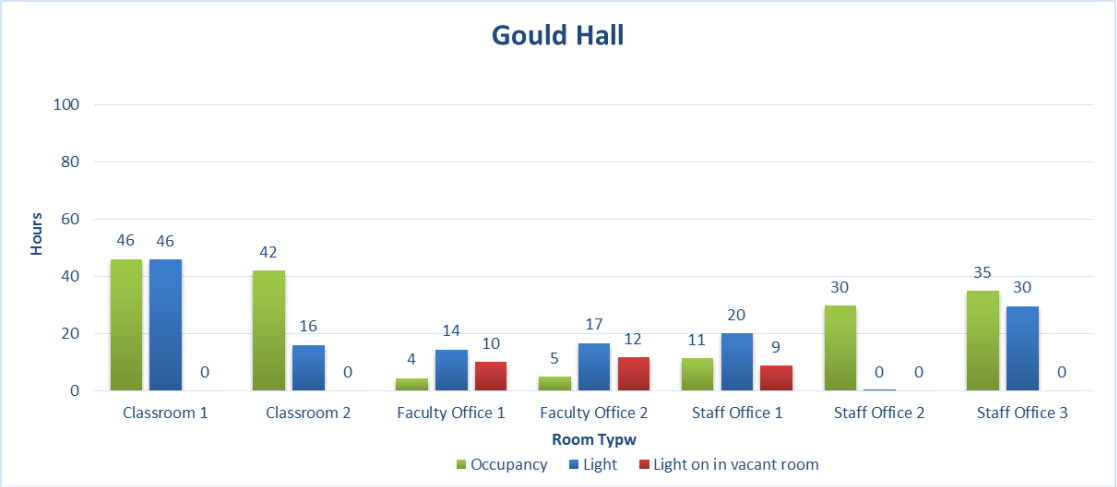
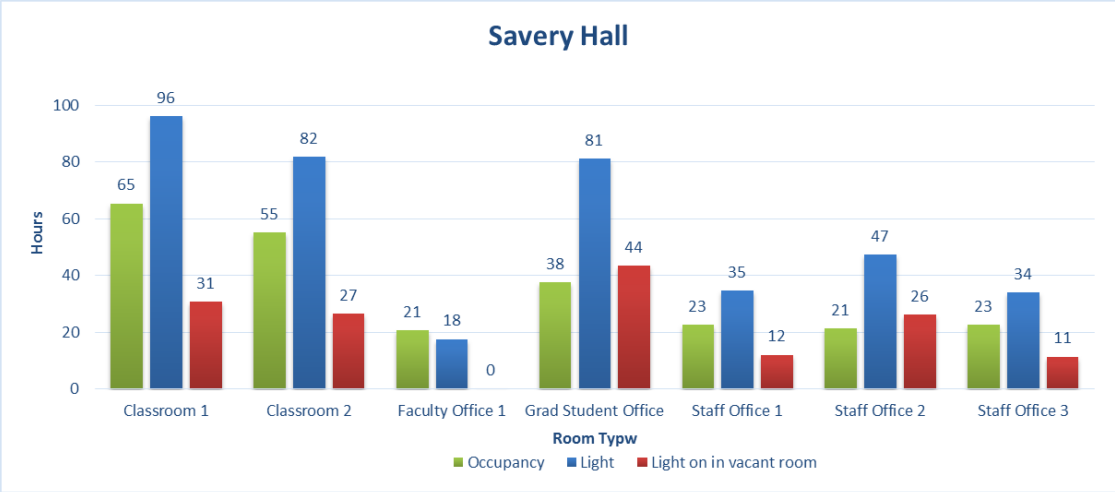


Fig. 19: Comparison between Time of Occupancy and Light on for a Typical Day (staff office)

Figure 20 is useful to compare room occupancy and lighting use between different types of spaces (rooms) and between buildings. Considering the number of rooms with red column (lights on in

vacant room) demonstrate that lights are left on when rooms are not occupied in 43% of the selected rooms in Gould Hall compared to 86% in Savery Hall, and 80% in Dempsey Hall.





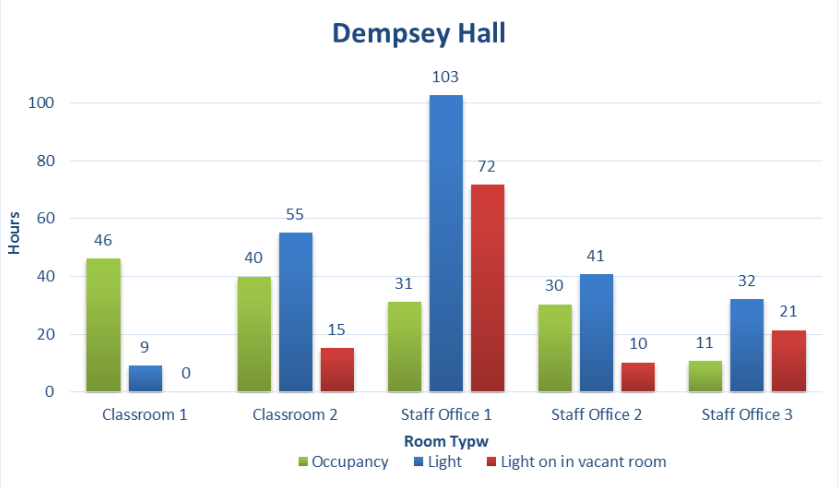


Fig. 20: Duration of Lights On in Vacant Rooms

Workstation Energy Use, MEL's

Watts Up meters were used to evaluate plug load energy use in selected workstations (namely desktop/ laptops and other small electrical devices usually used in an office room) in each building. Figure 21 shows the amount of electricity used by a sample workstation. It can be interpreted from this graph that the selected workstation has a high load (watts) during the business hours. Besides, the peak hours and difference of electricity use during and out of business hours is investigated. The second graph shows the same data overlaid in order to compare daily energy use patterns.

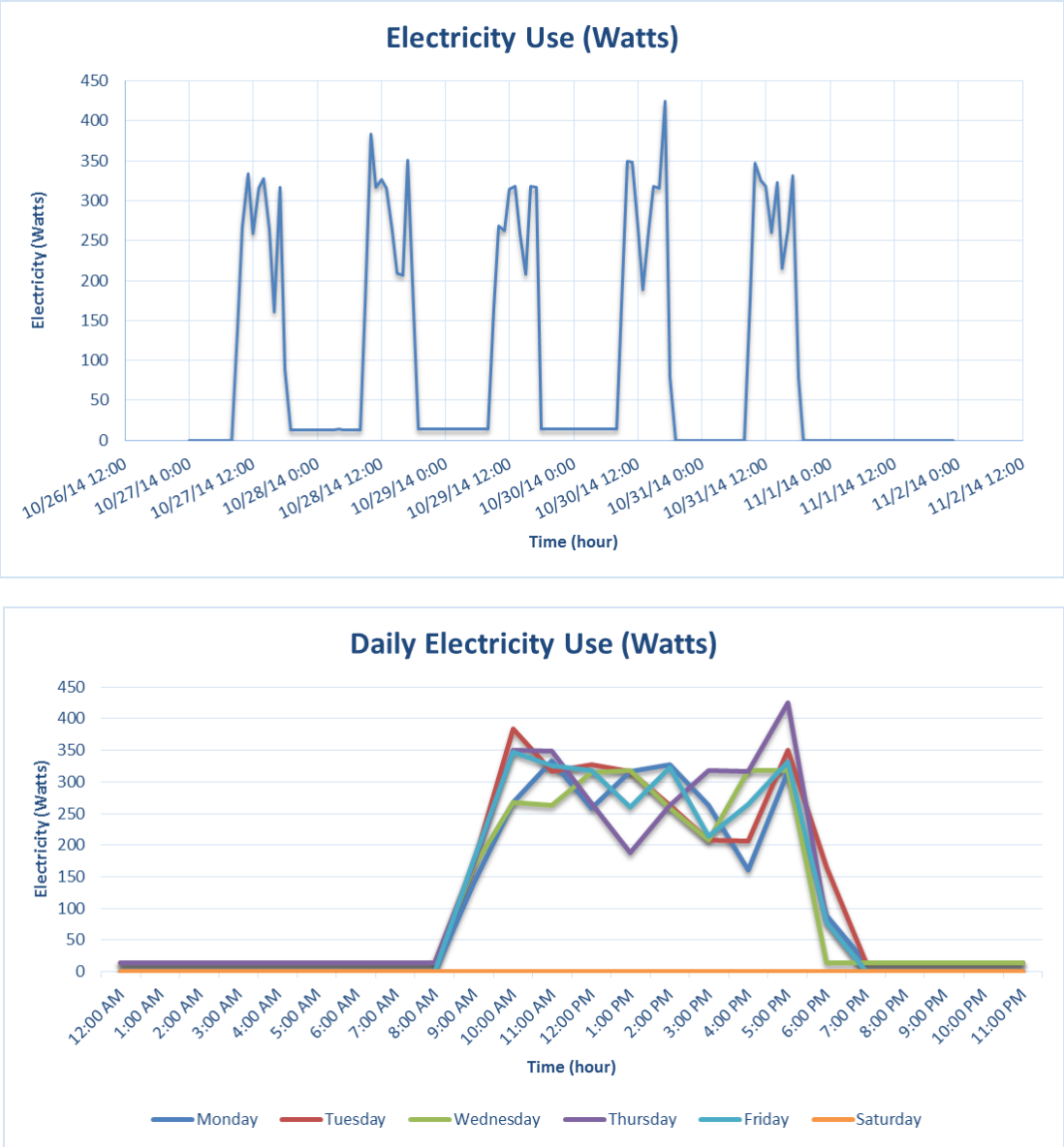


Fig. 21: The Amount and Pattern of Electricity Use for a Sample Workstation

Occupancy Counting

People counting system were used as a part of automated monitoring to capture the number of people enter and exit the building during one week of audit. This provides calibrated occupancy information about campus buildings that can be used in various ways including providing a benchmark occupancy diversity schedule for energy modeling. A secondary non-energy benefit is that the daily and weekly occupancy patterns can help building managers supply appropriate resources (such as janitorial services) to the building to more effectively manage their facility.

Four types of information can be gained from the people counting data. Figure 22 indicates the pattern of people's movements (in/out) including peak hours and peak number of people for a sample building. Also, the total number of people entering and exiting the building were summarized in table 8 (it is assumed that the number of people entering the building is the same as number of people exiting the building by end of the day).

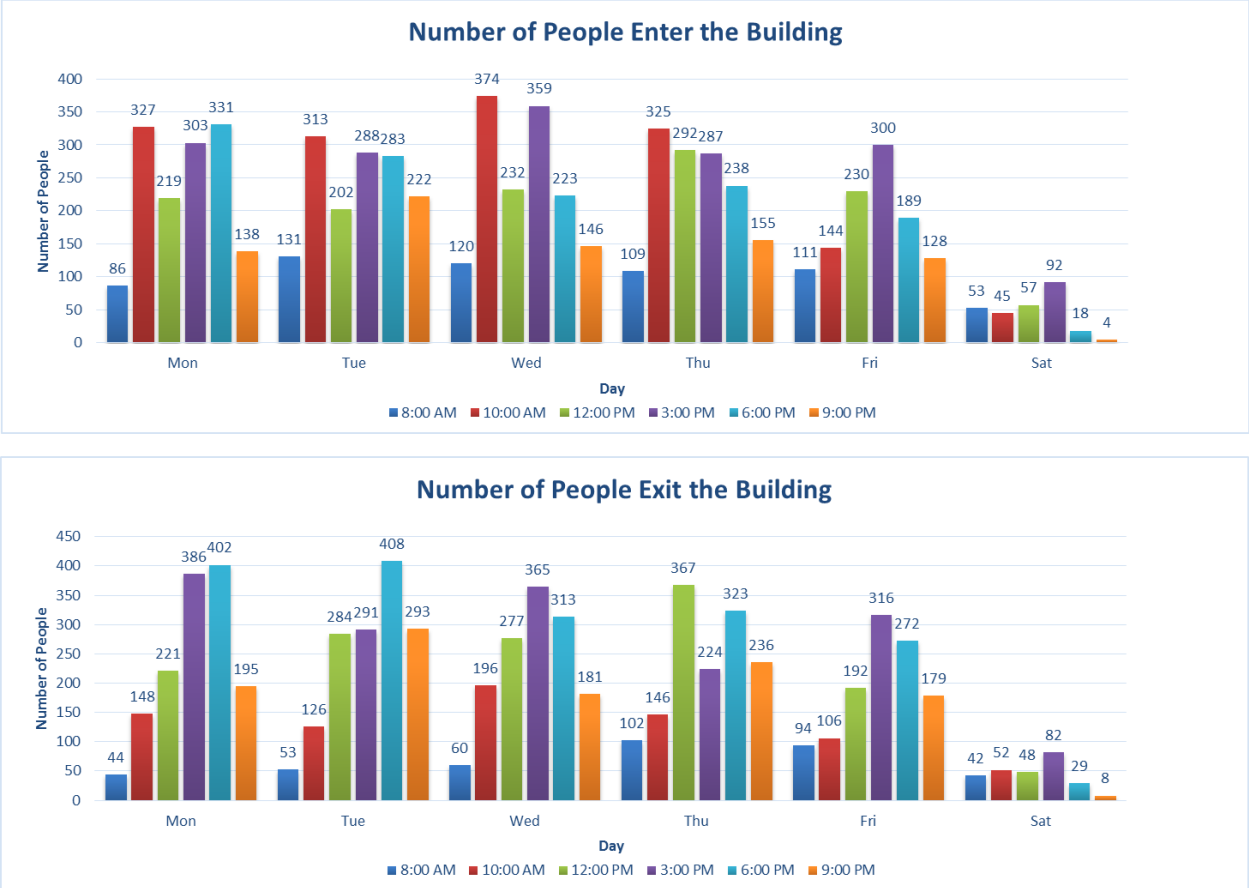


Fig. 22: The Pattern of People Movement

Table 8: Total Number of People In/Out during the Week

Total Number of People In/Out	
Mon	1404
Tue	1439
Wed	1454
Thu	1406
Fri	1157
Sat	263

Based on the data recorded by people counters, the pattern of building occupancy can be estimated and compared with the pattern of occupancy estimated by the manual observation. Figures 23-25 demonstrate this comparison for Gould, Savery, and Dempsey Halls.

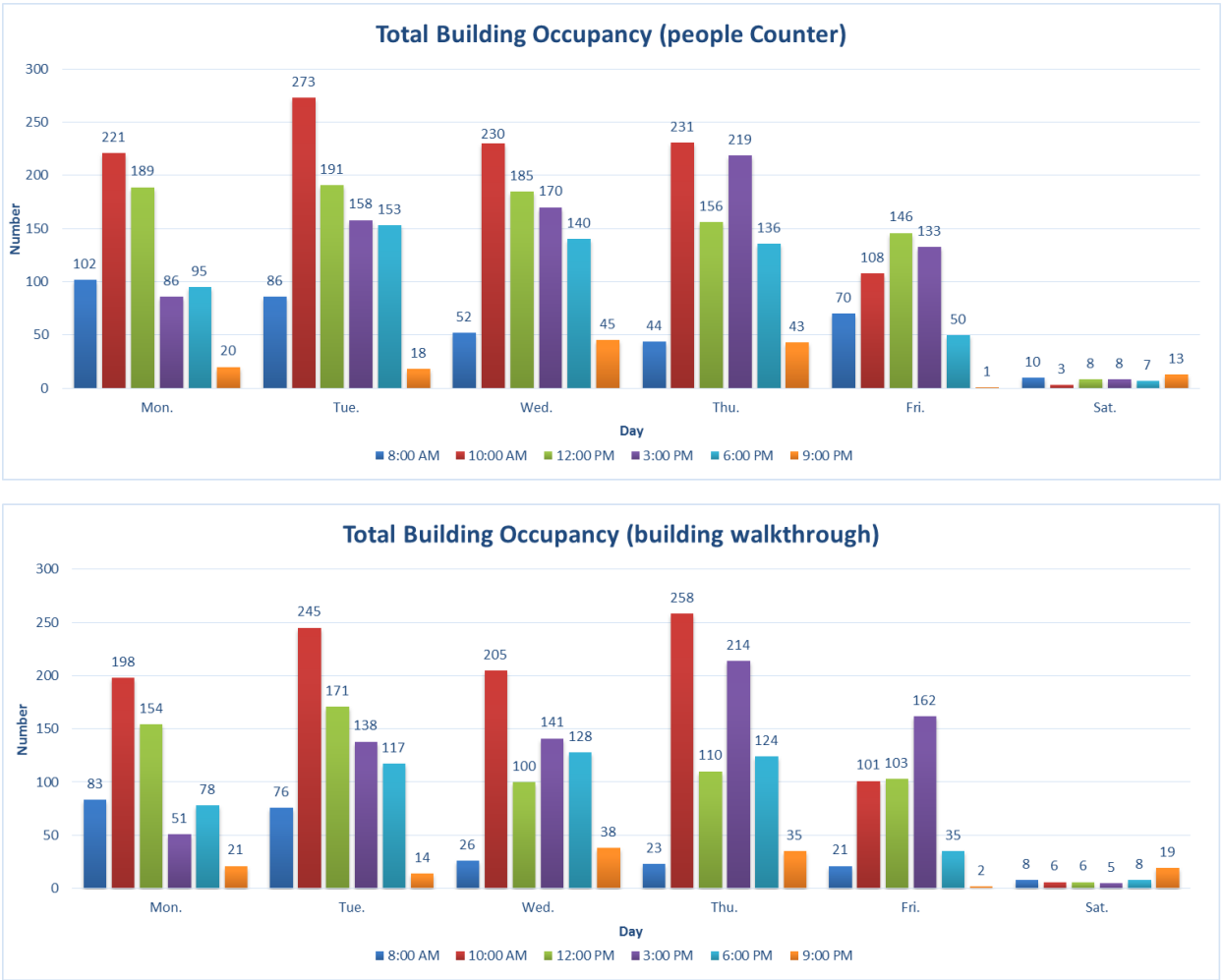
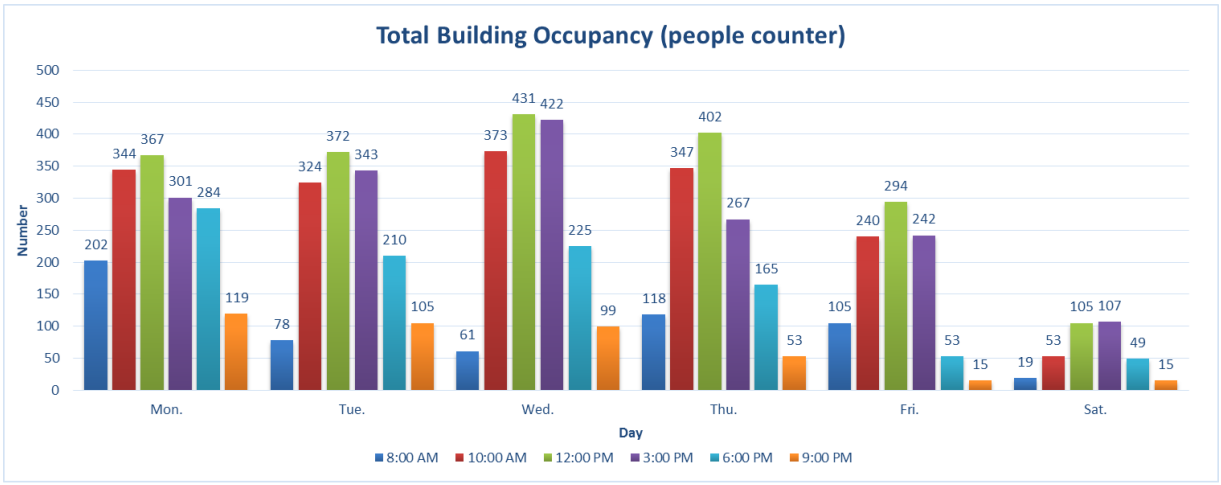


Fig. 23: Building Occupancy Estimated by two Different Methods (Gould Hall)



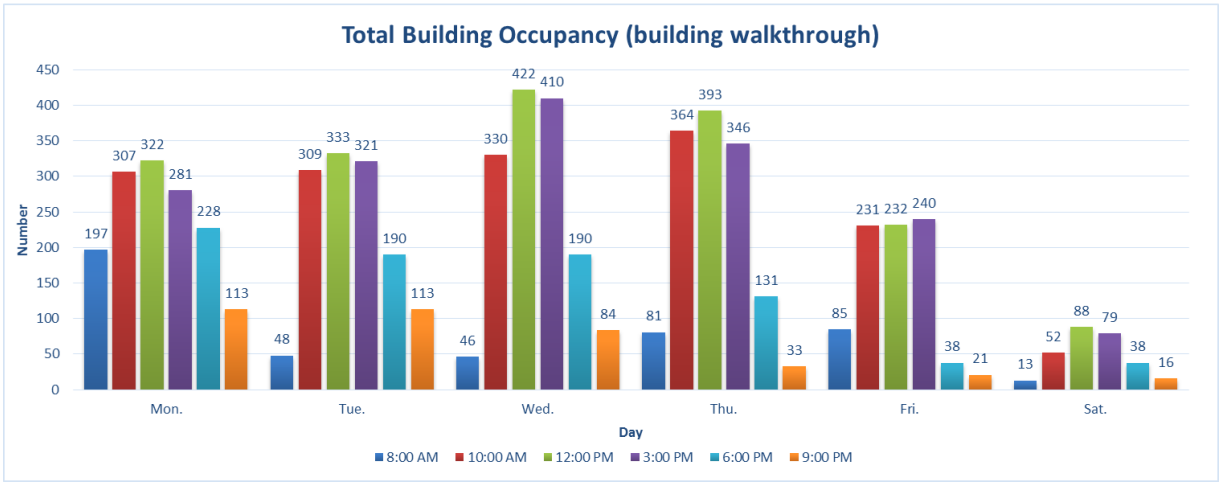


Fig. 24: Building Occupancy Estimated by two Different Methods (Savery Hall)

Fig. 25: Building Occupancy Estimated by two Different Methods (Dempsey Hall)

In all three buildings the numbers recorded automatically (people counters) are slightly higher than the numbers captured by auditors (manual observation). A reason could be that the library and many labs located in Gould Hall were excluded from the manual observation so the users of these areas were not counted by the auditors, but were counted by the automated people counters. In Savery and Dempsey Halls, the large number of offices with closed doors or frosted glass on doors, prevented the auditors from counting the occupants in all rooms and offices.

Finally, the number of people in and out from each entrance of the building should be recorded on the floor plan of the building. This data may help the property manager to organize the location of equipment present in the building and also provides a benchmark in case of building remodeling or renovation. This form of data visualization is shown in Figure 26.

The location of building entrances are indicated on the floor plans. The tables show the number of people in/out on a weekly basis. The averages are added to the end of tables to show which entrances have the greatest utilization

	In	Out
Mon	2	62
Tue	0	53
Wed	2	57
Thu	1	75
Fri	3	55
Sat	0	12
AVG	2	60

	In	Out
Mon	221	430
Tue	201	293
Wed	207	348
Thu	205	361
Fri	150	300
Sat	41	63
AVG	197	346

	In	Out
Mon	208	162
Tue	296	249
Wed	250	273
Thu	313	221
Fri	271	228
Sat	193	120
AVG	268	227

	In	Out
Mon	14	69
Tue	25	61
Wed	12	77
Thu	17	65
Fri	8	72
Sat	3	16
AVG	15	69

	In	Out
Mon	126	105
Tue	213	187
Wed	198	234
Thu	127	130
Fri	169	193
Sat	35	48
AVG	166	170

Fig. 26: Number of People in/out from each Entrances of Building

4.3. User Survey

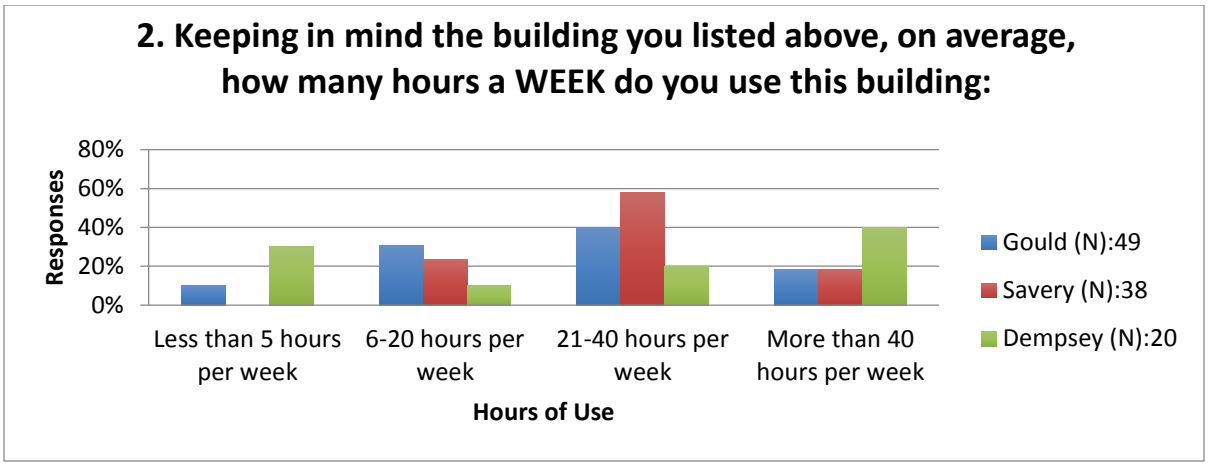
A web-based user survey were sent to the three building occupants to investigate their perceived building/energy use behaviors and also identify and beliefs and values that impacts their environmental behaviors. In total, 121 respondents completed the survey during the second round audit in fall (compared to 146 respondents of spring survey).

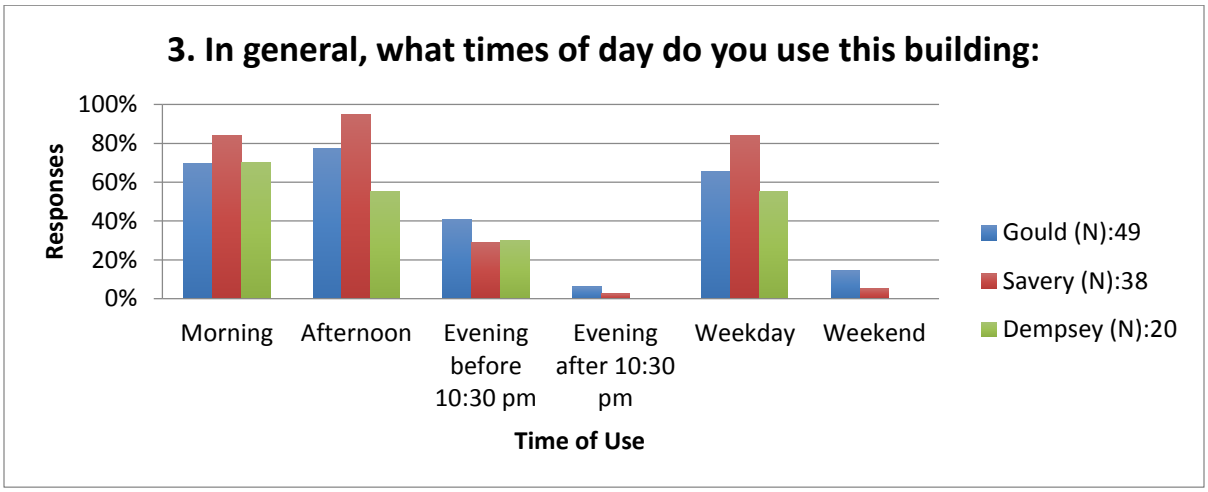
In general, survey questions 1-11 set a baseline of building/equipment use and related physical characteristics of user behaviors. While questions 12- 15 ask questions about user values and pro-environmental behavior. Questions 16- 20 are related to the socio-demographics of building users.

In particular, questions 1- 4 (shown in Figures 27) ask about the respondent's building use and times of use. Accordingly, between 5% (Savery) and 10% (Gould) of users report using the building after 10:30 pm in the evening while Dempsey reports no use during this time (because Dempsey Hall is not accessible after its business hours). Basically, students of studio programs (e.g. in department of architecture, Gould Hall) and research labs may use the buildings after hours or at weekends. But further investigation is still required to determine how and why people are using buildings after hours.

Questions 5 and 6 ask about different types of miscellaneous electric loads (MELs) that are usually used by occupants. According to figure 28 computers and monitors are used much higher than other devices. Over 65% of all respondents reported that they use their computer and monitor more than 40 hours a week. Laptop use was much lower with Gould Hall reporting 50%, Savery Hall just under 50%, and Dempsey below 20%. Comparing these values with the data captured by manual observation namely 19% (Gould), 25% (Savery), and 27% (Dempsey) reveals a gap between perceived and actual use in this case.

In addition, approximately 20% of Gould and Dempsey occupants reported that they use personal heaters to adjust their level of comfort while no personal heater were reported by Savery users (Savery Hall is the oldest building, but recently renovated). However, personal heaters and fans were counted in all three buildings during the manual observation with slightly higher number of devices than what was reported.





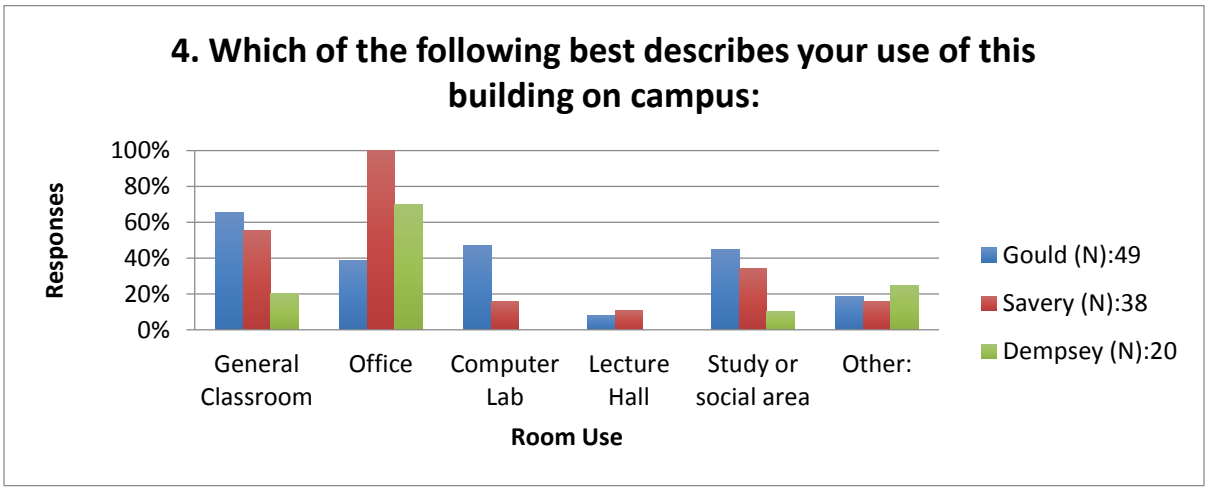


Fig. 27: A Summary of Buildings Use

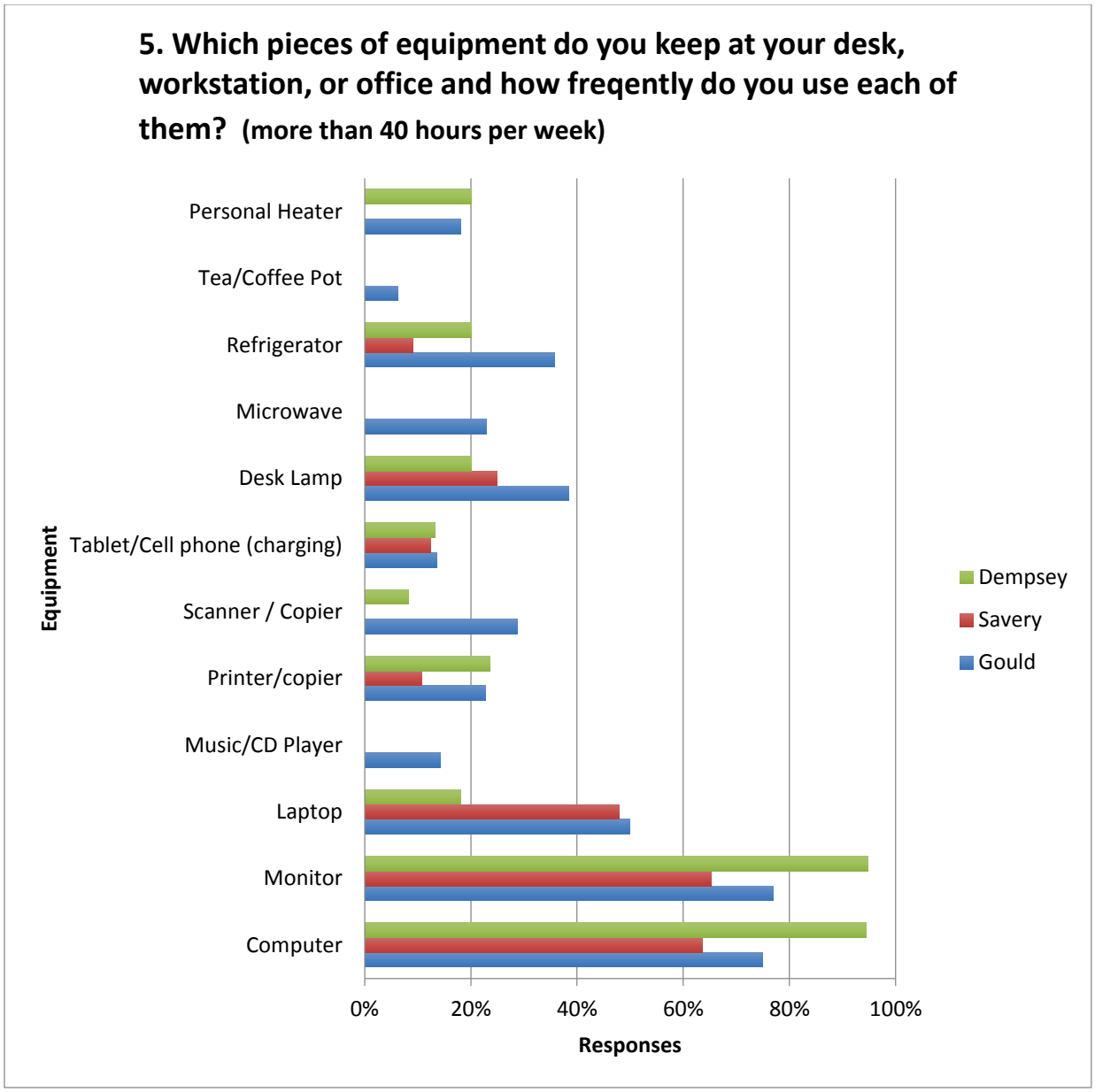


Fig. 28: Frequently Used Equipment in Offices

Questions 7- 9 (shown in figures 29-31) were asked to understand user's energy related actions and behaviors. Data analysis indicated that more than 50% of users in Gould, Savery, and Dempsey almost always turn off lights, close windows, and turn off their computers on leaving offices/ classrooms and incorporated those activities into their daily routine. In addition, more than 80% of users in all buildings believed that they have no control on indoor temperature. Over 60% of Gould Hall and Dempsey Hall think they do not control fresh air supply and water supply compared to 40% of Savery Hall.

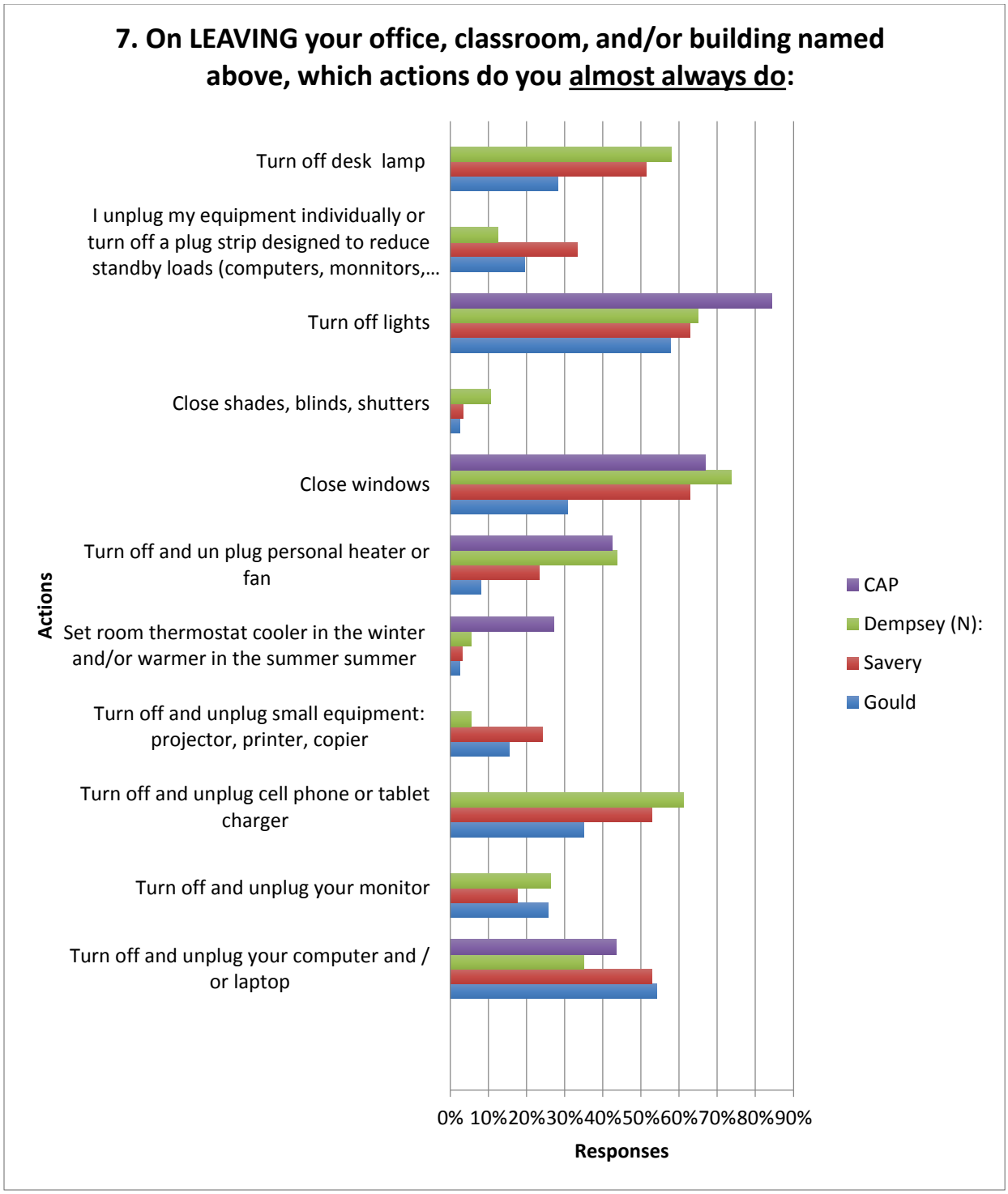


Fig. 29: Occupant's Actions on Leaving Offices/Classrooms/ Building

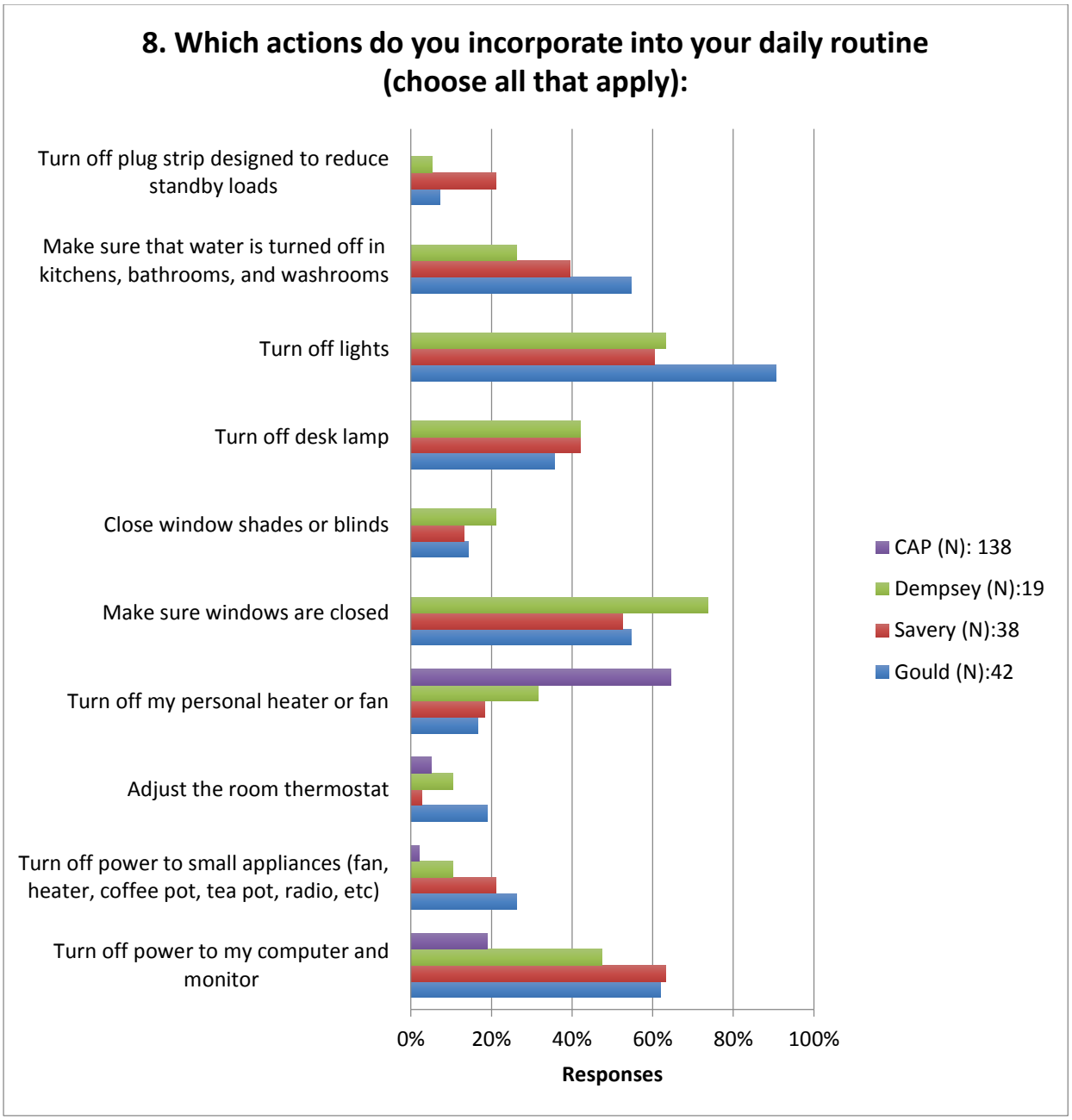


Fig. 30: Building Occupant's Actions in Their Daily Routine

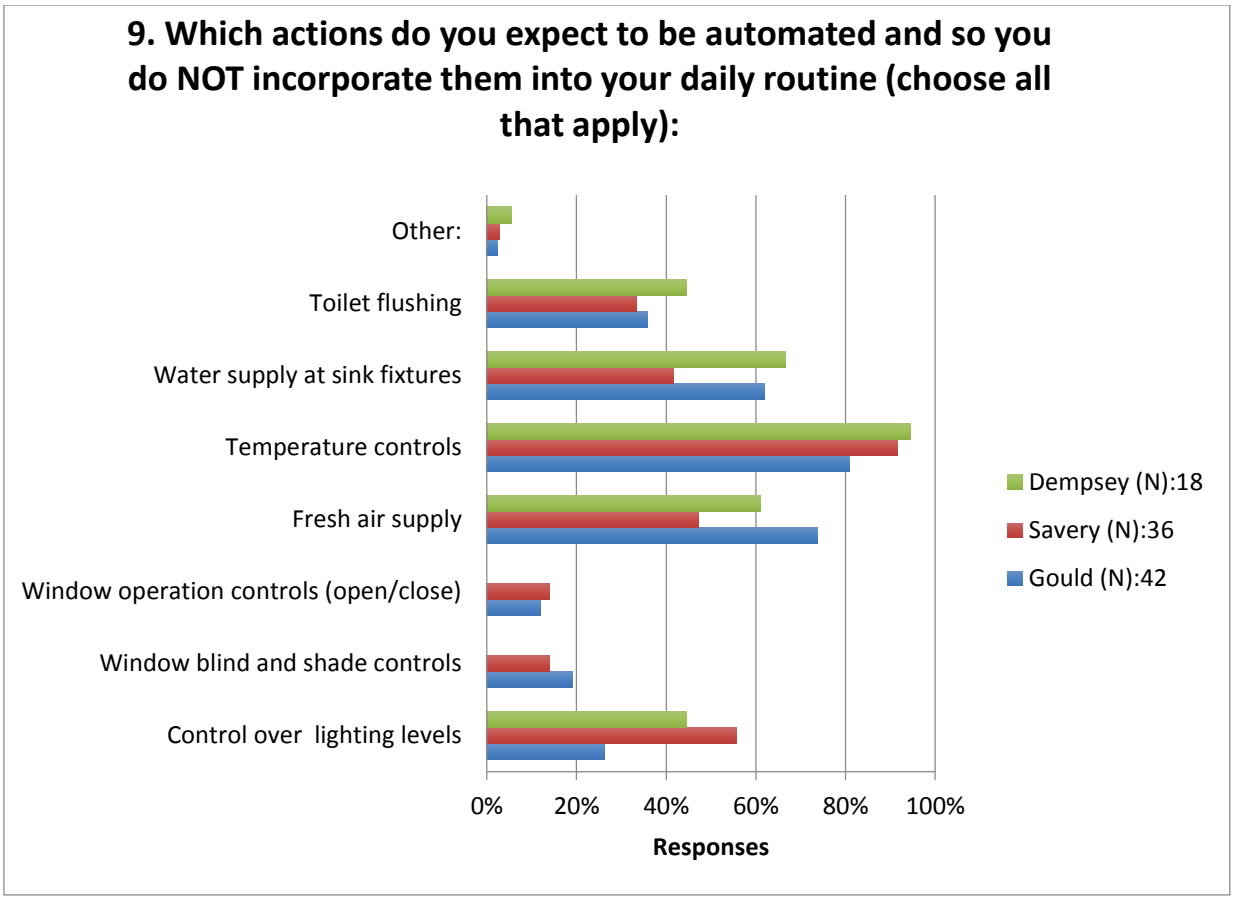
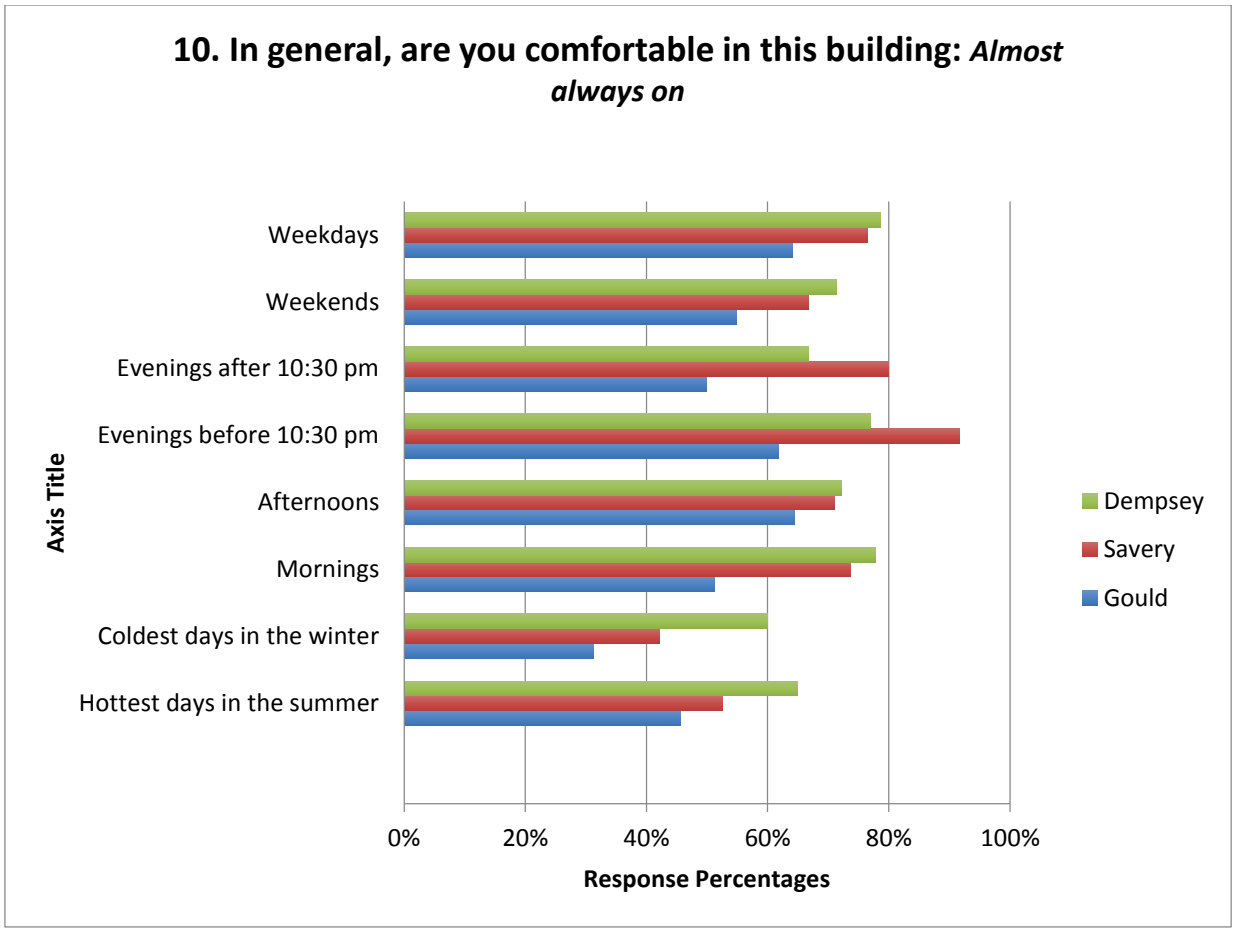


Fig. 31: Actions Expected to be Automated (not Controlled by Building Users)

Questions 10 and 11 (shown in figure 32) measure the level of thermal comfort in the audited buildings and identify the strategies the occupants use to adjust their comfort level. Figure 32 shows that more than 70% of Savery and Dempsey respondents feel comfortable almost always compared to 50-60% of users in Gould. However, these percentages decrease by 10-20% in all buildings in coldest days (in the winter) and in hottest days (in the summer).

In order to adjust the level of thermal comfort in buildings, most of users (about 90%) adjust their clothing layers, followed by opening/closing windows that reported by 60% of users in Gould, 71% in Savery, and 47% in Dempsey.



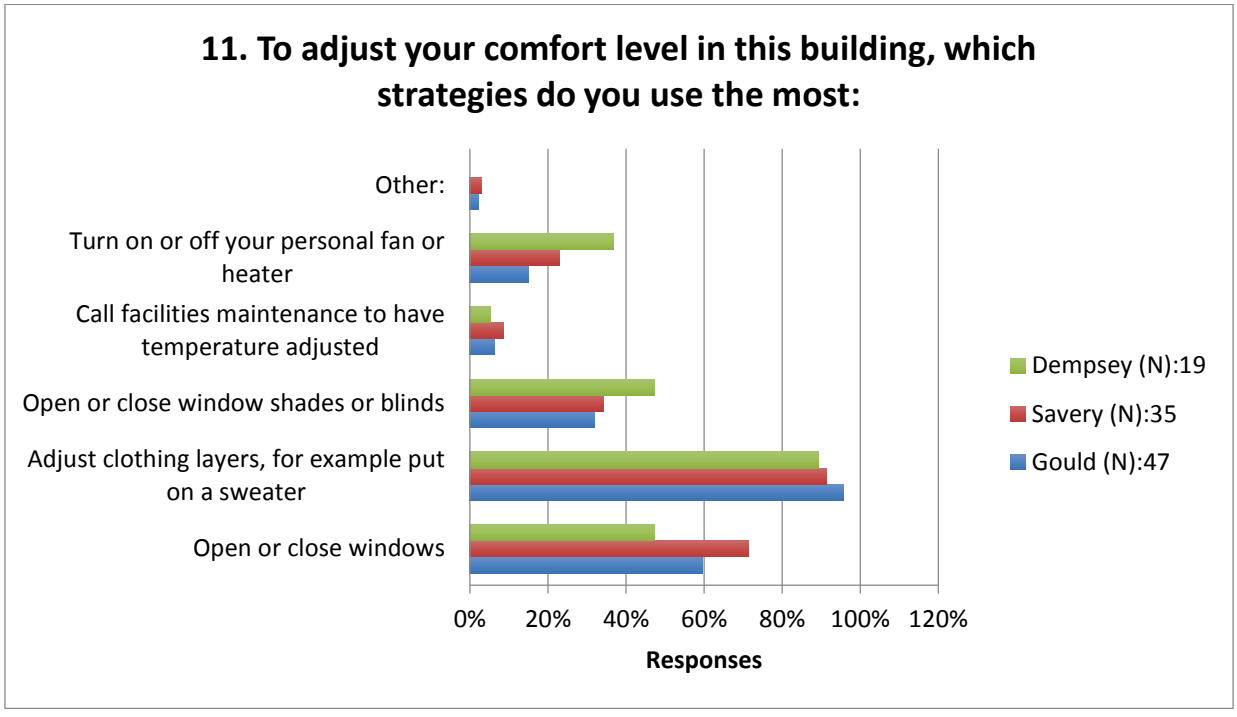


Fig. 32: Thermal Comfort in the Building and the Utilized Strategies for Adjustments

Question 12 (shown in figure 33) addresses the values affect people actions and behaviors. Building users were asked to rate each value (in the scale of -1 to 7) as guiding principle in their life. As a result, about one third of those surveyed ranked environmental values such as Preventing Pollution, Protecting the Environment, Respecting the Earth, Social Justice, and Equality as very important as a guiding principal in life. It shows that all buildings occupants have a potential to be engaged in pro-environmental behaviors.

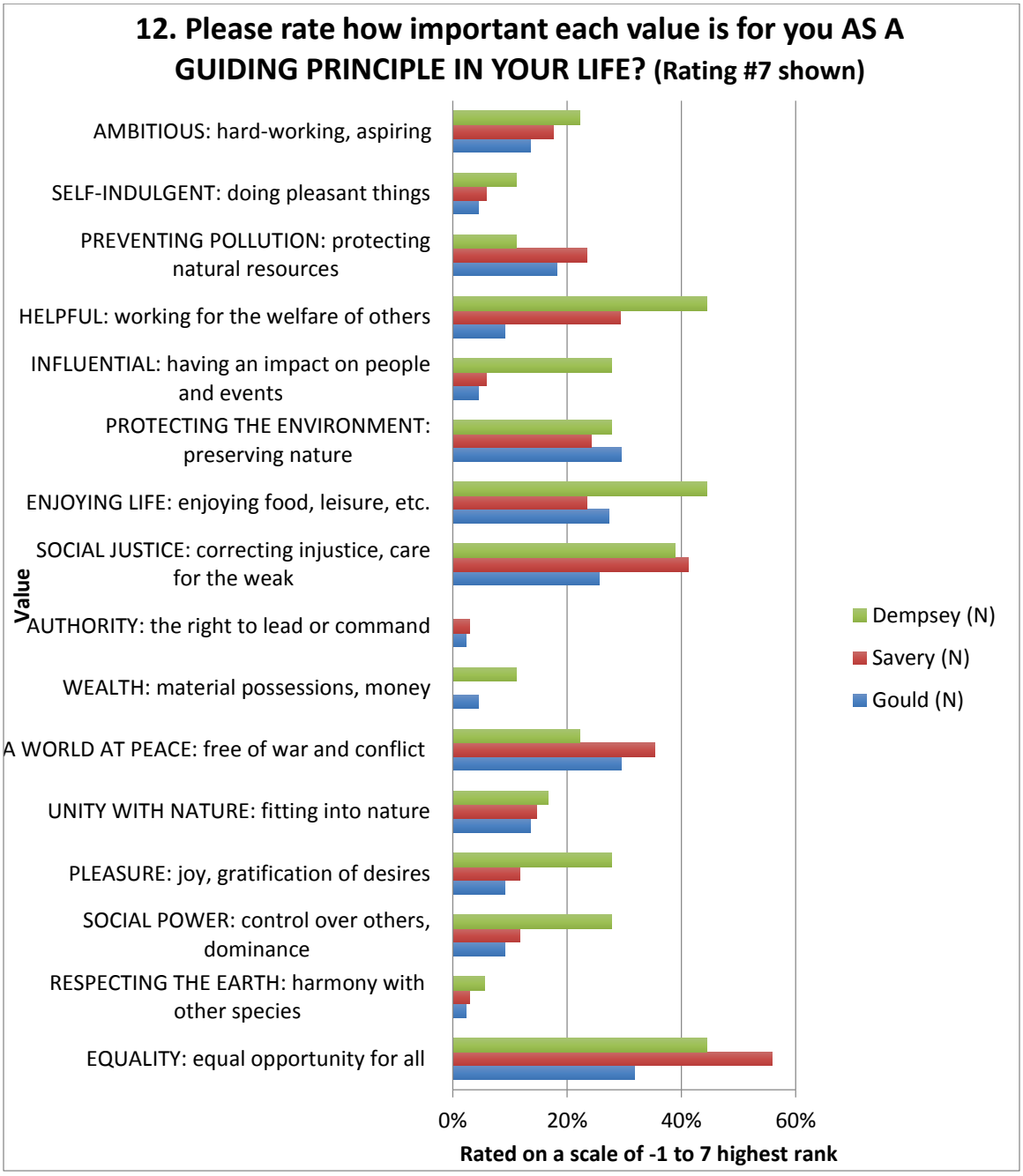


Fig. 33: Respondent's Core Values (Rating #7)

Questions 13 and 14 (shown in Figures 34-35) ask about the user's awareness and impact of the UW initiatives to reduce its carbon emissions. Accordingly, In general, less than 30% of respondents were "very aware" about the UW on-going initiatives with an exception of "offering bike lockers and racks". The buildings users were also asked to rate different initiatives in terms of their high impact on carbon emission reduction. In this case, three initiatives with the highest impact were selected including 1.maintaining campus energy consumption at current levels despite increase in buildings and population, 2.decrease the number of UW community members who drive alone to campus, 3. Decreasing amount of waste sent to landfills.

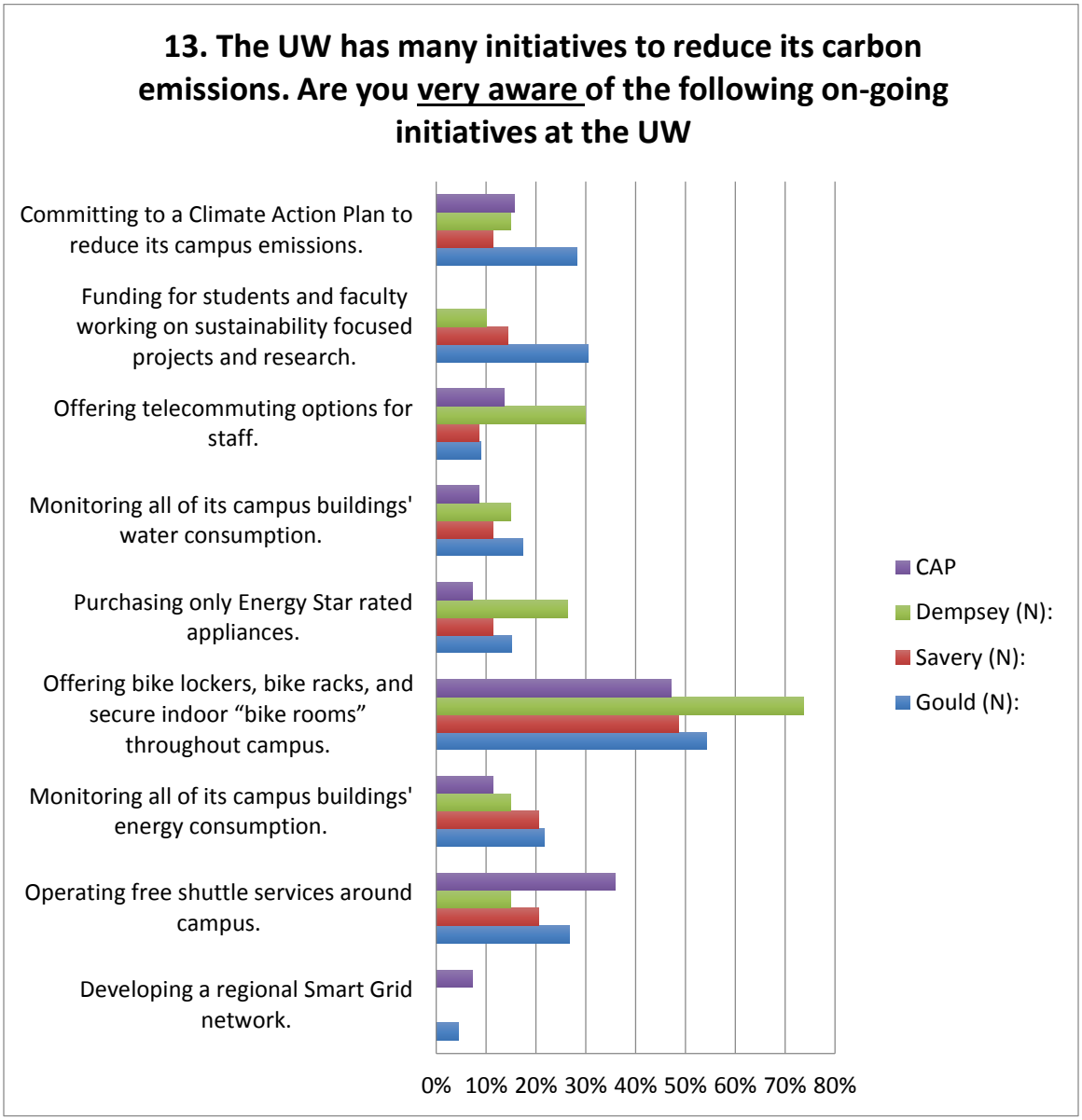


Fig. 34: Carbon Emission Reduction Measures

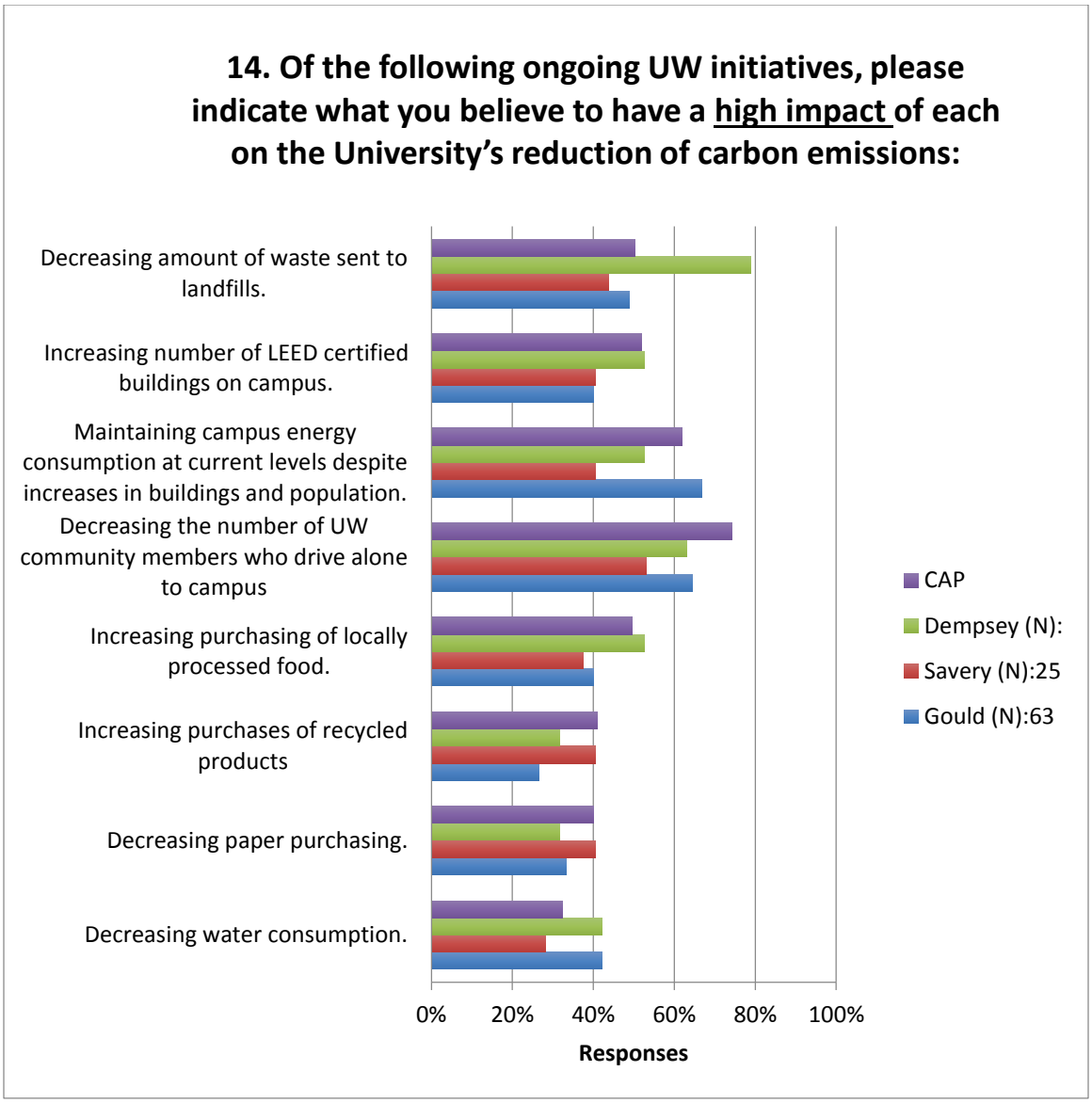


Fig. 35: High Impact Carbon Emission Reduction Measures

Question 15 were particularly included to discover user's opinion related to solutions to climate change and the building user's perceived ability to impact climate change. Over 40% of respondents were strongly agree with acting environmentally-friendly is an important part of who they are; they are the type of person who acts environmentally-friendly; and they see themselves as an environmentally-friendly persons. Furthermore, only less than 5% believe that we do not need to worry about global warming. These data generally support the result of question 12 about the values reported as Guiding Principles of Life. However, as part of the current question less than 25% of Gould, 35% of Dempsey and 45% of Savery occupants think they can do something

about climate change. This suggests that despite of respondent's pro-environmental values they do not still think actively about their impact on climate change.

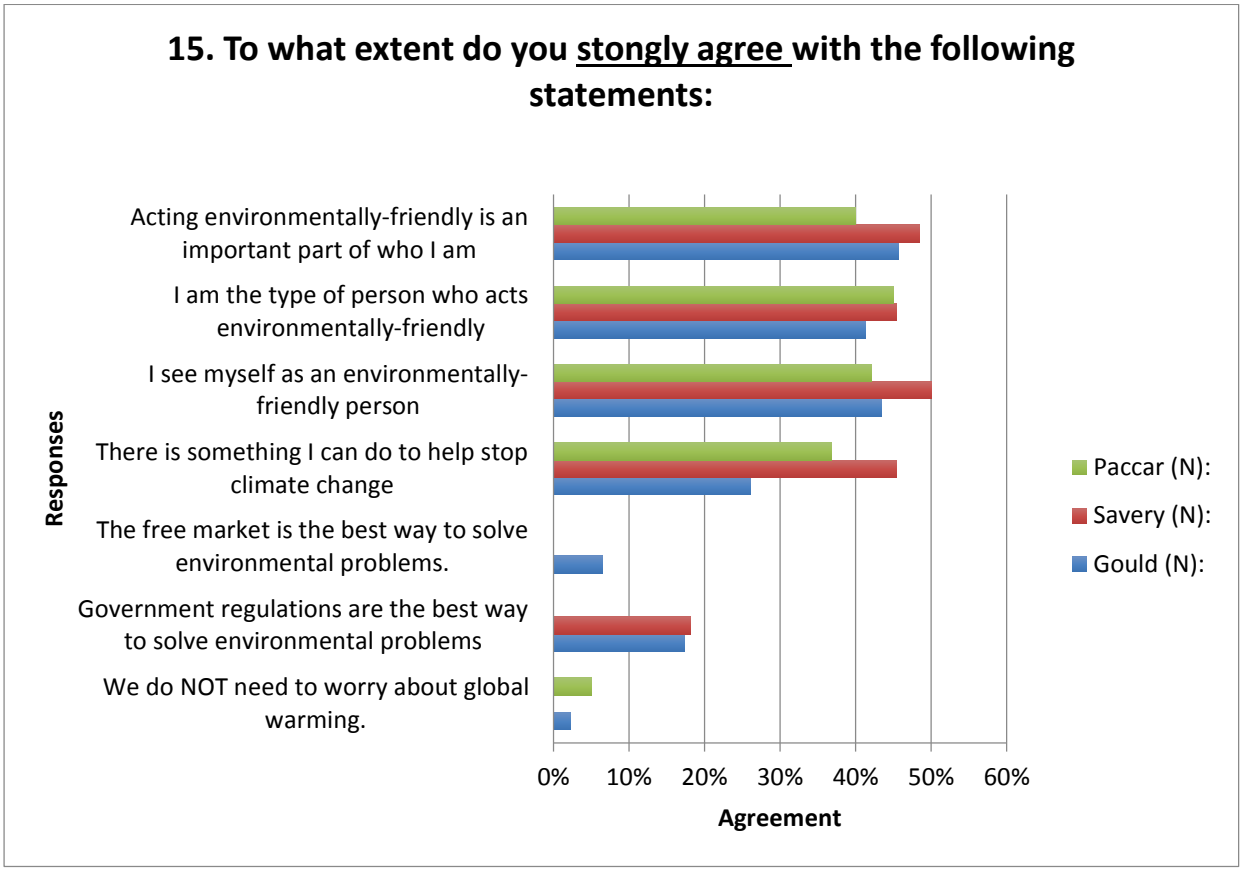
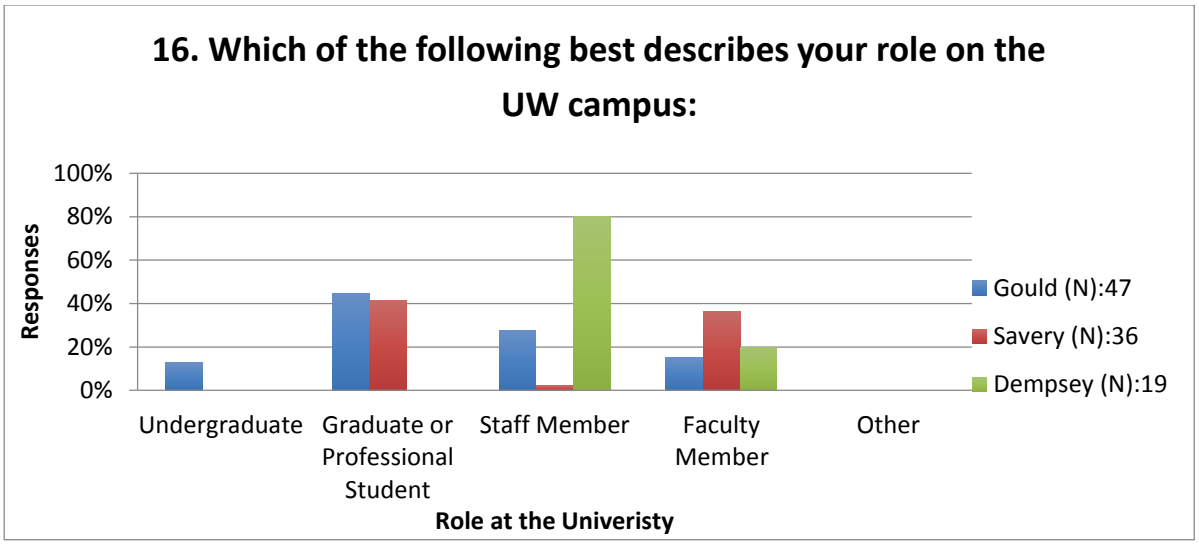
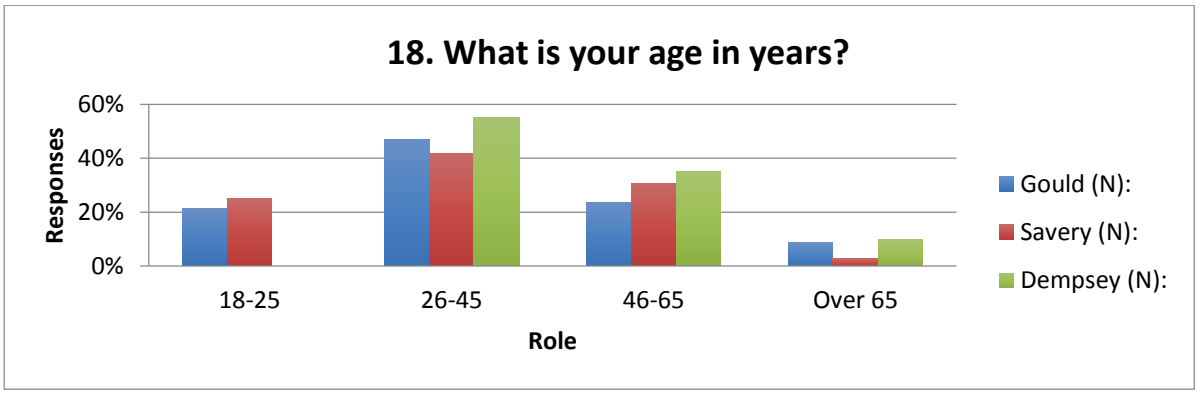


Fig. 36: Summary of User Beliefs about Climate Change

Finally, Questions 16- 20 (shown in Figures 37 and 38) capture socio-demographic characteristics of the respondents. These data are specifically used to predict the pro-environmental behavior of users. For instance, studies (Clayton, ed. 2012) have found that younger people, female, people with middle/upper middle socioeconomic status, and people with environmental related education are potentially more engaged in acting pro-environmentally.



17. What college, department, or major do you most identify with?



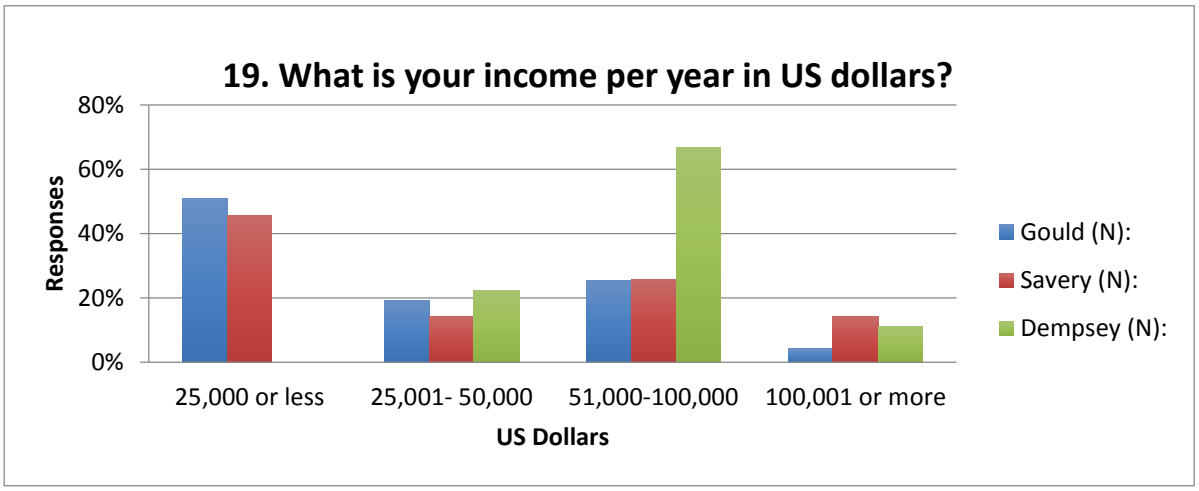


Fig. 37: Respondent's Socio-Demographic Information (Role in UW, Age, and Income)

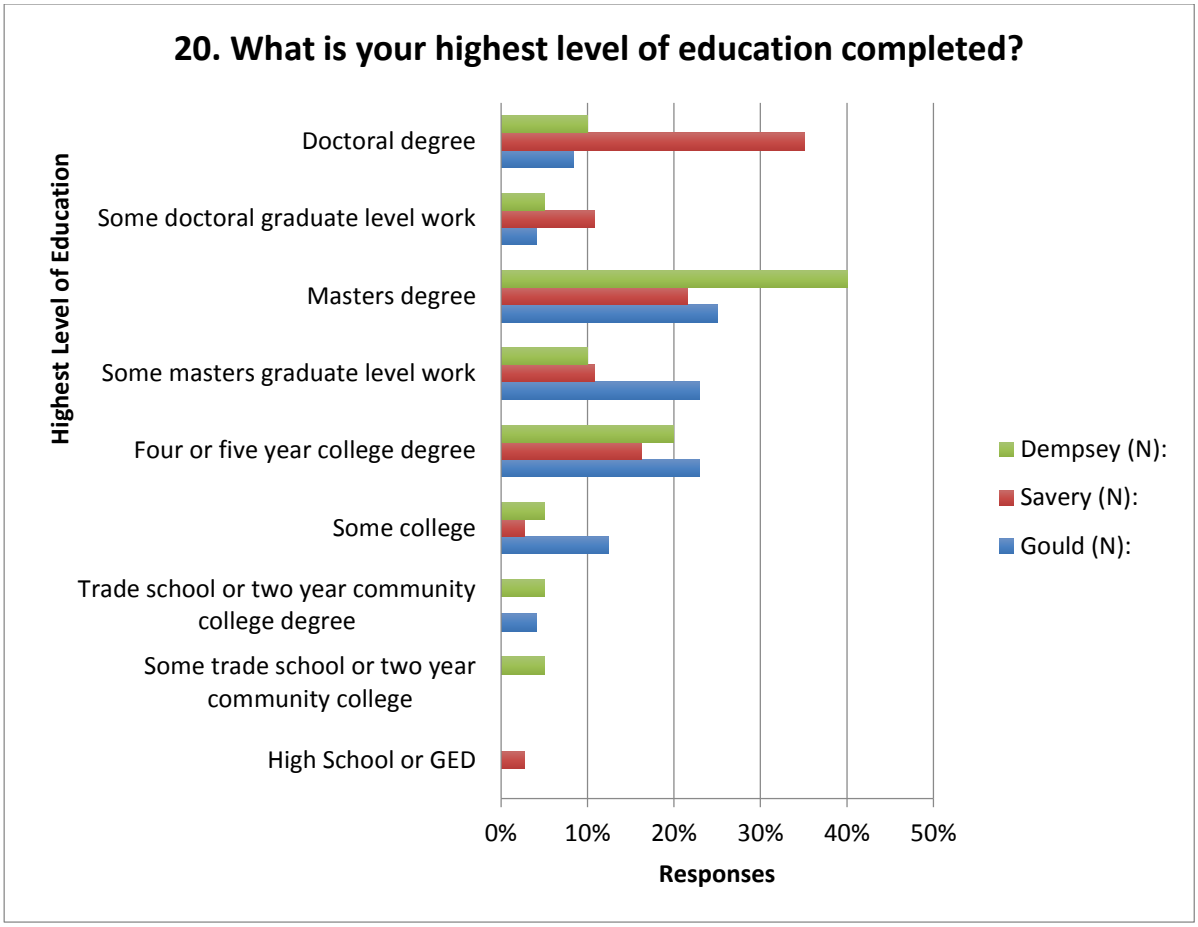


Fig. 38: Respondent's Socio-Demographic Information (Level of Education)

4.4. Findings and discussion

For a comprehensive analysis of occupants' behavior, the results of three audit methods were compared with each other and also correlated to the other related databases provided by UW. The purpose is to gain the best understanding of the influences of the occupant's behavior on the building and energy use. In particular, the following examples of valuable information can be generated by correlating the results of different analyses:

Difference between expected and actual use of equipment and energy: one of the main goals of the building user audit is to develop an understanding of how users perceive their energy use behavior compared to their actual behavior. In this case, the data analysis of three audit methods were correlated. The result of such analysis shows a significant difference between the number of electrical devices (e.g. microwave, refrigerators, and personal heaters/fans) reported by the occupants in the survey and the numbers counted by the auditors. The reported numbers (user

survey) are much higher than those observed by the auditors (manual observation). 50-65% of respondents in Gould, Savery, and Dempsey Halls reported that they turn off the electric light when leaving their offices. The results of automated monitoring indicates, however, that in Gould Hall (in selected rooms) 38% of energy used for lighting in offices is actually wasted because the light is left on in a vacant room. This amount reaches to 43% in Savery Hall and 51% in Dempsey Hall. In terms of using computers and other small equipment, the result of manual and automated monitoring generally confirms the results of survey which shows about 50% of occupants in Gould and Savery (about 30% in Dempsey) turn off their computers on leaving. However, somewhat contradictory information was gathered on more close inspection in the selected staff rooms in Gould Hall where 2 of 3 staff almost never turn off their computers at night.

Unexpected use of building: this can be found out by comparing the number of students were expected to attend in the classes (by searching the "room schedule finder" database) with the actual number of people present in that class (captured during the manual observation). The results of this analysis show few unexpected uses in any of three audited buildings. However, in Savery Hall some unexpected use of classrooms after business hours, found through manual and automated monitoring. It seems that some students stay at classrooms after business hours to study. Also, some workshops, small seminars, or meetings took place in the classrooms that were not recorded by the room schedule finder database. In addition, the data extracted from the "schedule finder" database seems to be very roughly estimated. Because in some comparisons, those numbers were much higher than the actual number of students manually observed by the auditors.

Comfort in the Building and Occupant's reactions:

Thermal Comfort. It is surprising to see that 20% of both Dempsey and Gould Halls report using personal heaters to maintain comfort while Savery (the oldest building, but recently renovated) reports using no auxiliary heating devices. It might be that Gould Hall (primarily a concrete structure with little direct sunlight into classrooms) and Dempsey (primarily a glass building with south facing glazing primarily located in public spaces) are uncomfortable to building occupants who will readily lose heat to these cold surfaces. In addition, the range of indoor temperature and humidity in the buildings can be compared to the standard ranges. The ASHRAE and OSHA standards (AET 2010) recommend a range of temperature between 68-76 and a range of humidity between 30-50% in the winter in order to keep the indoor environment comfortable (Table 9). The

result of automated monitoring (Table 10) reveals that the range of temperature in all three buildings is close to the standard range. However, the range of relative humidity is vastly different in three buildings and also compared to the standard range. Savery Hall has the most standard range of humidity (40-60%) in comparison with 50-75% in Gould Hall and 15-35% in Dempsey Hall. Interestingly, between 60-80% of the respondents to the survey (in all audited buildings) reported that they feel comfortable in the building. Additionally, a difference between the results of survey and manual/automated monitoring arose in user's reactions to adjusting the level of comfort in the offices.

Table 9: Recommended range of indoor temperature and humidity

	Temperature ^{o}F	Humidity %
Summer	73 - 79	40 - 65
Winter	68 - 76	30 - 50

Table 10: Average Range of Indoor Temperature and Humidity in the Audited Buildings

	Temperature	Humidity
Gould Hall	60 – 75 °F	50 – 75 %
Savery Hall	65 – 74 °F	40 – 60 %
Dempsey Hall	65 – 75 °F	15 – 35 %

Operable Windows: According to the survey, 50-70% of respondents open and close the windows in their offices. Based on the manual observation, however, the number of rooms with open windows was less than 5% of the total number of rooms with operable windows in all three buildings. This can be explained by users acknowledging that they open and close their windows, yet they do so on a periodic or sporadic basis, since the number of windows open during the walk-throughs was vastly lower than self-reported behavior. The time of year of the audit is also clearly a factor, it is probable that during warmer months, users will open windows more than was observed in the spring and fall audits.

Blinds: The manual observation shows that 25-35% of rooms surveyed had open blinds. The remaining observed rooms had blinds that were either all the way or partially closed. Based on the User Survey, 40% of Savery and Dempsey Hall respondents report that they never close shades,

blinds or shutters (almost 30% for Gould Hall). It can be concluded that in practice, building occupants use natural daylight and ventilation through operable windows much less than what they report (an average of 15%). This is also an important observation for design or future intervention programs - occupants have the opportunity to utilize natural lighting and turn off electric lighting, however, with the vast majority of rooms having blinds deployed, the building and occupants are not taking advantage of natural resources for lighting or the intended building design.

Whole user-influenced energy use: to better understand the portion of building energy that is influenced by occupants in the buildings, the amounts of monthly energy used by lights and plug loads were calculated for each of the audited buildings. These energy end-uses were then compared to the total electrical energy used by each building, provided by the UW energy dashboard. It is useful to mention that in a typical education building (according to CBECS 2003 national average) 23% of total building electrical energy consumed is by lighting and 7% of energy consumed is by computers. According to the BUAP Audit, the energy used for lighting (controlled by users) and plug loads accounts for about 10% of electrical energy consumed in Gould Hall and Dempsey Hall and 18% in Savery Hall. However, it should be noticed that Gould and Dempsey Halls use natural gas besides of electricity. Therefore, the energy used for lighting and plug loads is about 4% of total energy used in each of these two buildings. The amounts of electrical energy used and total energy used are the same in Savery Hall because no natural gas is consumed in this building. There are clearly indirect influences on building energy use beyond those studied in the BAUP such as effects of people and equipment on heating and cooling loads. These energy interactions were not studied as part of this analysis, but are an important indication for whole building energy use auditing. Detailed calculation of user influenced energy used for lighting and plug loads are provided in tables 11 and 12. The following formula were used in calculations:

Amount of energy used for lighting [KWh] = Avg. duration of light use [hrs] X Area [SF] X LPD [Watt/SF] X 4 [month/week] / 1000 [KW/Watt].

Amount of energy used for plug loads [KWh] = Avg. amount of electricity use [KWh] X Number of rooms X 4 [month/week] / 1000 [KW/Watt]

In the first equation, the average amount of light use were calculated by using the data of HOBO UX90 and the areas (classrooms and offices) were estimated using the floor plans. The value of

LPD* for Gould, Savery, and Dempsey Halls were assumed as 1.5, 1.2, and 1.0, respectively. Also, in the second equation, the first parameter were captured by using the data of WattsUP Meters and the number of rooms (faculty office, staff office, etc.) were approximately estimated using the floor plans. It is also assumed that all faculty, staff, and grad student uses either desktop or laptop in their offices.

* Lighting Power Density (LPD) is a factor defined by ANSI/ASHRAE as the maximum lighting power per unit area of a building classification of space function (ASHRAE 2012).

Table 11: Calculation of Energy Used by Lighting

Energy Use/Lights	Energy Use In Offices	Energy Use In Classrooms	Sum of Two Values	Share of Total Energy Use
Gould Hall	1,197 KWh	3,506 KWh	4,704 KWh	5.9 %
Savery Hall	5,944 KWh	7,896 KWh	13,840 KWh	13.8 %
Dempsey Hall	2,689 KWh	1,756 KWh	4,445 KWh	7.6 %

Table 12: Calculation of Energy Used by Plug Loads

Energy Use/Plugs	Energy Use In Staff Offices	Energy Use In Faculty Offices	Energy Use in Computer Labs	Energy Use in Grad Student Offices	Sum of all Values	Share of Total Energy Use
Gould Hall	1,657 KWh	84 KWh	565 KWh	331 KWh	2,637 KWh	3.3 %
Savery Hall	1,685 KWh	519 KWh	2,182 KWh	356 KWh	4,742 KWh	4.7 %
Dempsey Hall	1,078 KWh	NA	NA	NA	1,078 KWh	1.8 %

5. Conclusion

5.1. Research Summary

This study is answering the question that how does building user's behavior impact the building's energy consumption? For this purpose, an exhaustive literature review were done to establish a framework for the building user audit in accordance with the current energy audit tools. Also, the major user influenced energy end uses in educational buildings were identified and the criteria impacts the environmental behaviors were studied. These two body of knowledge were subsequently used to design the BUAP methods for capturing physical and cultural aspects of building user behaviors.

The BUAP tool was tested in three buildings at University of Washington (UW) and revised during two rounds of audits; first, in the Spring of 2014 and the second, in the Fall of 2014. Three different methods of data collection (manual observation, automated monitoring, and user survey) were designed for this research with several purposes including capturing maximum data about energy use and occupant's behaviors in buildings, validating data, and comparing data (data integration) to extract most reliable information regarding building performance.

The results of data analysis and major findings from auditing the three case studies are summarized as follows:

Findings specific to manual observation and automated monitoring:

- The manual observation reveals that in general 10am and 3pm are the peak hours of building space, equipment, and energy use in all three audited buildings.
- About 25% of users bring their laptops to the building and about 50% of them are plugged in.
- It is interpreted that the building occupants are using natural lighting and ventilation much less than what is expected and what they report.

Findings specific to user survey:

- After hours building use is higher than expected in buildings with restricted hours demonstrating unanticipated times of energy consumption.

- "Office" uses in social or common spaces suggests including these spaces in future audits to capture MEL's (miscellaneous electric loads) of computers, tablets and cell phone charging.
- Over 40% of building users (mainly faculty and staff) believe acting pro-environmentally is an "important part of who they are" yet less than one third believe that they can do something about climate change revealing an incongruence between values and actions.
- The environmental values section of the survey predicts that building occupants are very likely to engage in pro-environmental behaviors suggesting that this population would be receptive to UW campaigns fostering pro-environmental actions to reduce energy consumption.

Overall findings (triangulated between the three methods of audit):

In summary, The Building User Audit reveals a considerable influence of building occupants on energy use. For example, the project team estimated the amount of energy used for electrical lighting in classrooms and offices (which is controlled by the occupants) and the energy used by plug loads (MEL's) in offices. As a result, these two sources consume about 10% of electrical energy consumed in Gould Hall (equal to 7,341 KWh) and Dempsey Hall (equal to 5,523 KWh). This percentage is about 18% (of total energy used) in Savery Hall (equal to 18,583 KWh).

In addition, this study shows a gap between the occupants expected behaviors/actions and their actual behaviors/actions in terms of space and energy use. For instance, about 60% of respondents to the survey report that they turn off the lights when leaving their offices. While the result of the building audits indicates that electric lights were left on between 40%-50% of the time in vacant offices, leading to a significant waste of energy and a gap between perceived behavior and actual behavior.

Based on the data collection and analysis it is inferred that the BUAP use the raw data captured by the three methods of building auditing as the input and produces the following group of information about building performance as the output:

- Whole energy use: user-influenced energy used by lights and plug loads.
- Level of Comfort: level of thermal comfort in building and user reactions for adjustments.
- Use of equipment: total number of equipment, peak hours, and pattern of use.

- Building Occupancy: number of people present, besides of the pattern of occupancy and movements.
- Building use: unexpected use of building, after-hour use, and user perceived behaviors.

An accurate implementation of the BUAP will give an opportunity to stakeholders for setting appropriate strategies and improving energy efficiency in the audited buildings. For this purpose, an effective model of data visualization is required. Such model is presented as the "building factsheet" that provides an overview of building information, summarizes the results of manual observation and automated monitoring, and make an opportunity for better data comparison and interpretation. The complete building factsheet of each audited building is found in the appendices.

5.2. Contribution to the body of knowledge

This research project identified a gap in analysis of building user-influenced energy use. As it was discussed in the section "literature review" there are many building audit tools that evaluate energy efficiency mostly by focusing only on building systems. Almost in all cases, these tools either overlook the role of occupants in energy consumption or consider it through a roughly estimation of user presence rather than an exhaustive user behavior assessment. Also, several researches are found that study the environmental behaviors from social and psychological perspective. However, The BUAP as the main outcome of this research combines these two approaches to achieve an optimized solution for understanding the energy related user behaviors. Consequently, the BUAP is providing a comprehensive method for the whole process of building user audit including an innovative method of data integration and visualization (building factsheets).

The BUAP is specially prepared to address the GHG emissions reduction goal that set by the University of Washington (based on its climate action plan). This study provides the knowledge the UW needs to understand the current level of energy efficiency in its buildings and find potential chances for improvements. In addition, the presented building user audit procedure is applicable in other educational buildings so that other US universities can benefit from using this tool.

Finally, this research indicates a right direction for the future research studies by asking the right questions regarding buildings energy efficiency, demonstrating a discrepancy between expected and actual user behaviors, and offering feasible recommendations for the next steps.

5.3. Next Steps

BUAP enables the building managers and O&M staffs to understand the actual building condition (in terms of performance and energy consumption) and to characterize the user behavior and its influences. Subsequently, two important actions can be taken in the audited buildings:

- Creating intervention programs (like occupants training programs) for the user of each audited buildings according to the results of the building audit and their unique behavior characteristics.
- Incorporating the BUAP to the building automation systems (BAS) for real time data collection/processing and optimized facility management.

Both of these two ideas are preliminary and need further investigations and academic researches. Also an interdisciplinary system approach is required for the success of any research on this topic. The process and findings of this research demonstrate that more investments on the research projects in the field of energy efficiency and analysis of user behaviors are needed and may generate substantial environmental, economic, and social benefits.

6. Bibliography

Accredited Environmental Technologies. “IAQ 101: Temperature and Humidity”. AET Insights March 2010 (http://aetinc.biz/newsletters/2010-insights/march-2010, Accessed 06/15/2015).

Alajmi, Ali. “Energy Audit of an Educational Building in a Hot Summer Climate”. Energy & Buildings. Vol.47. 2012. Pp. 122-130.

ASHRAE. “Energy Standards for Buildings Except Low-Rise Residential Buildings”. ANSI/ASHRAE/IES Standard 90.1-2010 (I-P Edition). 2012. P. 12

Azar, Elie; Menassa, Carol C. “A Data Collection and Analysis Framework to Improve the Performance of Energy-Intensive Commercial Buildings”. Computing in Civil and Building Engineering. ASCE. 2014. Pp. 1142-1149.

Barley, D.; Deru, M.; Pless, S.; Torcellini, P. “Procedure for Measuring and Reporting Commercial Building Energy Performance”. National Renewable Energy Laboratory (NREL). Colorado. 2005. Pp. 1-2.

Beachler, Michael; Strecker, Cindy; Shafer, Jennifer. “Building Technologies Program, a Guide to Energy Audits“. Pacific Northwest National Laboratory, Portland Energy Conservation, Inc. Prepared for U.S. Department of Energy. Richland, Washington. 2011. Pp. 1-4.

Clayton, Susan D. ed. “The Oxford Handbook of Environmental and Conservation Psychology”. Oxford University Press. New York, NY. 2012. Pp. 66-70.

Crosby, Kate; Metzger, Anisa Baldwin. “Powering Down: A Toolkit for Behavior-Based Energy Conservation in K-12 Schools”. The Center for Green Schools at the U.S. Green Building Council (USGBC). Pp. 2, 4.

Deru, Michael P; Kelsey, Jim. “Procedures for Commercial Building Energy Audit“. 2nd Ed. ASHRAE. Atlanta, GA. 2011. Pp. 1-9.

Dubois, M.-C.; Blomsterberg, A. “Energy saving potential and strategies for electric lighting in future North European, low energy office buildings: a literature review”. Energy & Buildings. Vol.43. 2011. Pp. 2572-2582.

Eggink, John. “Managing Energy Costs: A Behavioral and Non-Technical Approach”. Taylor & Francis Ltd. USA. 2007. Pp. 4, 29-44.

Galarraga, Ibon; Gonzalez-Equino, Mikel; Markandya, Anil ed. “Handbook of Sustainable Energy”. Edward Elgar Publishing Limited. UK. 2011. Pp. 181-183.

Guerra-Santin, Oliva; Tweed, Christopher Aidan. “In-use monitoring of buildings: An overview of data collection methods”. Energy and Buildings. Vol.93. 2015. Pp. 189-207.

Gul, Mehreen S.; Patidar, Sandhya. “Understanding the energy consumption and occupancy of a multi-purpose academic building”. Energy and Buildings. Vol.87. 2015. Pp. 155-165.

Hoes, P.; Hensen, J.L.M; Loomans, M.G.L.C.; De Vries, B.; Bourgeois, D. “User behavior in whole building simulation”. Energy and Buildings. Vol.41. 2009. 295-302.

Kamilaris, Andreas; Kalluri, Balaji; Kondepudi, Sekhar; Kwok Wai, Tham. “A Literature Survey on Measuring Energy Usage for Miscellaneous Electric Loads in Offices and Commercial Buildings”. Renewable and Sustainable Energy Reviews. Vol.34. 2014. Pp. 536-550.

Kelsey, Jim; Pearson, Dick. “Updating Procedures for Commercial Building Energy Audits”. ASHRAE Transactions. 2011. Pp. 374-382

Krajhanzl, Jan. “Environmental and Pro-Environmental Behavior”. Health Education: International Experiences. School and Health 21. 2010. Pp. 251-274.

Lindenberg, S.; Steg, L. “Normative, gain and hedonic goal-frames guiding environmental behavior”. Journal of Social Issues, Vol.63. 2007. Pp. 117-137.

Lynn, Abraham C.; Reitherman, Robert ed. “AEI 2011: Building Integration Solutions”. Proceedings of the 2011 Architectural Engineering National Conference. The Architectural Engineering Institute (AEI), American Society of Civil Engineers (ASCE). California. USA. 2011. Pp. 228-234.

Mckenney, Kurtis; Roth, Kurt; Paetsch, Chris; Ponoum, atcharit. “U.S. Residential Miscellaneous Electric Loads Electricity Consumption”. ACEEE Summer Study on Energy Efficiency in Buildings. 2008. Pp. 258-269.

Menezes, Anna Carolina; Cripps, Andrew; Bouchlaghem, Dino; Buswell, Richard. "Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap". Applied Energy. Vol.97. 2012. Pp. 355-364.

Milfont, Taciano L.; Duckitt, John; Wagner, Claire. "A Cross-Cultural Test of the Value-Attitude-Behavior Hierarchy". Journal of Applied Social Psychology. Vol.40. Wiley Periodicals, Inc. 2010. Pp. 2791-2813.

National Center for Education Statistics (NCES). "Fast Facts". U.S. Department of Education, Institute of Education Sciences. (http://nces.ed.gov/fastfacts/display.asp?id=98, accessed 06.05.2015).

National Science Board. "Building a Sustainable Energy Future". National Science Foundation (NSF). 2009. Pp. 6-8, p. 31.

Reinhart, C.F. "Lightswitch-2002: a model for manual and automated control of electric lighting and blinds". Solar Energy. Vol.77. 2004. Pp. 15-28.

Steg, Linda; Bolderdijk, Jan Willem; Keizer, Kees; Perlaviciute. "An Integrated Framework for Encouraging Pro-environmental Behaviour: The role of values, situational factors and goals". Journal of Environmental Psychology. Vol.38. 2014. Pp. 104-115.

Steg, Linda; Vlek, Charles. "Encouraging pro-environmental behaviour: An integrative review and research agenda". Journal of Environmental Psychology. Vol.29. 2009. Pp. 309-317.

University of Washington (UW). Energy Dashboard. (http://dashboard.mckinstry.com/uw/, Accessed 06/15/2015).

University of Washington (UW). Office of Registrar. Room Schedule Finder. (https://depts.washington.edu/registra/RATS/availability/index.php, Accessed 06/15/2015).

Vicente-Molina, Maria Azucena; Fernandez-Sainz, Ana; Izagirre-Olaizola, Julen. "Environmental knowledge and other variables affecting pro-environmental behaviour: comparison of university students from emerging and advanced countries". Journal of Cleaner Production. Vol.61. 2013. Pp. 130-138.

Wilson, R.; Rutherford, P.; Bridges, A.; Branki, C. “Virtual Agents and building performance evaluation-a position paper”. In Proceedings of IBPSA Australasia 2006 Conference. Adelaide, Australia. 2006. Pp. 110–117.

Yu, Zhun; Fung, Benjamin C.M.; Haghighat, Fariborz; Yoshino, Hiroshi; Morofsky, Edward. “A Systematic Procedure to Study the Influence of Occupant Behavior on Building Energy Consumption”. Energy & Buildings. Vol.43. 2011. Pp. 1409-1417.

7. Appendices

The following appendices are attached to the thesis:

- Glossary (Frequently used expressions)
- Building factsheet (a completed results of data analysis for each of audited buildings)
- Auditing Materials (Building managers handout, invitation letters for voluntary automated monitoring and participation in survey)

Appendix I

Glossary

(Frequently Used Expressions)

To use the BUAP most effectively, it is necessary to define some frequently used.

Analyst Building Walkthrough: The analyst should conduct this walkthrough to count the total number of pieces of equipment present and also identify the vacant rooms in the building. It is recommended that this audit be conducted on the first day of manual observation.

Auditor: The individual who conducts the building walkthrough to collect the data required for the manual observation. Ideally, six auditors should be recruited for this purpose. The auditors should be trained by the analyst before starting the audit.

Automated Monitoring: A method of data gathering & analysis includes installing automated data loggers in selected rooms in the building being audited.

Building Factsheet: A completed profile of the building audit that summarizes the final results of an in depth data analysis. It contains tangible findings about the building performance and the influences of user's behavior.

Energy Analyst: The individual who leads the whole process of the audit. The responsibilities of the analyst includes, but is not limited to, performing the preliminary analysis, adjusting (if needed) and implementing all three methods of the audit, and creating all needed reports.

Manual Observation: A method of data gathering & analysis that includes performing a building walkthrough and capturing the required data by filling out a data check sheet.

Preliminary Analysis: The first step of Building user audit. During this phase, the audited building should be selected and the access to the databases should be gained.

User Survey: A method of data gathering through the implementation of a survey instrument. The online user survey is sent to the building's users to capture various aspects of user culture and behavior related to energy consumption.

User-influenced Energy Consumption: The goal of the audit is to identify the influence of the building user behavior on energy consumption. Therefore, this concept refers to the share of energy influenced by the occupants. For instance, the amount of energy used by HVAC systems would be excluded from the purpose of this audit.

Walk-through Analysis: The second stage of the audit contains an interview with the building manager(s) and a basic building walkthrough. This audit helps the analyst to become more familiar

with audited building, adjust the methods of audit if necessary, and prepare for the implementation of the audit.

Workstation: It is defined as any electrical devices (except hard-wired lighting sources) which are used by one occupant in his/her office. Usually, a computer/laptop and a personal printer/copier/scanner machine would be considered as a workstation. During the automated monitoring, the amount of electricity consumed by a workstation (in selected rooms) will be audited by means of Watts Up meters.

Appendix II

Building Factsheet: Gould Hall

GOULD HALL

The summary sheets provide the results of manual observation and automated monitoring:

1. An overview of the building information
2. Quick facts from the data summarization & analysis
3. A summary data collected through the manual observation. First table organizes data based on different days of the week. Second table organizes data based on different hours per day.
4. The extent & pattern of building occupancy, desktops use, and lighting use (indicated in graphs).
5. Number of laptops present and plugged in
6. The results of automated monitoring (HOBO devices) in the selected rooms including extent & pattern of room occupancy, light use, and average room temperature & humidity.
7. The results of automated monitoring (Watts Up meters) in the selected rooms including the extent & pattern of electricity use.

Building Overview	
Number of Stories	1 Basement + 4 stories
Departments of	Architecture, Construction Management, Landscape Architecture, Urban Design + Planning, Real Estate
Number of Offices	54
Number of Classrooms	15
Number of Computer labs	1
Number of Rooms with Operable Windows	40

Building Fact Sheet

Manual Observation & Automated Monitoring Quick Facts	
Time period of audit	13 – 18 October 2014
Audit time slots	8am, 10am, 12pm, 3pm, 6pm, 9pm
10 AM and 3 PM are the peak hours of the building use (Number of people present, desktops in use, and rooms with light on)	
In average, the number of rooms with opened windows is less than 5% of the total number of rooms with operable windows.	
In average, the number of rooms with opened blinds/drapes is about 35% of the total number of rooms with windows.	
Almost, 19% of building users bring their laptops to the building and 51% of laptops are plugged in.	
Range of indoor temperature	60 – 75 °F (Standard range: 68-76 °F)
Range of indoor humidity	50 – 75 % (Standard range: 30-50 %)
Total number of equipment in the building	
Printer/Scanner/Copier : 16	Projector : 5 (very much in use)
TV : 2 (not much in use)	Personal heater/fan : 3/6 (much in use)
Desktop : 86	Refrigerator : 4 Microwave : 5

The tables show a summary of data collected through the manual observation

Type of Data	Mon.						Tue.						Wed.						Thu.						Fri.						Sat.					
	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM
Total number of people present	83	198	154	51	78	21	76	245	171	138	117	14	26	205	100	141	128	38	23	258	110	214	124	35	21	101	103	162	35	2	8	6	6	5	8	19
Total number of room with light on	15	32	17	26	24	9	18	29	21	28	24	6	12	34	18	20	17	6	11	32	11	26	20	5	12	29	12	22	13	1	3	6	1	4	14	2
Total number of rooms with opened windows	0	4	2	0	3	0	0	2	0	0	0	0	0	2	0	0	2	0	0	1	1	0	1	0	0	2	1	0	1	0	1	3	0	0	2	0
Total number of rooms with opened blinds/drapes	14	6	11	23	0	0	21	15	8	18	2	0	17	16	13	14	5	2	15	17	3	20	1	0	13	19	3	13	4	0	10	10	1	3	2	1
Average rooms temperature	62	65	64	65	64	NA	61	66	62	64	63	NA	62	65	67	67	0	NA	69	69	70	65	NA	NA	61	71	NA	67	70	NA	70	71	NA	NA	71	NA
																							0													
Total number of desktops on	19	63	33	27	30	15	23	45	61	46	19	2	11	71	51	44	25	13	6	69	25	49	14	33	4	40	32	35	6	1	0	4	2	4	8	5
																							0													
Total number of laptops present	13	39	34	15	15	6	18	30	27	17	35	4	6	48	13	39	30	4	7	44	16	27	19	5	6	49	20	16	0	1	0	1	3	0	1	1
Total number of laptops plugged in	3	6	15	14	3	5	10	20	18	11	8	3	3	18	8	25	11	1	5	16	7	18	2	5	1	24	8	16	0	1	0	1	1	0	0	0
																							0													
Total number of projectors in use	0	1	2	1	3	0	1	1	4	4	5	0	0	3	1	4	0	0	0	1	1	4	2	0	0	5	1	1	0	0	0	2	0	0	0	0
																							0													
Total number of TV's in use	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
																							0													
Total number of desk/floor lamps	5	0	0	2	0	0	14	9	8	9	1	0	8	7	10	10	4	0	6	11	7	6	2	0	2	12	7	6	8	0	0	1	0	0	1	0
Total number of personal fans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of personal heaters	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of cell phones plugged in	0	0	4	0	0	1	2	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Total number of tablets plugged in	0	0	0	0	0	1	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Uwarch-belog.com

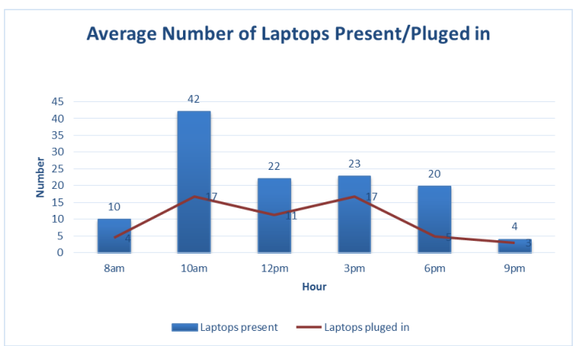
Type of Data	8 AM						10 AM						12 PM						3 PM						6 PM						9 PM					
	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
Total number of people present	83	76	26	23	21	8	198	245	205	258	101	6	154	171	100	110	103	6	51	138	141	214	162	5	78	117	128	124	35	8	21	14	38	35	2	19
Total number of room with light on	15	18	12	11	12	3	32	29	34	32	29	6	17	21	18	11	12	1	26	28	20	26	22	4	24	24	17	20	13	14	9	6	6	5	1	2
Total number of rooms with opened windows	0	0	0	0	0	1	4	2	2	1	2	3	2	0	0	1	1	0	0	0	0	0	0	0	3	0	2	1	1	2	0	0	0	0	0	0
Total number of rooms with opened blinds/drapes	14	21	17	15	13	10	6	15	16	17	19	10	11	8	13	3	3	1	23	18	14	20	13	3	0	2	5	1	4	2	0	0	2	0	0	1
Average rooms temperature	62	61	62	69	61	70	65	66	65	69	71	71	64	62	67	70	NA	NA	65	64	67	65	67	NA	64	63	NA	NA	70	71	NA	NA	NA	NA	NA	NA
Total number of desktops on	19	23	11	6	4	0	63	45	71	69	40	4	33	61	51	25	32	2	27	46	44	49	35	4	30	19	25	14	6	8	15	2	13	33	1	5
Total number of laptops present	13	18	6	7	6	0	39	30	48	44	49	1	34	27	13	16	20	3	15	17	39	27	16	0	15	35	30	19	0	1	6	4	4	5	1	1
Total number of laptops plugged in	3	10	3	5	1	0	6	20	18	16	24	1	15	18	8	7	8	1	14	11	25	18	16	0	3	8	11	2	0	0	5	3	1	5	1	0
Total number of projectors in use	0	1	0	0	0	0	1	1	3	1	5	2	2	4	1	1	1	0	1	4	4	4	1	0	3	5	0	2	0	0	0	0	0	0	0	0
Total number of TV's in use	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
Total number of desk/floor lamps	5	14	8	6	2	0	0	9	7	11	12	1	0	8	10	7	7	0	2	9	10	6	6	0	0	1	4	2	8	1	0	0	0	0	0	0
Total number of personal fans	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of personal heaters	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of cell phones plugged in	0	2	1	0	0	0	0	0	0	0	0	0	4	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Total number of tablets plugged in	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

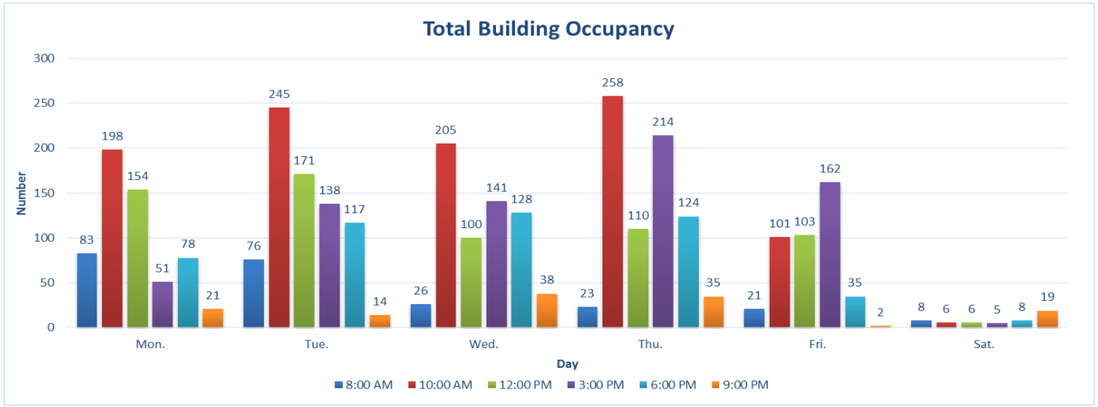
GOULD HALL

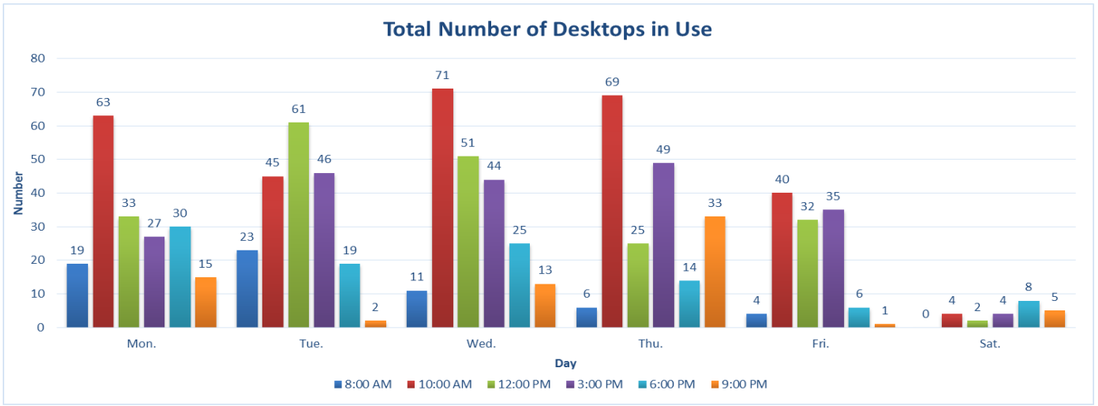
These graphs summarizes the results of **Manual Observation**.

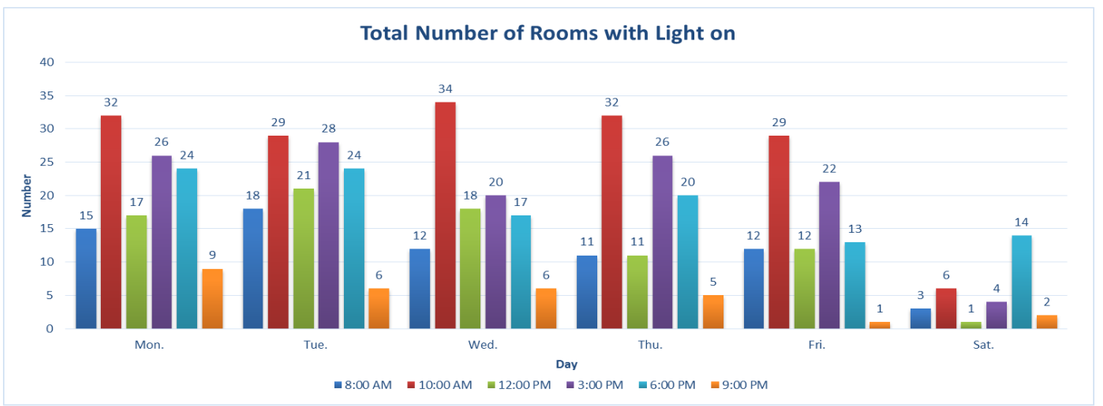
The graphs show the total number of people present, desktops in use, and rooms with light on. The amounts can be compared between different days of a week and different hours of a day.

The graph below shows the average number of laptops present and the numbers of them that were plugged in.









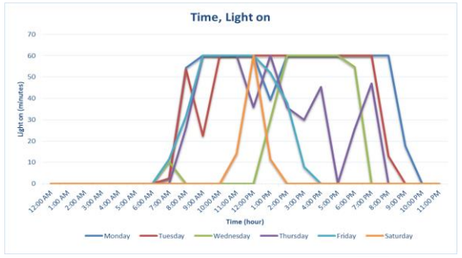
GOULD HALL

Classroom 1

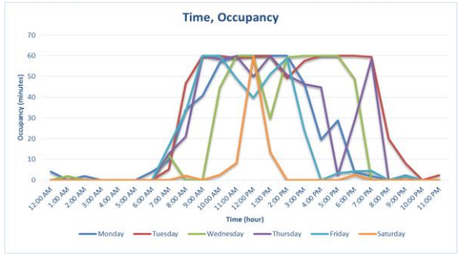
Summary of occupancy & light use

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	4	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	2	0	0	0	0	0	0	0	0
2:00 AM	0	2	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	4	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	2	9	3	5	10	12	0	13	12	17	0	0	0	1
8:00 AM	54	34	54	47	0	0	26	21	32	33	0	2	3	2
9:00 AM	60	41	22	60	0	0	60	60	60	60	0	0	3	4
10:00 AM	60	57	60	60	0	45	60	58	60	60	0	2	4	5
11:00 AM	60	60	60	59	0	60	60	60	60	49	14	8	4	5
12:00 PM	60	60	60	60	0	60	36	50	60	40	60	60	5	5
1:00 PM	39	60	17	60	30	30	60	60	52	51	11	13	4	5
2:00 PM	60	60	60	49	60	59	36	51	38	59	0	0	4	5
3:00 PM	60	47	60	58	60	60	30	46	8	24	0	0	4	4
4:00 PM	60	19	60	60	60	60	45	45	0	0	0	0	4	3
5:00 PM	60	29	60	60	60	60	0	2	0	3	0	0	3	3
6:00 PM	60	4	60	60	55	49	26	29	0	4	0	3	3	2
7:00 PM	60	2	60	60	0	0	47	58	0	4	0	0	3	2
8:00 PM	60	0	13	20	0	0	0	0	0	0	0	0	1	0
9:00 PM	18	2	0	8	0	0	0	0	0	2	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	12.9	8.2	11.5	12.1	5.6	8.3	8.1	9.2	6.3	6.8	1.4	1.5		
Average Use (min/hr)	32.2	20.6	28.8	30.3	14.0	20.7	20.2	23.1	15.9	17.0	3.6	3.7		

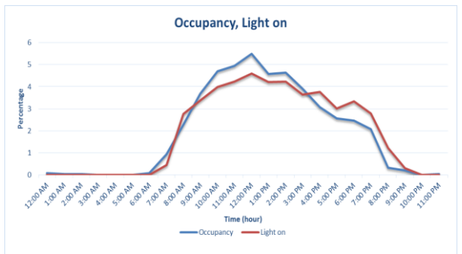
The pattern of lighting use



The pattern of occupancy

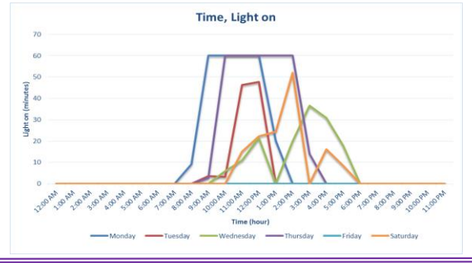


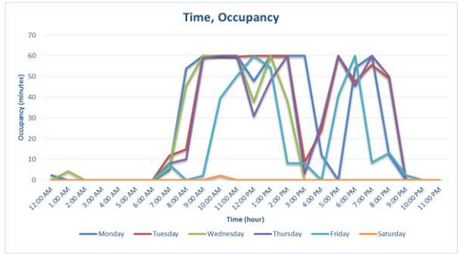
Average hour of daily space & lighting

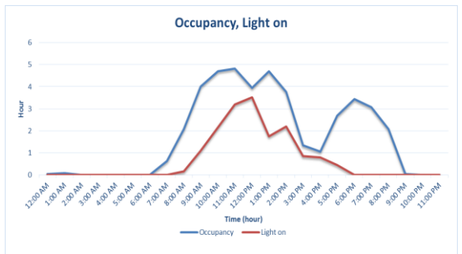


Classroom 2

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	2	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	4	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	5	0	12	0	6	0	8	0	8	0	0	0	1
8:00 AM	9	54	0	15	0	46	0	10	0	0	0	0	0	2
9:00 AM	60	60	4	60	0	60	3	59	0	2	0	0	1	4
10:00 AM	60	60	3	60	6	60	60	60	0	40	0	2	2	5
11:00 AM	60	60	46	60	11	60	60	60	0	50	15	0	3	5
12:00 PM	60	48	48	60	21	38	60	31	0	60	22	0	4	4
1:00 PM	20	60	0	60	0	60	60	48	0	54	24	0	2	5
2:00 PM	0	60	0	60	20	38	60	60	0	8	52	0	2	4
3:00 PM	0	60	0	9	37	0	14	3	0	8	0	0	1	1
4:00 PM	0	12	0	24	31	0	0	27	0	0	16	0	1	1
5:00 PM	0	0	0	60	18	0	0	60	0	41	9	0	0	3
6:00 PM	0	54	0	47	0	0	0	45	0	60	0	0	0	3
7:00 PM	0	60	0	56	0	0	0	60	0	9	0	0	0	3
8:00 PM	0	12	0	49	0	0	0	50	0	13	0	0	0	2
9:00 PM	0	0	0	0	0	0	0	0	0	2	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	4.5	10.1	1.7	10.5	2.4	6.2	5.3	9.7	0.0	5.9	2.3	0.0		
Average Use (min/hr)	11.2	25.3	4.2	26.3	6.0	15.5	13.2	24.3	0.0	14.8	5.8	0.1		

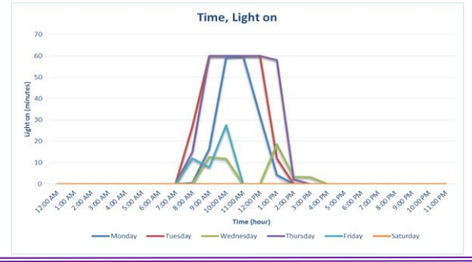


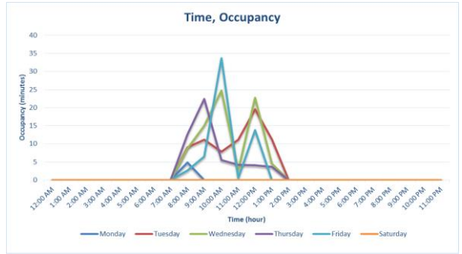


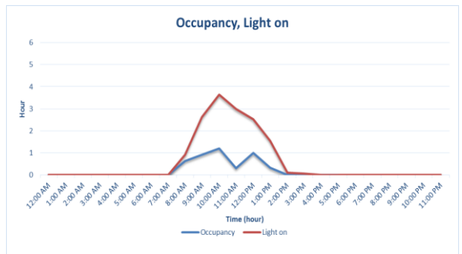


Faculty Office 1

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	1	5	27	9	0	9	15	13	12	3	0	0	1	1
9:00 AM	17	0	60	11	13	15	60	22	8	6	0	0	3	1
10:00 AM	59	0	60	8	12	25	60	6	27	34	0	0	4	1
11:00 AM	60	0	60	11	0	3	60	4	0	1	0	0	3	0
12:00 PM	32	0	60	20	0	23	60	4	0	14	0	0	3	1
1:00 PM	4	0	12	11	19	5	58	4	0	0	0	0	2	0
2:00 PM	0	0	0	0	3	0	2	0	0	0	0	0	0	0
3:00 PM	0	0	0	0	3	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	2.9	0.1	4.6	1.2	0.8	1.3	5.3	0.9	0.8	1.0	0.0	0.0		
Average Use (min/hr)	7.2	0.2	11.6	2.9	2.1	3.3	13.1	2.2	2.0	2.4	0.0	0.0		

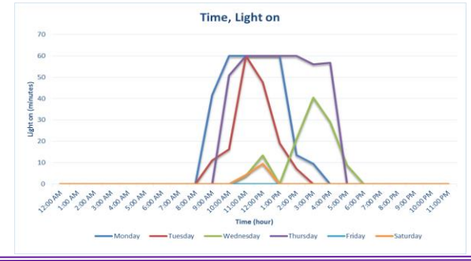


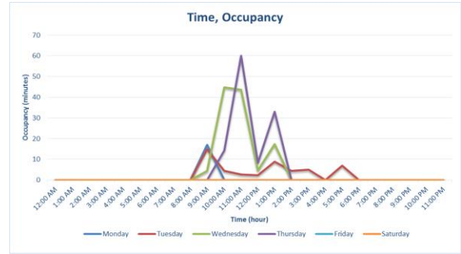


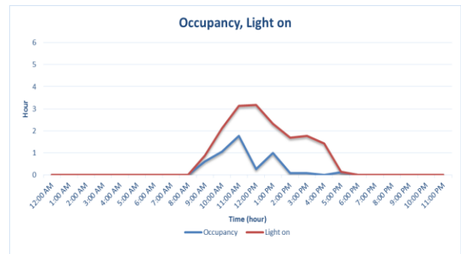


Faculty Office 2

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 AM	42	17	11	15	0	4	0	0	0	0	0	0	1	1
10:00 AM	60	0	16	5	0	45	51	14	0	0	0	0	2	1
11:00 AM	60	0	60	3	4	44	60	60	0	0	0	0	4	3
12:00 PM	60	0	48	2	13	5	60	8	0	0	9	0	3	0
1:00 PM	60	0	19	9	0	17	60	33	0	0	0	0	2	1
2:00 PM	14	0	7	4	21	0	60	0	0	0	0	0	2	0
3:00 PM	9	0	0	5	41	0	56	0	0	0	0	0	2	0
4:00 PM	0	0	0	0	29	0	57	0	0	0	0	0	1	0
5:00 PM	0	0	0	7	9	0	0	0	0	0	0	0	0	0
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	5.1	0.3	2.7	0.8	1.9	1.9	6.7	1.9	0.0	0.0	0.2	0.0		
Average Use (min/hr)	12.7	0.7	6.7	2.1	4.8	4.8	16.8	4.8	0.0	0.0	0.6	0.0		







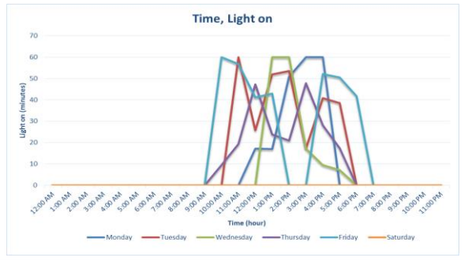
GOULD HALL

Staff Office 1

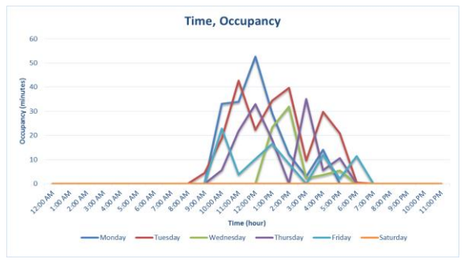
Summary of occupancy & light use

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 AM	0	0	0	4	0	0	0	0	0	0	0	0	0	0
10:00 AM	0	33	0	19	0	0	10	6	60	23	0	0	1	1
11:00 AM	0	34	60	43	0	0	19	22	57	4	0	0	2	2
12:00 PM	17	53	26	22	0	0	47	33	41	10	0	0	2	2
1:00 PM	17	29	52	35	60	23	24	18	43	17	0	0	3	2
2:00 PM	51	12	54	40	60	32	21	0	0	8	0	0	3	2
3:00 PM	60	3	17	10	17	2	48	35	0	0	0	0	2	1
4:00 PM	60	14	41	30	10	4	28	6	52	12	0	0	3	1
5:00 PM	0	0	39	21	7	5	17	11	50	2	0	0	2	1
6:00 PM	0	0	0	0	0	0	0	0	42	12	0	0	1	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	3.4	3.0	4.8	3.7	2.6	1.1	3.6	2.2	5.8	1.5	0.0	0.0		
Average Use (min/hr)	8.5	7.4	12.0	9.3	6.4	2.8	8.9	5.4	14.4	3.7	0.0	0.0		

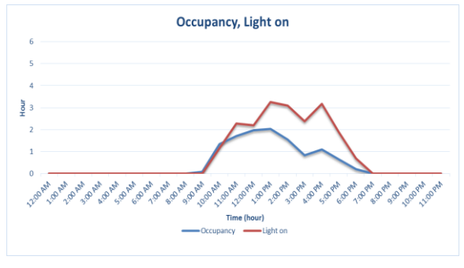
The pattern of lighting use



The pattern of occupancy

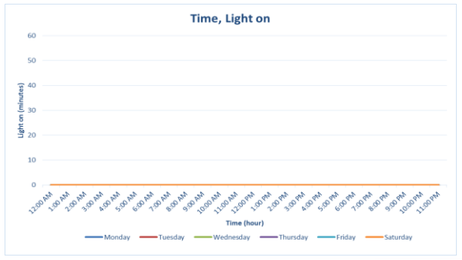


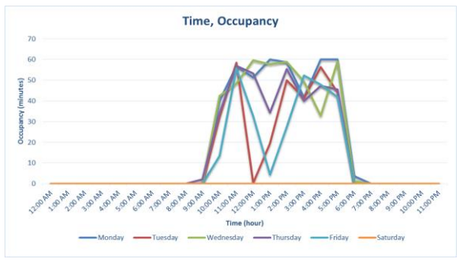
Average hour of daily space & lighting

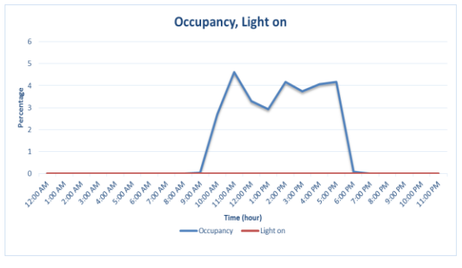


Staff Office 2

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 AM	0	0	0	0	0	0	0	2	0	0	0	0	0	0
10:00 AM	0	40	0	32	0	43	0	34	0	14	0	0	0	3
11:00 AM	0	57	0	59	0	49	0	57	0	56	0	0	0	5
12:00 PM	0	51	0	0	0	60	0	53	0	33	0	0	0	3
1:00 PM	0	60	0	20	0	58	0	34	0	4	0	0	0	3
2:00 PM	0	59	0	50	0	59	0	55	0	27	0	0	0	4
3:00 PM	0	42	0	41	0	49	0	40	0	52	0	0	0	4
4:00 PM	0	60	0	56	0	33	0	47	0	48	0	0	0	4
5:00 PM	0	60	0	44	0	59	0	46	0	42	0	0	0	4
6:00 PM	0	4	0	0	0	1	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	0.0	7.2	0.0	5.0	0.0	6.8	0.0	6.2	0.0	4.6	0.0	0.0		
Average Use (min/hr)	0.0	18.0	0.0	12.6	0.0	17.1	0.0	15.4	0.0	11.5	0.0	0.0		

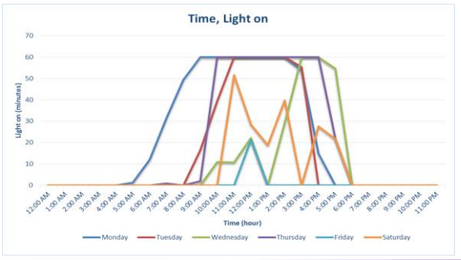


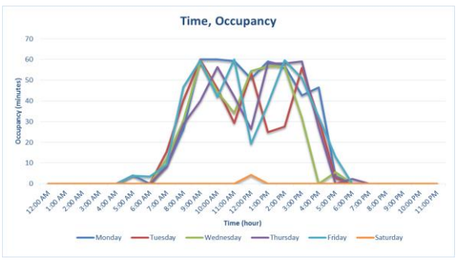


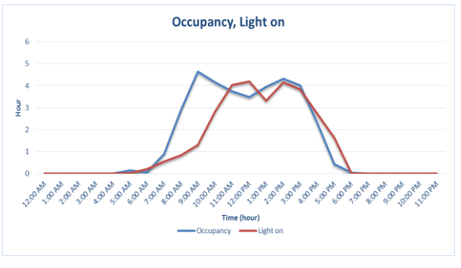


Staff Office 3

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	1	4	0	0	0	0	0	0	0	4	0	0	0	0
6:00 AM	12	0	0	0	0	0	0	0	0	4	0	0	0	0
7:00 AM	32	9	0	15	0	12	1	8	0	9	0	0	1	1
8:00 AM	49	26	0	40	0	31	0	29	0	47	0	0	1	3
9:00 AM	60	60	16	60	0	59	2	40	0	60	0	0	1	5
10:00 AM	60	60	39	46	11	44	60	56	0	42	0	0	3	4
11:00 AM	60	59	60	29	11	34	60	42	0	60	52	0	4	4
12:00 PM	60	51	60	54	22	54	60	26	21	19	28	4	4	3
1:00 PM	60	59	60	25	0	57	60	58	0	38	19	0	3	4
2:00 PM	60	57	60	28	29	57	60	58	0	60	40	0	4	4
3:00 PM	54	43	55	56	60	32	60	59	0	51	0	0	4	4
4:00 PM	15	47	0	31	60	0	60	27	0	32	28	0	3	2
5:00 PM	0	4	0	3	55	6	22	0	0	13	22	0	2	0
6:00 PM	0	0	0	0	0	0	0	2	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	8.7	8.0	5.9	6.5	4.1	6.4	7.4	6.8	0.4	7.3	3.1	0.1		
Average Use (min/hr)	21.8	19.9	14.6	16.1	10.3	16.1	18.5	16.9	0.9	18.3	7.8	0.2		



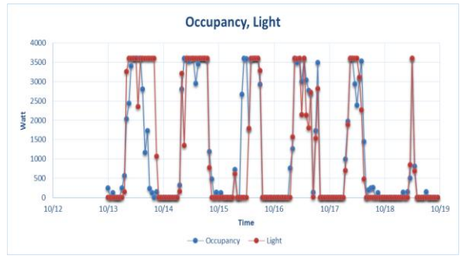




GOULD HALL

Classroom 1

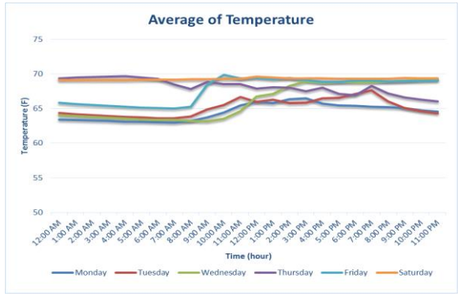
Comparison of occupancy & light on



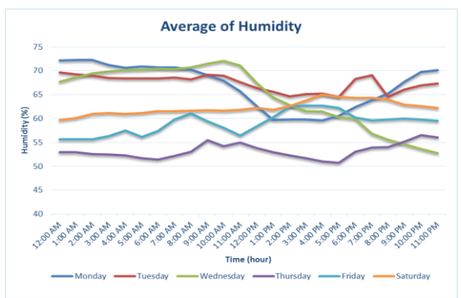
Summary of room temperature

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	63	72	64	70	64	68	69	53	66	56	69	60
1:00 AM	63	72	64	69	64	69	69	53	66	56	69	60
2:00 AM	63	72	64	69	64	69	70	53	66	56	69	61
3:00 AM	63	71	64	68	64	70	70	52	65	56	69	61
4:00 AM	63	71	64	68	64	70	70	52	65	57	69	61
5:00 AM	63	71	64	68	63	70	70	52	65	56	69	61
6:00 AM	63	71	64	68	63	70	69	51	65	57	69	62
7:00 AM	63	71	64	69	63	70	68	52	65	60	69	61
8:00 AM	63	70	64	68	63	71	68	53	65	61	69	62
9:00 AM	64	69	65	69	63	72	69	55	68	59	69	62
10:00 AM	64	68	66	69	64	72	69	54	70	58	69	62
11:00 AM	66	66	67	68	65	71	69	55	69	56	69	62
12:00 PM	66	63	66	66	67	67	68	54	69	58	70	62
1:00 PM	66	60	66	66	67	64	68	53	69	60	69	62
2:00 PM	66	60	66	65	68	63	68	52	69	63	69	63
3:00 PM	66	60	66	65	69	62	68	52	69	63	69	64
4:00 PM	66	60	66	65	69	61	68	51	69	63	69	65
5:00 PM	65	61	67	64	69	60	67	51	69	62	69	65
6:00 PM	65	62	67	68	69	60	67	53	69	60	69	64
7:00 PM	65	64	68	69	69	57	68	54	69	60	69	64
8:00 PM	65	65	66	65	69	56	67	54	69	60	69	64
9:00 PM	65	68	65	66	69	55	67	55	69	60	69	63
10:00 PM	65	70	65	67	69	54	66	57	69	60	69	63
11:00 PM	65	70	64	67	69	53	66	56	69	59	69	62
Average	64.5	66.9	65.2	67.4	66.1	64.7	68.2	53.2	67.7	59.0	69.3	62.3

Average room temperature

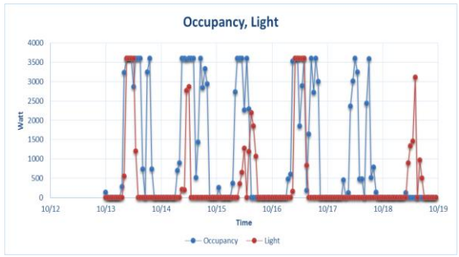


Average room humidity



Classroom 2

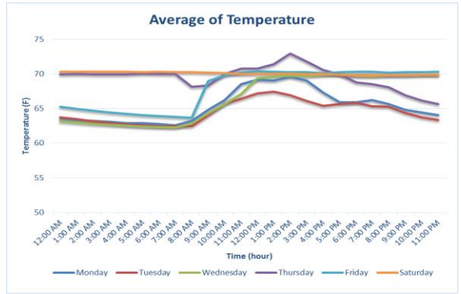
Comparison of occupancy & light on



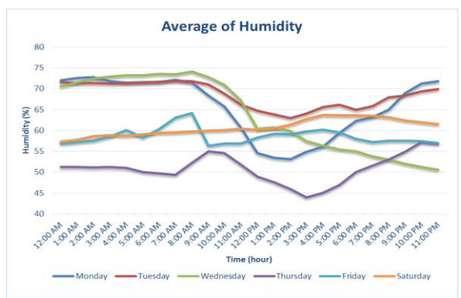
Summary of room temperature

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	64	72	64	72	63	71	70	51	65	57	70	57
1:00 AM	63	73	63	71	63	71	70	51	65	57	70	58
2:00 AM	63	73	63	71	63	72	70	51	65	58	70	59
3:00 AM	63	72	63	71	63	73	70	51	64	59	70	59
4:00 AM	63	71	63	71	63	73	70	51	64	60	70	59
5:00 AM	63	72	63	72	62	73	70	50	64	58	70	59
6:00 AM	63	72	62	72	62	74	70	50	64	60	70	59
7:00 AM	63	72	62	72	62	73	70	49	64	63	70	60
8:00 AM	63	71	62	72	63	74	68	52	64	64	70	60
9:00 AM	65	68	64	71	64	73	68	55	69	56	70	60
10:00 AM	66	66	66	69	66	71	70	55	70	57	70	60
11:00 AM	69	61	66	66	67	67	71	52	70	57	70	60
12:00 PM	69	55	67	65	69	60	71	49	70	58	70	60
1:00 PM	69	53	67	64	70	61	71	48	70	59	70	60
2:00 PM	70	53	67	63	70	60	73	46	70	59	70	61
3:00 PM	69	55	66	64	70	57	72	44	70	60	70	63
4:00 PM	67	56	65	66	70	56	71	45	70	60	70	64
5:00 PM	66	59	66	66	70	55	70	47	70	60	70	64
6:00 PM	66	62	66	65	70	55	69	50	70	58	70	64
7:00 PM	66	63	65	66	70	54	69	52	70	57	70	63
8:00 PM	66	65	65	68	70	53	68	53	70	58	70	63
9:00 PM	65	69	64	68	70	52	67	55	70	58	70	62
10:00 PM	64	71	64	69	70	51	66	57	70	57	70	62
11:00 PM	64	72	63	70	70	51	66	57	70	57	70	62
Average	65.4	65.7	64.5	68.5	66.6	63.8	69.5	50.9	68.0	58.6	70.1	60.8

Average room temperature

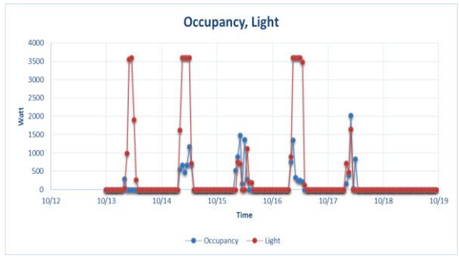


Average room humidity



Faculty Office 1

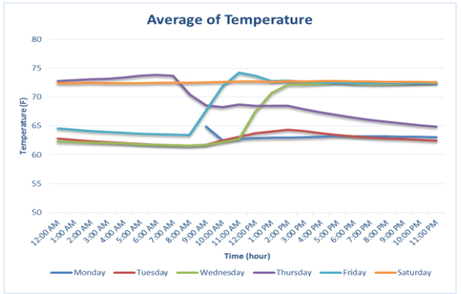
Comparison of occupancy & light on



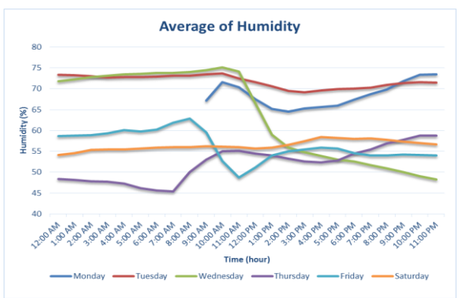
Summary of room temperature

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM			63	73	62	72	73	48	65	59	72	54
1:00 AM			62	73	62	73	73	48	64	59	72	55
2:00 AM			62	73	62	73	73	48	64	59	72	55
3:00 AM			62	73	62	73	73	48	64	59	72	55
4:00 AM			62	73	62	73	73	47	64	60	72	55
5:00 AM			62	73	62	74	74	46	64	60	72	56
6:00 AM			62	73	62	74	74	46	64	60	72	56
7:00 AM			62	73	62	74	74	45	63	62	72	56
8:00 AM			62	73	62	74	70	50	63	63	72	56
9:00 AM	65	67	62	73	62	74	69	53	68	60	73	56
10:00 AM	62	72	63	74	62	75	68	55	72	53	73	56
11:00 AM	63	70	63	72	63	74	69	55	74	49	73	56
12:00 PM	63	67	64	72	67	66	68	55	74	51	73	56
1:00 PM	63	65	64	71	71	59	69	54	73	54	73	56
2:00 PM	63	65	64	69	72	56	69	53	73	55	73	57
3:00 PM	63	65	64	69	72	55	68	53	73	55	73	57
4:00 PM	63	66	64	70	72	54	67	52	73	56	73	58
5:00 PM	63	66	63	70	73	53	67	53	72	56	73	58
6:00 PM	63	67	63	70	72	53	66	54	72	55	73	58
7:00 PM	63	69	63	70	72	52	66	55	72	54	73	58
8:00 PM	63	70	63	71	72	51	66	57	72	54	73	57
9:00 PM	63	72	63	71	72	50	65	58	72	54	73	57
10:00 PM	63	73	63	72	72	49	65	59	72	54	73	57
11:00 PM	63	73	62	73	73	48	65	59	72	54	73	57
Average	63.1	68.5	62.8	71.8	66.9	63.7	69.3	52.1	69.2	56.4	72.6	56.4

Average room temperature

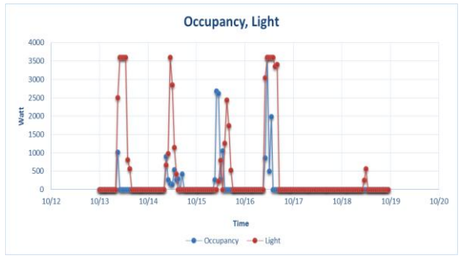


Average room humidity



Faculty Office 2

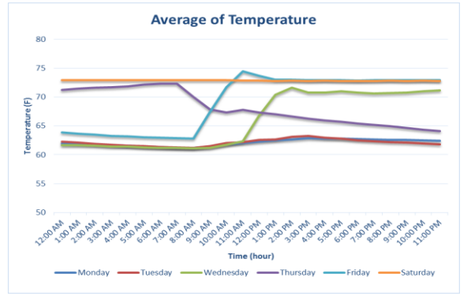
Comparison of occupancy & light on



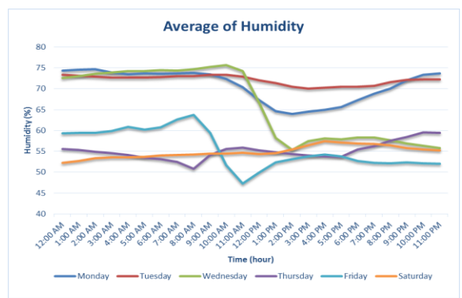
Summary of room temperature

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	62	74	62	73	62	73	71	56	64	59	73	52
1:00 AM	62	75	62	73	62	73	71	55	64	59	73	53
2:00 AM	62	75	62	73	62	74	72	55	63	59	73	53
3:00 AM	62	74	62	73	61	74	72	55	63	60	73	54
4:00 AM	62	73	62	73	61	74	72	54	63	61	73	54
5:00 AM	61	74	61	73	61	74	72	53	63	60	73	54
6:00 AM	61	74	61	73	61	74	72	53	63	61	73	54
7:00 AM	61	74	61	73	61	74	72	53	63	63	73	54
8:00 AM	61	74	61	73	61	75	70	51	63	64	73	54
9:00 AM	61	73	62	73	61	75	68	54	67	59	73	54
10:00 AM	62	72	62	73	62	76	67	56	72	52	73	54
11:00 AM	62	70	62	73	62	74	68	56	74	47	73	55
12:00 PM	62	67	63	72	67	67	67	55	74	50	73	54
1:00 PM	63	65	63	71	70	58	67	55	73	52	73	55
2:00 PM	63	64	63	70	72	55	67	54	73	53	73	55
3:00 PM	63	64	63	70	71	57	66	54	73	54	73	56
4:00 PM	63	65	63	70	71	58	66	54	73	54	73	57
5:00 PM	63	66	63	70	71	58	66	54	73	54	73	57
6:00 PM	63	67	63	70	71	58	65	55	73	53	73	57
7:00 PM	63	69	62	71	71	58	65	56	73	52	73	57
8:00 PM	63	70	62	72	71	58	65	58	73	52	73	56
9:00 PM	63	72	62	72	71	57	65	58	73	52	73	56
10:00 PM	63	73	62	72	71	56	64	59	73	52	73	55
11:00 PM	62	74	62	72	71	56	64	59	73	52	73	55
Average	62.1	70.7	62.1	72.1	66.0	66.1	68.1	55.1	69.1	55.6	72.9	54.9

Average room temperature



Average room humidity



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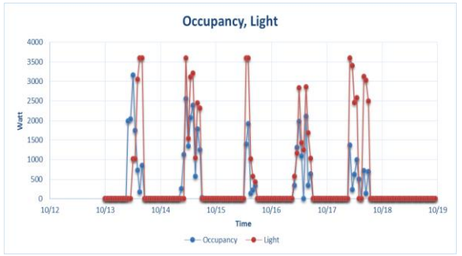
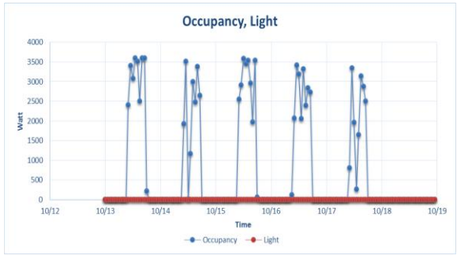
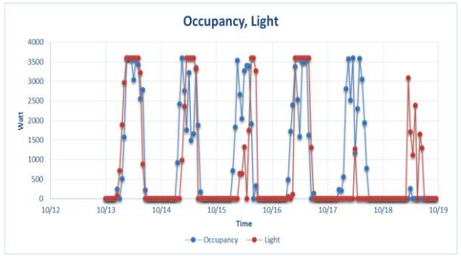
	Staff Office 1	Staff Office 2	Staff Office 3
Comparison of occupancy & light on			

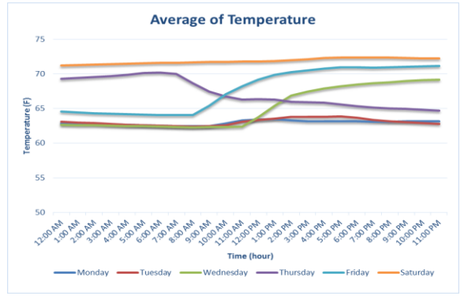
Summary of room temperature

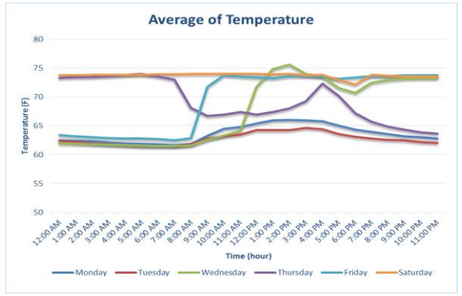
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	63	77	63	76	63	74	69	57	65	62	71	59
1:00 AM	63	77	63	75	63	75	69	57	64	62	71	59
2:00 AM	63	77	63	75	63	76	70	56	64	61	71	60
3:00 AM	63	76	63	75	63	76	70	56	64	62	71	60
4:00 AM	63	75	63	74	62	76	70	56	64	63	71	60
5:00 AM	63	75	63	74	62	76	70	55	64	62	72	60
6:00 AM	63	75	63	74	62	76	70	54	64	63	72	60
7:00 AM	62	75	62	75	62	76	70	54	64	65	72	60
8:00 AM	62	75	62	75	62	76	69	55	64	66	72	60
9:00 AM	62	75	62	75	62	77	67	57	65	65	72	60
10:00 AM	63	74	63	76	62	77	67	59	67	63	72	60
11:00 AM	63	72	63	75	62	77	66	60	68	61	72	60
12:00 PM	63	70	63	74	64	74	66	60	69	62	72	60
1:00 PM	64	67	64	73	65	71	66	59	70	62	72	60
2:00 PM	63	67	64	73	67	69	66	58	70	62	72	61
3:00 PM	63	68	64	72	67	67	66	58	71	62	72	61
4:00 PM	63	68	64	73	68	65	66	57	71	62	72	62
5:00 PM	63	69	64	72	68	64	66	57	71	61	72	62
6:00 PM	63	70	64	72	68	63	65	59	71	60	72	61
7:00 PM	63	72	63	72	69	61	65	60	71	59	72	61
8:00 PM	63	73	63	73	69	60	65	61	71	59	72	61
9:00 PM	63	75	63	74	69	59	65	62	71	59	72	60
10:00 PM	63	76	63	74	69	58	65	63	71	59	72	60
11:00 PM	63	76	63	74	69	57	65	62	71	59	72	60
Average	63.0	73.1	63.1	74.1	65.1	69.9	67.2	57.9	67.8	61.7	71.9	60.2

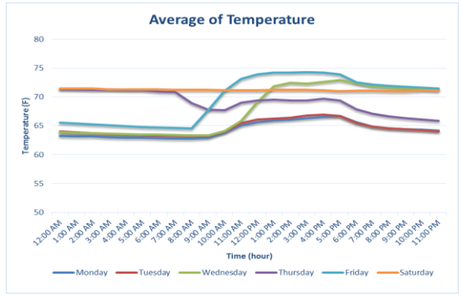
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	62	75	62	74	62	73	73	45	63	61	74	50
1:00 AM	62	75	62	74	62	74	73	45	63	61	74	51
2:00 AM	62	75	62	74	62	75	73	45	63	61	74	52
3:00 AM	62	74	62	74	62	75	74	45	63	62	74	52
4:00 AM	62	74	62	74	62	75	74	44	63	63	74	52
5:00 AM	62	74	62	74	62	75	74	43	63	61	74	52
6:00 AM	62	74	61	74	62	75	74	44	63	63	74	52
7:00 AM	62	74	61	74	61	75	73	44	63	66	74	52
8:00 AM	62	74	62	73	62	75	68	52	63	66	74	52
9:00 AM	63	71	63	72	63	75	67	55	72	52	74	53
10:00 AM	65	68	63	71	63	72	67	57	74	47	74	52
11:00 AM	65	65	64	71	64	70	67	55	74	48	74	52
12:00 PM	65	60	64	70	72	55	67	55	73	51	74	52
1:00 PM	66	57	64	68	75	48	67	54	73	52	74	53
2:00 PM	66	58	64	68	76	47	68	52	74	53	74	54
3:00 PM	66	59	65	68	74	49	69	49	74	53	74	55
4:00 PM	66	59	64	68	74	49	72	43	74	53	74	56
5:00 PM	65	61	64	69	72	52	70	46	73	53	73	57
6:00 PM	64	65	63	70	71	53	67	52	73	51	72	59
7:00 PM	64	67	63	70	73	48	66	55	74	51	74	55
8:00 PM	64	69	63	72	73	47	65	58	74	51	74	55
9:00 PM	63	73	62	72	73	46	64	60	74	51	74	54
10:00 PM	63	74	62	73	73	45	64	61	74	50	74	54
11:00 PM	63	74	62	73	73	45	64	61	74	50	74	54
Average	63.6	68.6	62.8	71.6	67.6	61.4	69.2	50.9	69.5	55.3	73.7	53.4

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	63	72	64	70	64	68	71	49	66	56	71	55
1:00 AM	63	73	64	70	64	69	71	49	65	56	71	55
2:00 AM	63	72	64	69	64	69	71	49	65	56	71	56
3:00 AM	63	71	64	69	64	70	71	49	65	57	71	56
4:00 AM	63	71	63	69	64	70	71	49	65	58	71	56
5:00 AM	63	71	63	69	64	70	71	48	65	57	71	57
6:00 AM	63	71	63	69	63	70	71	48	65	58	71	57
7:00 AM	63	71	63	69	63	70	71	48	65	60	71	57
8:00 AM	63	71	63	69	63	70	69	51	65	61	71	57
9:00 AM	63	70	63	69	63	71	68	53	68	58	71	58
10:00 AM	64	68	64	69	64	71	68	54	71	52	71	58
11:00 AM	65	64	65	67	66	67	69	53	73	49	71	58
12:00 PM	66	60	66	65	69	61	69	51	74	50	71	57
1:00 PM	66	57	66	64	72	56	70	50	74	50	71	57
2:00 PM	66	57	66	63	73	53	69	49	74	51	71	58
3:00 PM	66	58	67	63	72	53	69	48	74	52	71	60
4:00 PM	67	58	67	62	73	52	70	47	74	52	71	61
5:00 PM	67	58	67	62	73	51	69	47	74	52	71	61
6:00 PM	66	61	65	64	72	50	68	51	73	53	71	60
7:00 PM	65	64	65	65	72	50	67	52	72	53	71	60
8:00 PM	65	66	65	67	72	50	67	54	72	53	71	60
9:00 PM	64	69	64	67	72	49	66	55	72	54	71	59
10:00 PM	64	70	64	68	71	49	66	57	72	54	71	59
11:00 PM	64	71	64	68	71	48	66	56	71	54	71	58
Average	64.4	66.5	64.6	67.0	67.8	60.6	69.2	50.7	69.7	54.5	71.2	57.9

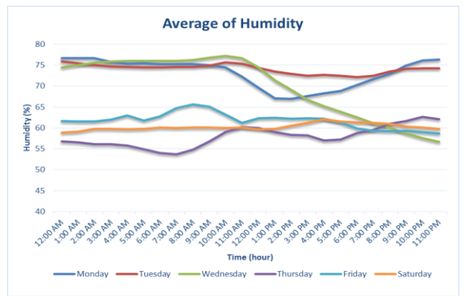
Average room temperature

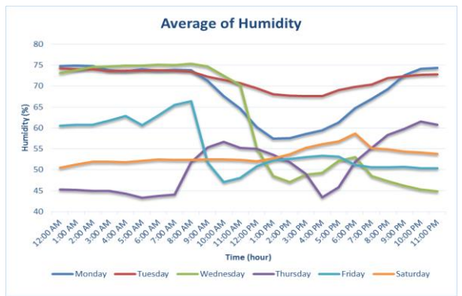


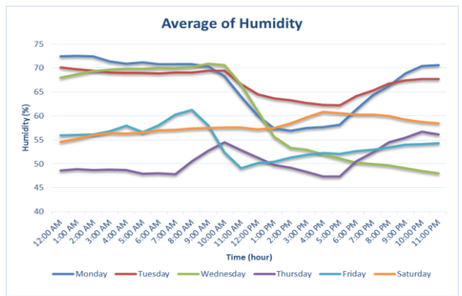




Average room humidity







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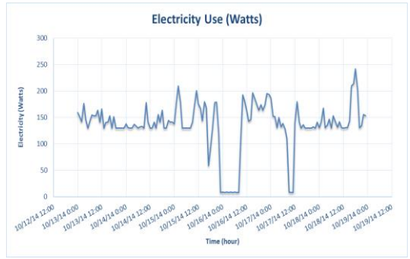
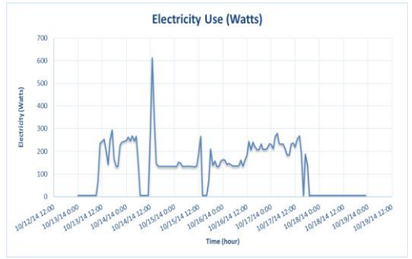
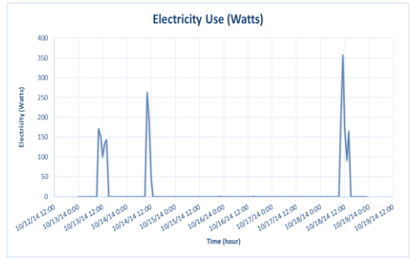
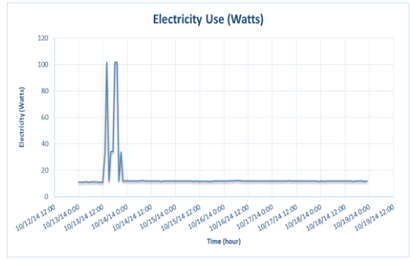
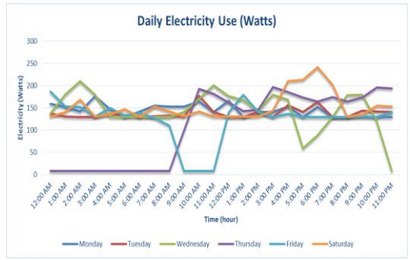
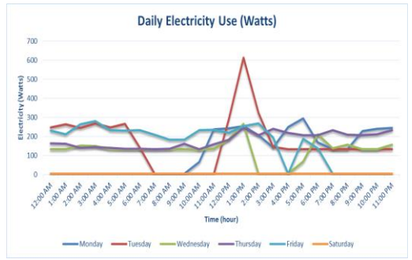
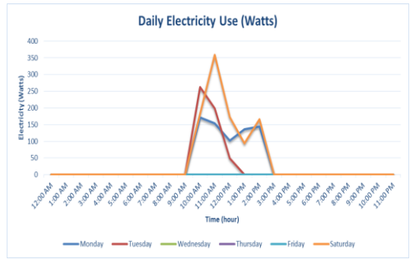
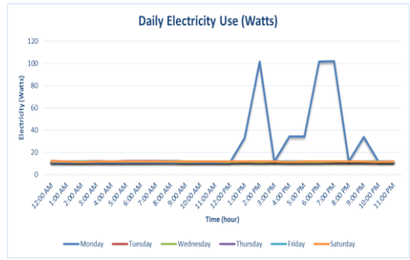
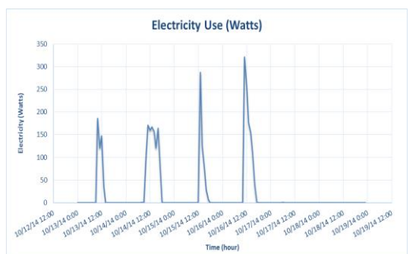
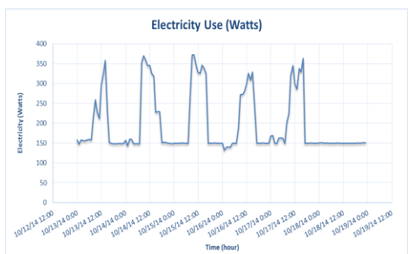
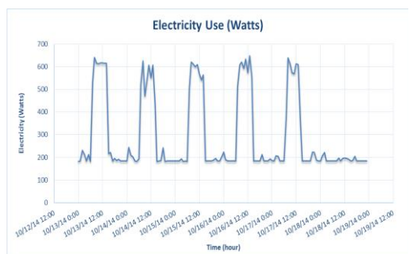
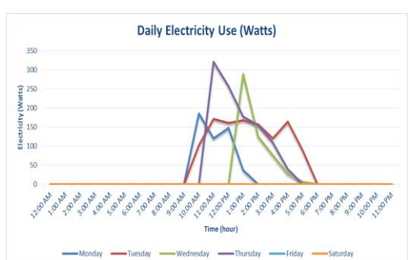
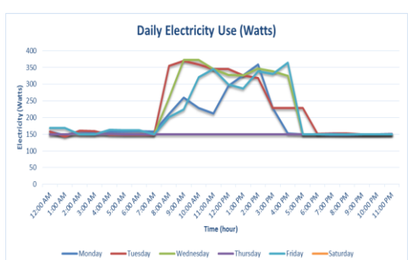
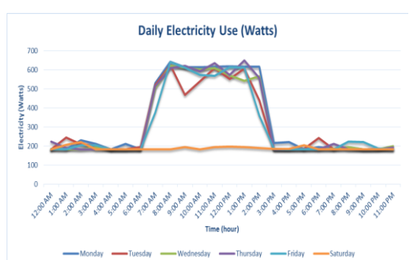
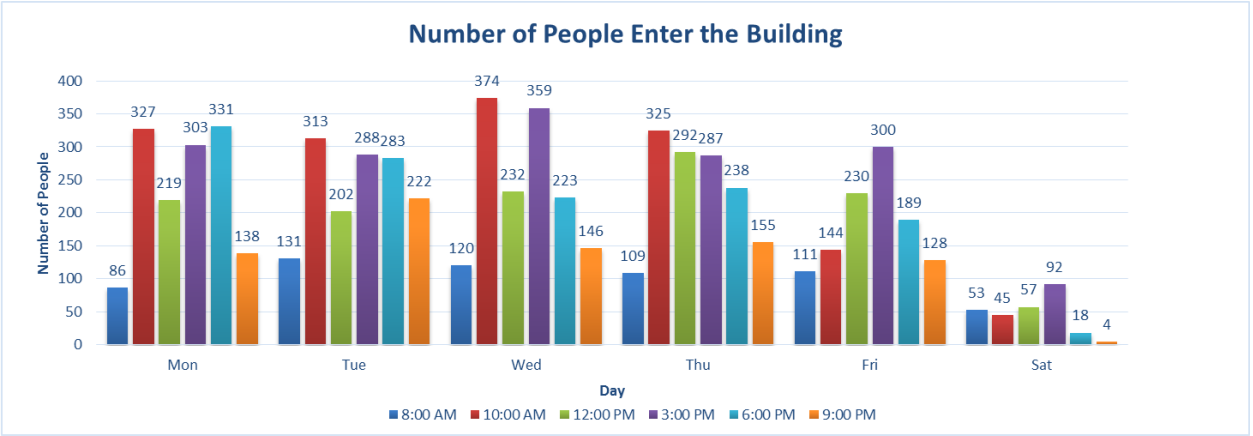
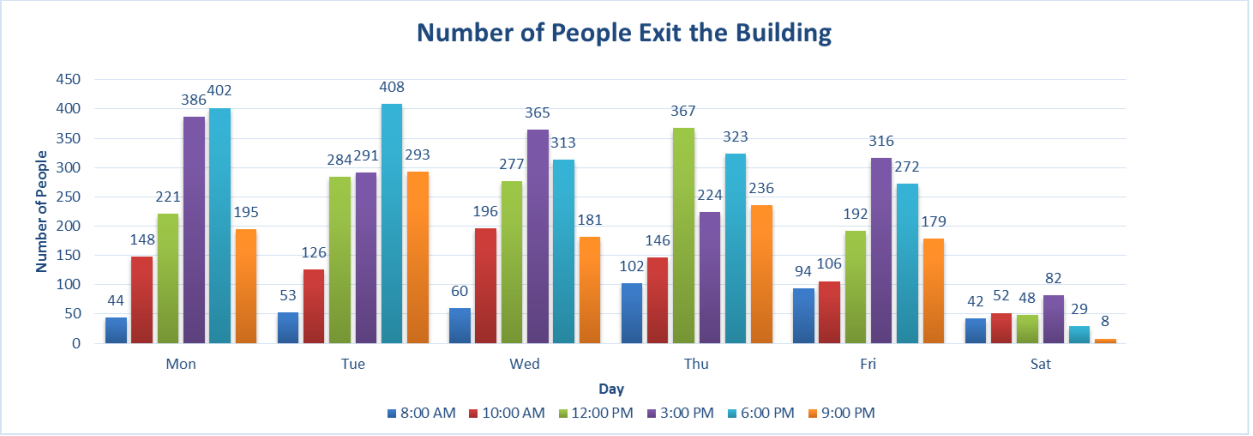
	Computer Lab 1	Computer Lab 2	Faculty Office 1	Faculty Office 2
Electricity use				
The pattern of daily electricity use				

	Staff Office 1	Staff Office 2	Staff Office 3
Electricity use			
The pattern of daily electricity use			

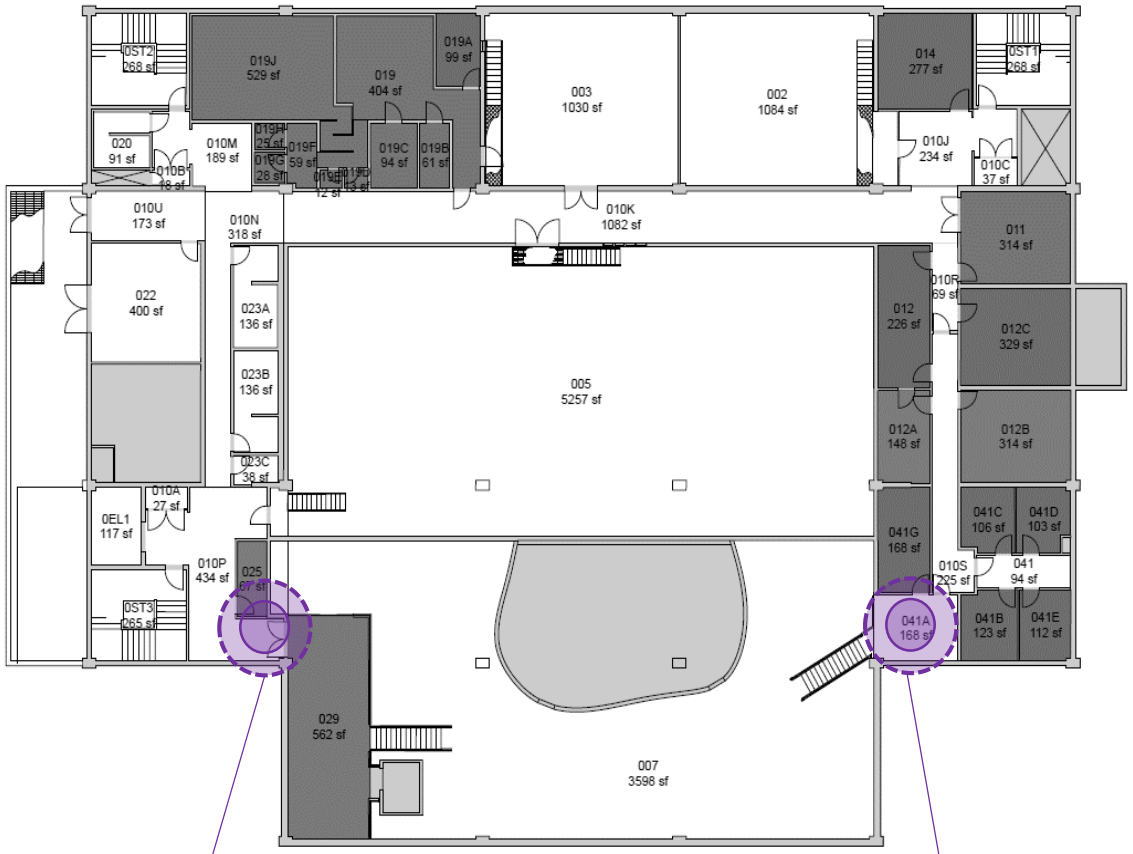
Profile of Building Occupancy (People Counters)





Total Number of People In/Out	
Mon	1404
Tue	1439
Wed	1454
Thu	1406
Fri	1157
Sat	263

Basement



	In	Out
Mon	344	358
Tue	444	481
Wed	409	378
Thu	321	298
Fri	336	328
Sat	51	47
AVG	371	368

	In	Out
Mon	52	38
Tue	97	64
Wed	61	83
Thu	47	55
Fri	44	54
Sat	3	6
AVG	60	59

First Floor

	In	Out
Mon	2	62
Tue	0	53
Wed	2	57
Thu	1	75
Fri	3	55
Sat	0	12
AVG	2	60

	In	Out
Mon	221	430
Tue	201	293
Wed	207	348
Thu	205	361
Fri	150	300
Sat	41	63
AVG	197	346

	In	Out
Mon	208	162
Tue	296	249
Wed	250	273
Thu	313	221
Fri	271	228
Sat	193	120
AVG	268	227

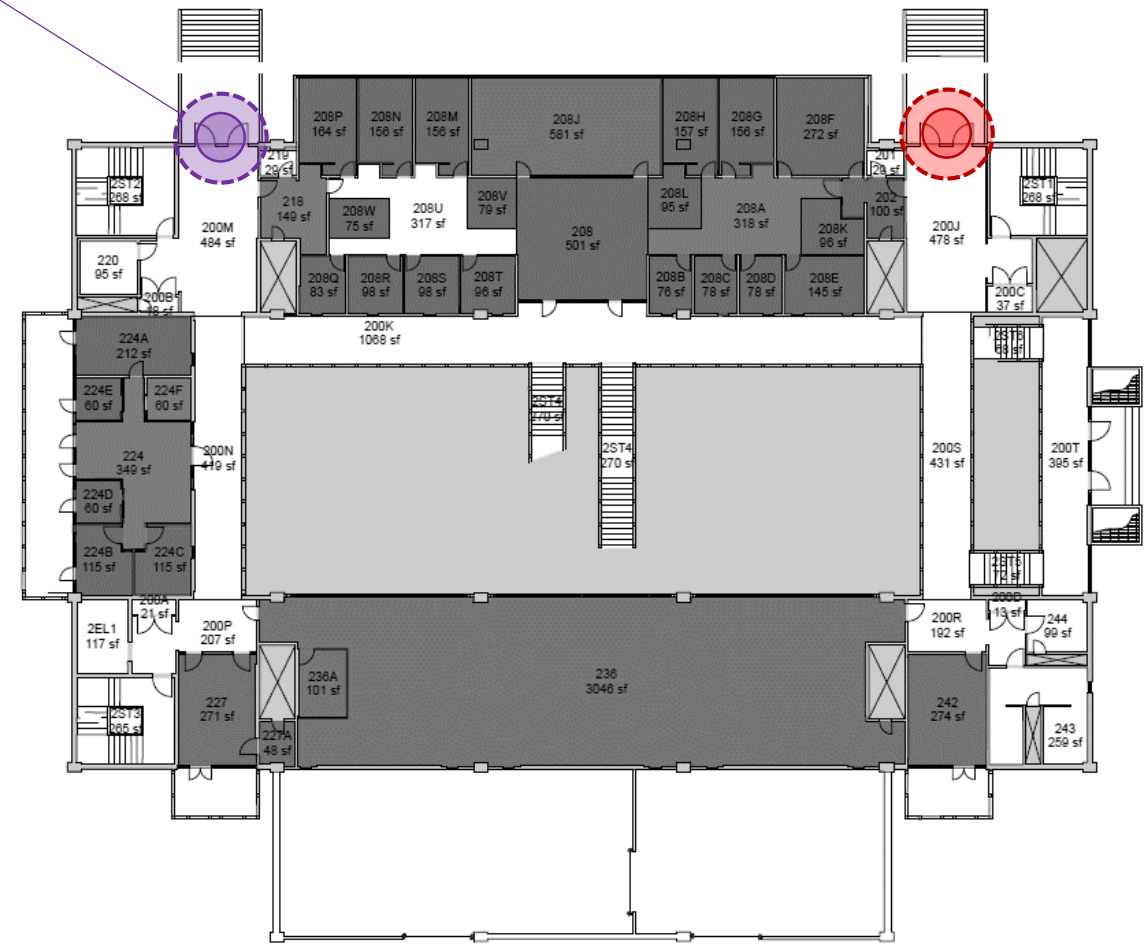
	In	Out
Mon	14	69
Tue	25	61
Wed	12	77
Thu	17	65
Fri	8	72
Sat	3	16
AVG	15	69

	In	Out
Mon	126	105
Tue	213	187
Wed	198	234
Thu	127	130
Fri	169	193
Sat	35	48
AVG	166	170

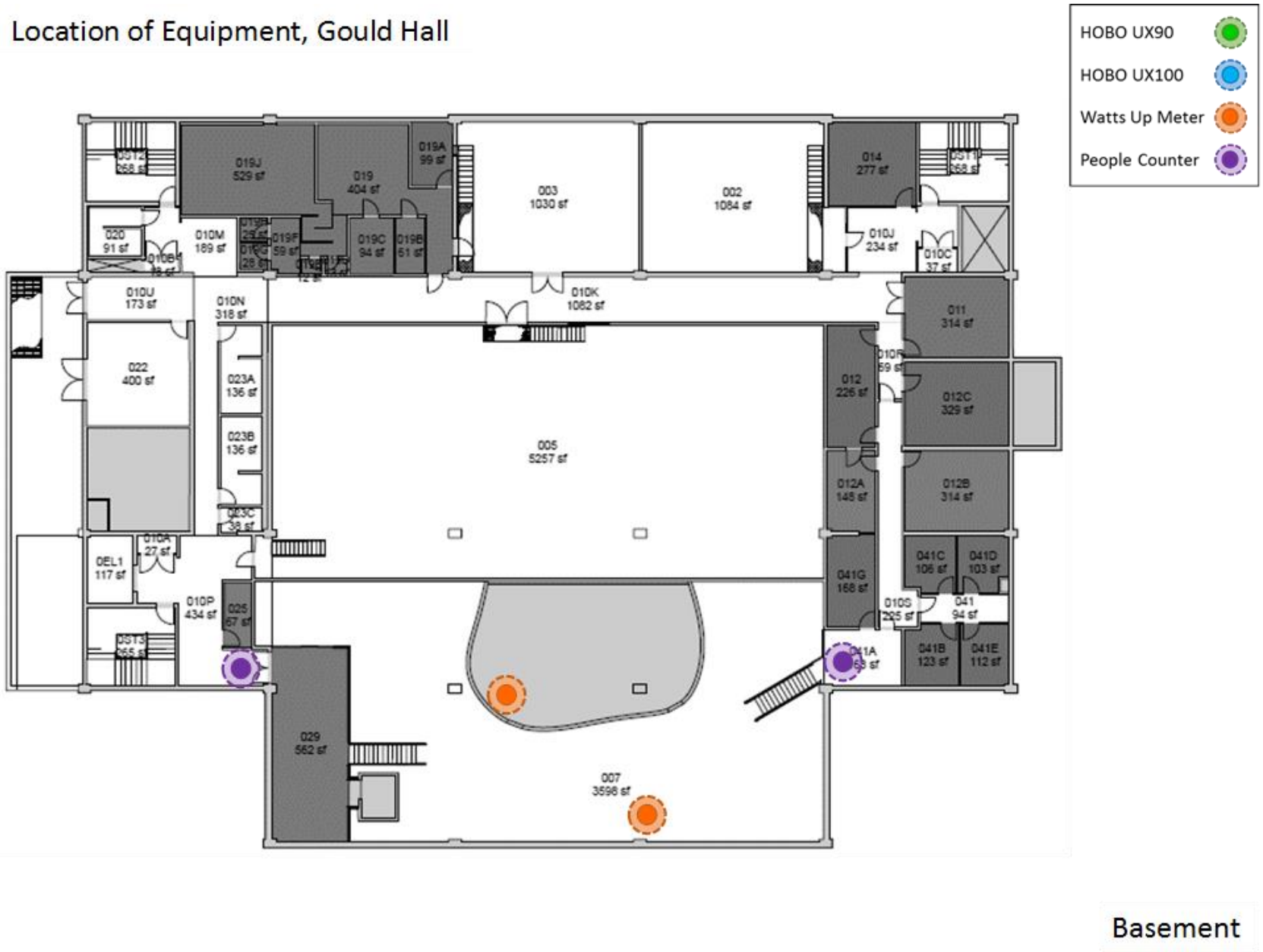
Second Floor

	In	Out
Mon	813	626
Tue	745	672
Wed	665	463
Thu	934	617
Fri	781	579
Sat	72	87
AVG	788	591

Temporarilly

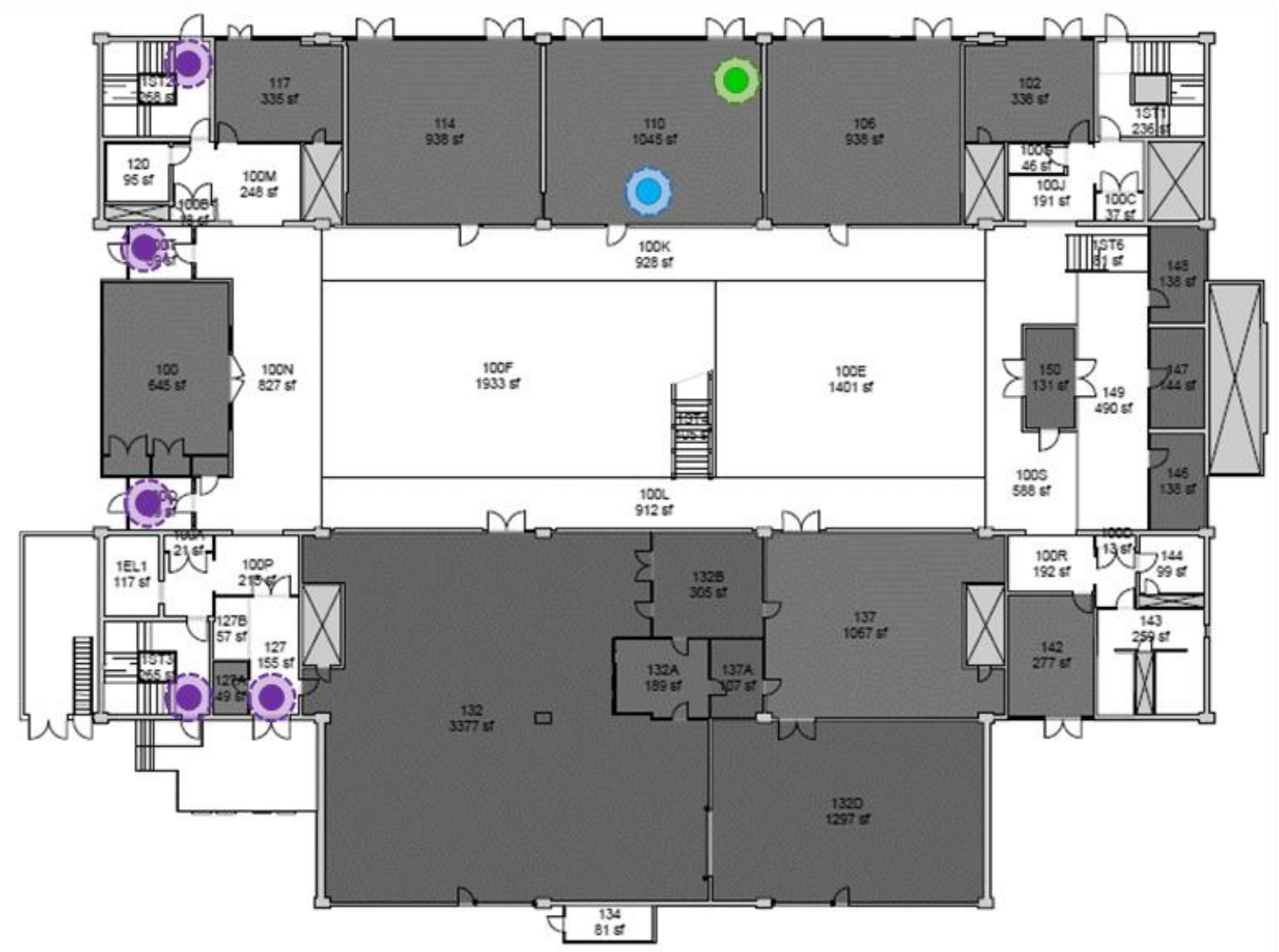


Location of Equipment, Gould Hall



Basement

Gould Hall



HOBO UX90

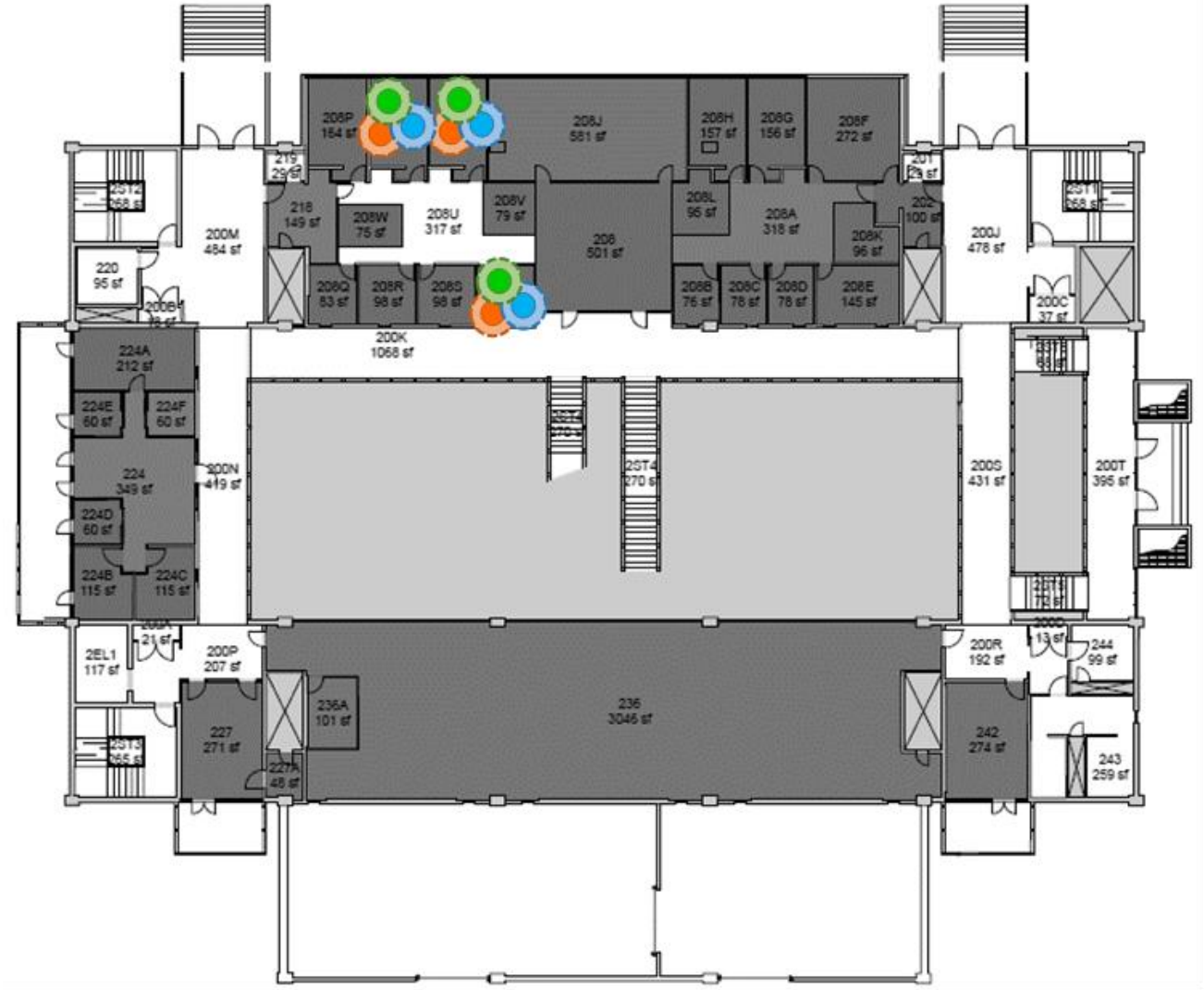
HOBO UX100

Watts Up Meter

People Counter

First Floor

Gould Hall



HOBO UX90

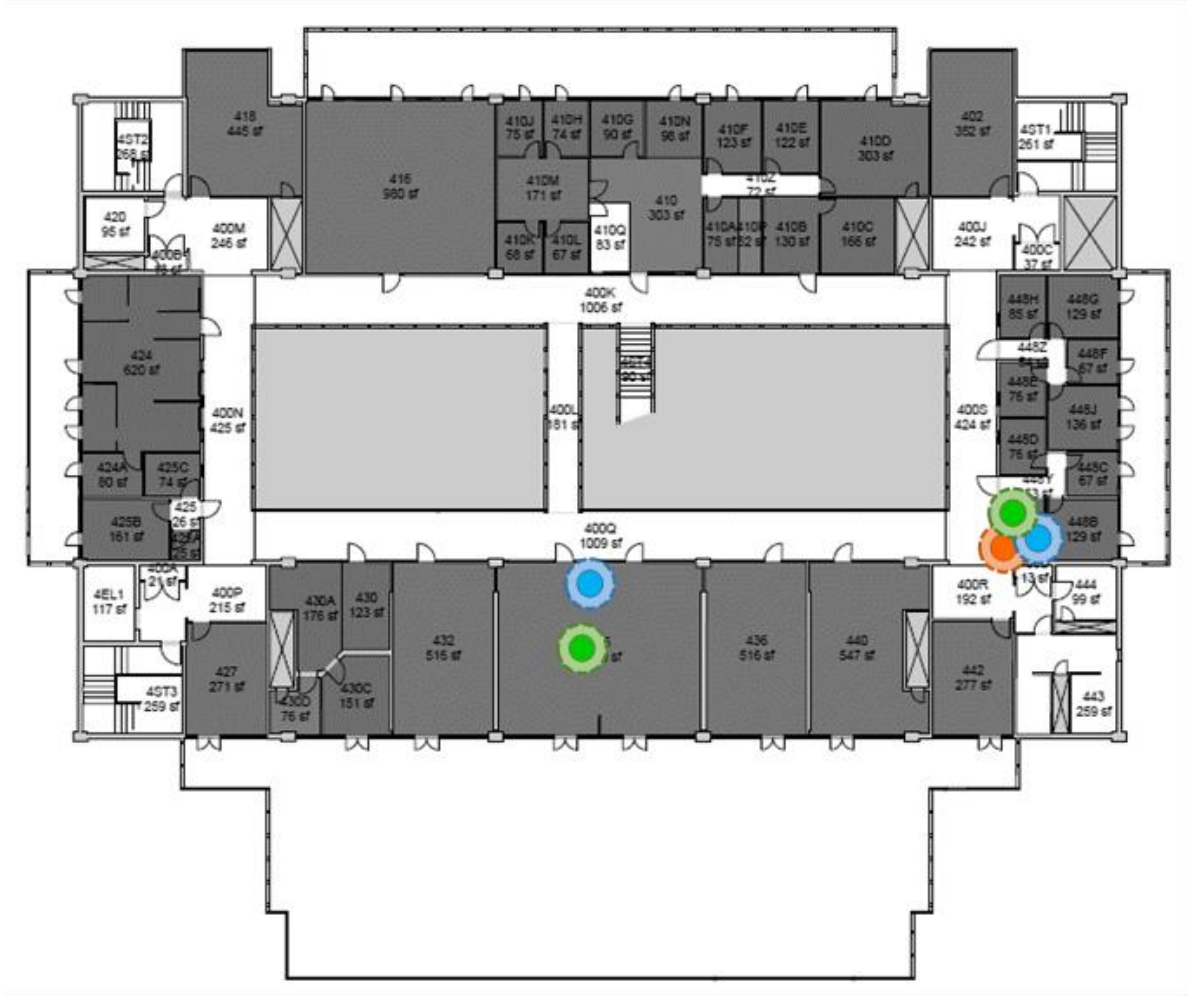
HOBO UX100

Watts Up Meter

People Counter

Second Floor

Gould Hall



Third Floor

Appendix III

Building Factsheet: Savery Hall

SAVERY HALL

The summary sheets provide the results of manual observation and automated monitoring:

1. An overview of the building information
2. Quick facts from the data summarization & analysis
3. A summary data collected through the manual observation. First table organizes data based on different days of the week. Second table organizes data based on different hours per day.
4. The extent & pattern of building occupancy, desktops use, and lighting use (indicated in graphs).
5. Number of laptops present and plugged in
6. The results of automated monitoring (HOBO devices) in the selected rooms including extent & pattern of room occupancy, light use, and average room temperature & humidity.
7. The results of automated monitoring (Watts Up meters) in the selected rooms including the extent & pattern of electricity use.

Building Overview	
Number of Stories	4 stories
Departments of	Economics, Sociology, Philosophy, Social Science Computation and Research
Number of Offices	148
Number of Classrooms	26
Number of Computer labs	2
Number of Rooms with Operable Windows	112

Building Fact Sheet

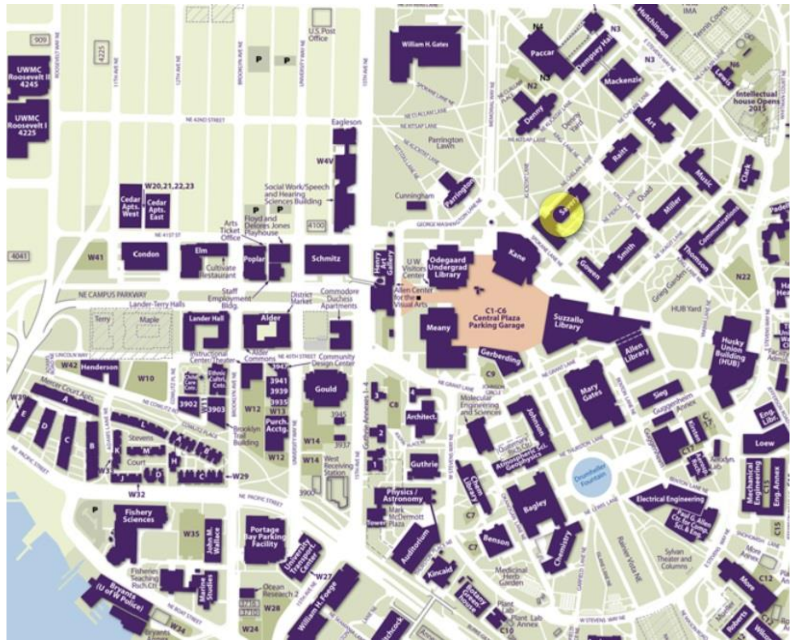
Manual Observation & Automated Monitoring Quick Facts	
Time period of audit	**27 October – 01 November 2014**
Audit time slots	**8am, 10am, 12pm, 3pm, 6pm, 9pm**
10 AM and 3 PM are the peak hours of the building use (Number of people present, desktops in use, and rooms with light on). However, 12 PM is the peak hour for the building occupancy, in particular.	
In average, the number of rooms with opened windows is about 4% of the total number of rooms with operable windows.	
In average, the number of rooms with opened blinds/drapes is about 26% of the total number of rooms with windows.	
Almost, 25% of building users bring their laptops to the building and 50% of laptops are plugged in.	
Range of indoor temperature	65 – 74 °F (Standard range: 68-76 °F)
Range of indoor humidity	40 – 60 % (Standard range: 30-50 %)
Total number of equipment in the building	
Printer/Scanner/Copier : 34	Projector : 21 (very much in use)
TV : 1 (not much in use)	Personal heater/fan : 7 (much in use)
Desktop : 175	Refrigerator : 5 Microwave : 8

The tables show a summary of data collected through the manual observation

Type of Data	Mon.						Tue.						Wed.						Thu.						Fri.						Sat.					
	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM
Total number of people present	197	307	322	281	228	113	48	309	333	321	190	113	46	330	422	410	190	84	81	364	393	346	131	33	85	231	232	240	38	21	13	52	88	79	38	16
Total number of room with light on	36	86	28	92	24	18	32	97	30	89	28	18	22	87	27	85	24	15	35	102	26	84	22	12	32	67	30	72	16	14	6	14	4	16	20	2
Total number of rooms with opened windows	0	7	0	0	1	0	1	6	0	0	1	0	14	7	0	0	3	0	4	8	0	4	4	0	3	4	0	0	2	0	4	5	0	0	3	0
Total number of rooms with opened blinds/drapes	28	34	0	40	10	5	22	37	16	41	17	5	15	42	17	41	16	11	23	41	17	31	10	4	20	32	16	36	11	0	10	15	0	15	12	0
Average rooms temperature	72	71	NA	73	69	NA	72	72	NA	73	NA	NA	73	72	NA	73	72	NA	71	72	NA	73	70	NA	71	71	NA	73	69	NA	70	70	NA	NA	70	NA
Total number of desktops on	19	106	31	48	9	2	47	74	26	47	12	2	12	45	23	58	10	6	79	74	28	49	48	1	33	43	19	29	1	2	0	3	0	1	2	0
Total number of laptops present	11	38	0	94	53	54	8	47	26	91	43	54	0	44	33	106	51	62	10	50	30	95	25	14	9	29	26	44	11	0	1	8	0	27	25	0
Total number of laptops plugged in	2	23	0	83	19	23	1	18	10	77	7	23	1	31	14	84	16	30	3	27	13	90	9	8	0	12	10	41	7	0	0	3	0	27	14	0
Total number of projectors in use	3	2	0	6	2	2	1	4	3	5	7	2	1	2	9	5	5	5	0	9	8	5	8	1	2	4	3	7	2	0	0	0	0	1	3	0
Total number of TV's in use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of desk/floor lamps	2	6	0	1	0	0	5	4	1	1	2	0	2	10	0	1	0	0	7	11	4	3	0	0	0	5	1	2	0	0	0	0	0	0	0	0
Total number of personal fans	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Total number of personal heaters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of cell phones plugged in	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
Total number of tablets plugged in	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	2	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0

Type of Data	8 AM						10 AM						12 PM						3 PM						6 PM						9 PM					
	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
Total number of people present	197	48	46	81	85	13	307	309	330	364	231	52	322	333	422	393	232	88	281	321	410	346	240	79	228	190	190	131	38	38	113	113	84	33	21	16
Total number of room with light on	36	32	22	35	32	6	86	97	87	102	67	14	28	30	27	26	30	4	92	89	85	84	72	16	24	28	24	22	16	20	18	18	15	12	14	2
Total number of rooms with opened windows	0	1	14	4	3	4	7	6	7	8	4	5	0	0	0	0	0	0	0	0	0	4	0	0	1	1	3	4	2	3	0	0	0	0	0	0
Total number of rooms with opened blinds/drapes	28	22	15	23	20	10	34	37	42	41	32	15	0	16	17	17	16	0	40	41	41	31	36	15	10	17	16	10	11	12	5	5	11	4	0	0
Average rooms temperature	72	72	73	71	71	70	71	72	72	72	71	70	NA	NA	NA	NA	NA	NA	73	73	73	73	73	NA	69	NA	72	70	69	70	NA	NA	NA	NA	NA	NA
Total number of desktops on	19	47	12	79	33	0	106	74	45	74	43	3	31	26	23	28	19	0	48	47	58	49	29	1	9	12	10	48	1	2	2	2	6	1	2	0
Total number of laptops present	11	8	0	10	9	1	38	47	44	50	29	8	0	26	33	30	26	0	94	91	106	95	44	27	53	43	51	25	11	25	54	54	62	14	0	0
Total number of laptops plugged in	2	1	1	3	0	0	23	18	31	27	12	3	0	10	14	13	10	0	83	77	84	90	41	27	19	7	16	9	7	14	23	23	30	8	0	0
Total number of projectors in use	3	1	1	0	2	0	2	4	2	9	4	0	0	3	9	8	3	0	6	5	5	5	7	1	2	7	5	8	2	3	2	2	5	1	0	0
Total number of TV's in use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of desk/floor lamps	2	5	2	7	0	0	6	4	10	11	5	0	0	1	0	4	1	0	1	1	1	3	2	0	0	2	0	0	0	0	0	0	0	0	0	0
Total number of personal fans	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of personal heaters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of cell phones plugged in	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2	0	1	1	1	1	1	0	0	0
Total number of tablets plugged in	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	0	0	2	1	0	0

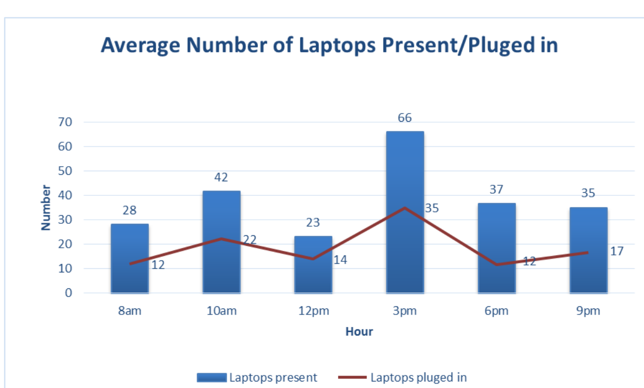
SAVERY HALL

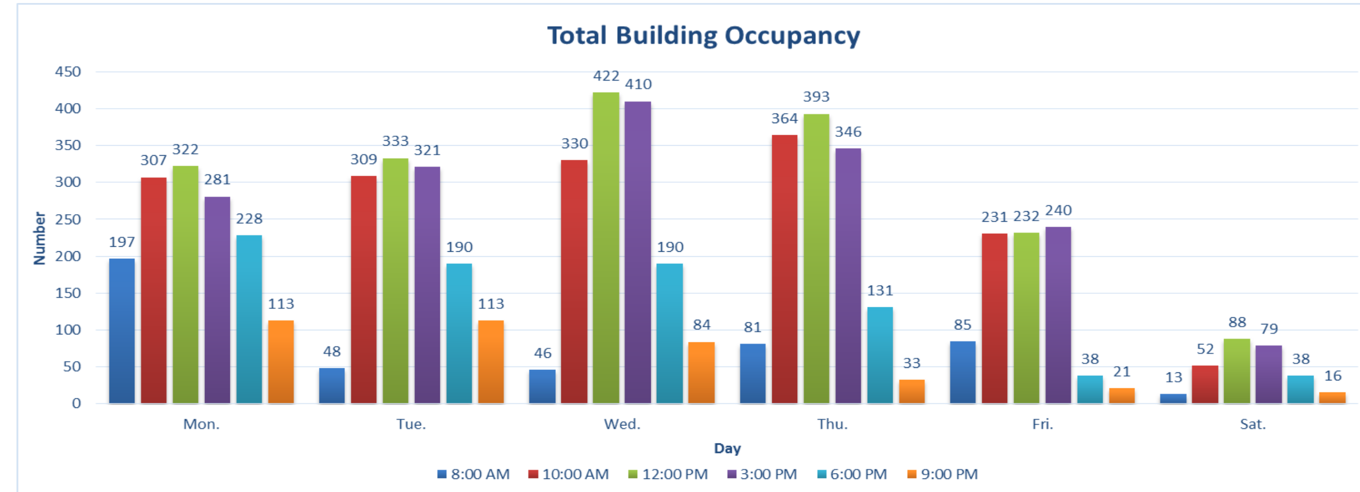


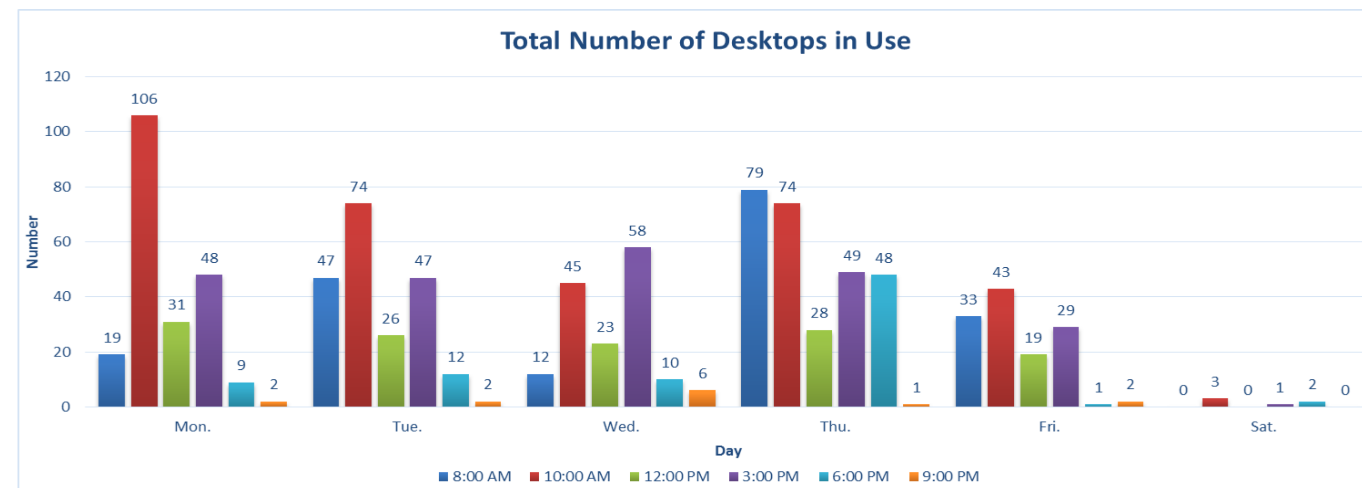
These graphs summarizes the results of **Manual Observation**.

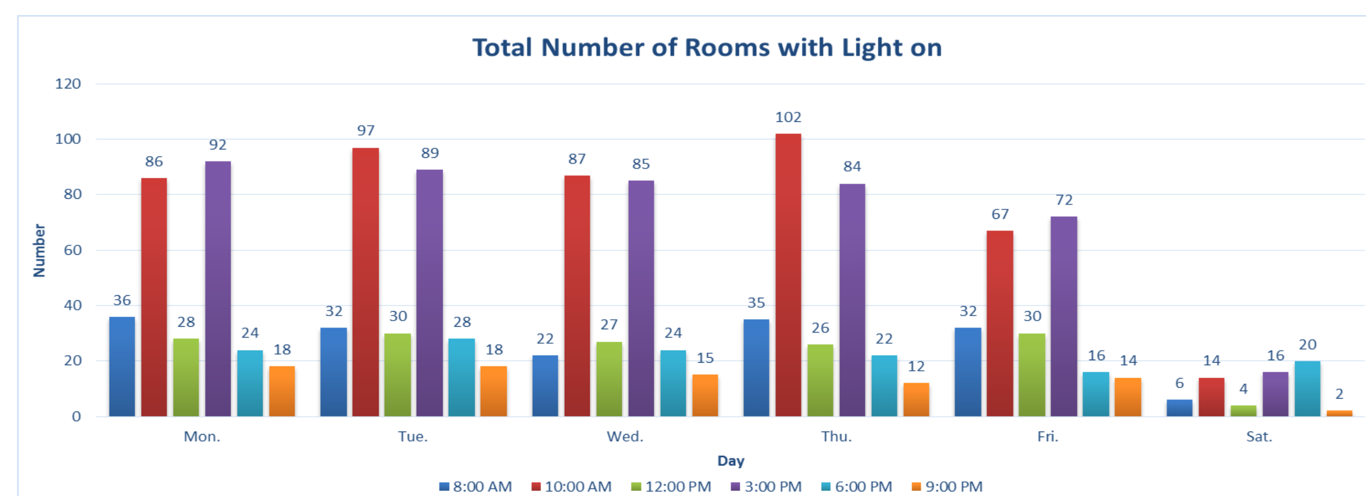
The graphs show the total number of people present, desktops in use, and rooms with light on. The amounts can be compared between different days of a week and different hours of a day.

The graph below shows the average number of laptops present and the numbers of them that were plugged in.









SAVERY HALL

Summary of occupancy & light use

Classroom 1

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	6	0	60	0	0	0	1	0
1:00 AM	0	0	0	0	0	0	0	0	42	2	0	0	1	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	16	4	5	2	17	0	7	2	8	0	0	0	1	0
6:00 AM	10	6	9	6	8	3	8	2	42	5	0	0	1	0
7:00 AM	11	5	11	3	0	0	9	3	60	10	0	0	2	0
8:00 AM	53	46	39	38	41	41	44	43	60	55	3	2	4	4
9:00 AM	60	60	60	60	60	60	60	60	35	24	0	2	5	4
10:00 AM	60	54	60	60	50	26	60	60	47	48	30	2	5	4
11:00 AM	60	59	60	60	18	0	60	60	60	60	60	2	5	4
12:00 PM	26	60	60	60	42	42	60	60	60	60	60	0	5	5
1:00 PM	37	60	60	60	60	60	60	60	38	33	60	0	5	5
2:00 PM	60	60	46	33	60	60	60	60	30	2	21	3	5	4
3:00 PM	60	38	60	56	60	60	57	60	0	0	45	15	5	4
4:00 PM	34	15	60	60	57	60	34	32	13	3	60	8	4	3
5:00 PM	60	53	41	37	59	60	41	33	6	2	60	2	4	3
6:00 PM	60	60	59	59	42	34	60	60	60	0	60	9	6	4
7:00 PM	60	60	60	60	58	42	60	54	60	0	51	9	6	4
8:00 PM	60	60	60	60	60	60	38	4	57	20	60	0	6	3
9:00 PM	54	60	31	33	60	31	60	2	7	3	52	2	4	2
10:00 PM	60	60	0	0	60	9	60	4	60	0	0	0	4	1
11:00 PM	36	27	0	0	59	17	60	10	48	3	0	0	3	1
Total Use (hrs/d)	14.6	14.1	13.0	12.5	14.5	11.1	15.1	11.2	14.2	5.5	10.4	1.0		
Average Use (min/hr)	36.6	35.2	32.6	31.2	36.3	27.7	37.7	27.9	35.5	13.8	25.9	2.4		

Classroom 2

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	6	2	60	58	0	0	60	11	0	0	2	1
1:00 AM	0	0	0	0	7	9	14	11	24	5	0	0	1	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	6	2	11	2	7	0	8	3	8	2	0	0	1	0
6:00 AM	7	4	60	3	48	3	56	3	28	4	59	0	4	0
7:00 AM	50	10	60	4	60	0	60	4	46	5	60	0	6	0
8:00 AM	60	58	60	41	60	44	60	48	60	8	30	15	5	4
9:00 AM	60	60	60	60	60	60	60	60	60	56	60	58	6	6
10:00 AM	60	60	60	60	60	60	60	60	60	60	60	0	6	5
11:00 AM	60	60	60	60	60	60	60	60	60	60	60	8	6	5
12:00 PM	60	29	60	60	60	30	60	60	60	33	60	5	6	4
1:00 PM	60	18	60	60	60	27	60	60	60	33	60	5	6	3
2:00 PM	60	60	60	60	60	60	60	60	60	60	60	3	6	5
3:00 PM	54	43	60	60	60	51	60	51	51	60	25	24	5	5
4:00 PM	56	51	60	60	60	41	60	60	22	33	31	7	5	4
5:00 PM	60	60	60	60	60	60	60	57	38	5	60	7	6	4
6:00 PM	60	60	60	60	60	58	60	60	60	2	60	2	6	4
7:00 PM	59	60	60	60	60	57	60	60	20	0	29	13	5	4
8:00 PM	60	60	53	49	60	58	60	60	0	0	13	36	4	4
9:00 PM	60	37	45	38	60	17	30	32	0	0	60	8	4	2
10:00 PM	59	21	60	60	60	13	15	2	0	0	9	20	3	2
11:00 PM	60	13	60	60	9	0	60	10	0	0	0	3	3	1
Total Use (hrs/d)	16.9	12.8	17.9	15.3	18.2	12.8	17.1	13.7	13.0	7.3	13.2	3.6		
Average Use (min/hr)	42.1	32.0	44.8	38.3	45.5	31.9	42.6	34.3	32.4	18.2	33.1	8.9		

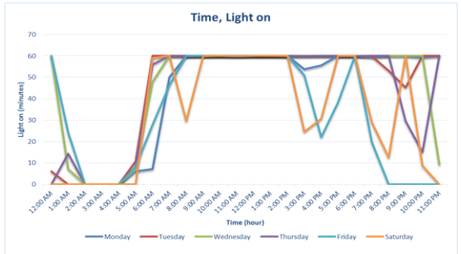
Faculty Office

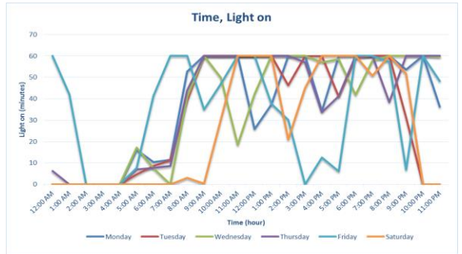
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	1	1	0	0	0	0	0	0	0	0
7:00 AM	39	41	23	24	47	46	0	0	0	0	0	0	2	2
8:00 AM	0	0	40	54	0	0	0	0	0	0	0	0	1	1
9:00 AM	26	26	38	55	30	30	0	0	0	0	0	0	2	2
10:00 AM	37	38	60	59	25	32	0	0	0	0	0	0	2	2
11:00 AM	1	0	60	55	0	0	14	22	0	0	0	0	1	1
12:00 PM	60	60	53	51	26	28	7	16	0	0	0	0	2	3
1:00 PM	60	55	60	57	1	56	0	0	0	0	0	0	2	3
2:00 PM	34	35	42	38	28	52	0	0	0	0	0	0	2	2
3:00 PM	60	57	0	0	0	50	0	0	0	0	0	0	1	2
4:00 PM	60	56	20	46	18	26	0	0	0	0	0	0	2	2
5:00 PM	60	50	13	13	0	0	0	0	0	0	0	0	1	1
6:00 PM	11	12	0	0	0	0	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	7.5	7.2	6.8	7.5	2.9	5.3	0.4	0.6	0.0	0.0	0.0	0.0		
Average Use (min/hr)	18.7	17.9	17.0	18.8	7.3	13.4	0.9	1.6	0.0	0.0	0.0	0.0		

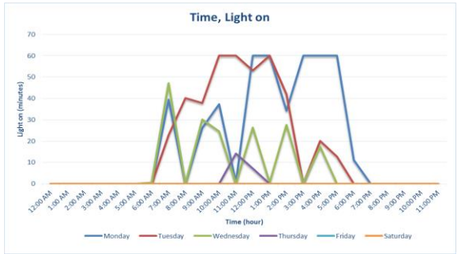
Grad Student Office

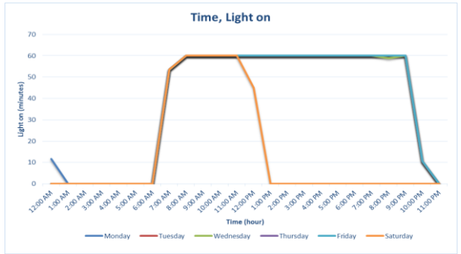
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	12	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	54	0	54	0	54	15	54	0	54	0	54	6	5	0
8:00 AM	60	0	60	7	60	34	60	21	60	14	60	17	6	2
9:00 AM	60	0	60	0	60	41	60	31	60	37	60	7	6	2
10:00 AM	60	0	60	20	60	57	60	51	60	34	60	36	6	3
11:00 AM	60	0	60	50	60	56	60	27	60	42	60	47	6	4
12:00 PM	60	5	60	49	60	44	60	31	60	51	45	39	6	4
1:00 PM	60	40	60	50	60	57	60	44	60	46	0	0	5	4
2:00 PM	60	37	60	59	60	47	60	40	60	28	0	0	5	4
3:00 PM	60	45	60	57	60	55	60	48	60	47	0	0	5	4
4:00 PM	60	28	60	41	60	55	60	18	60	54	0	0	5	3
5:00 PM	60	44	60	46	60	44	60	19	60	31	0	0	5	3
6:00 PM	60	13	60	24	60	45	60	12	60	48	0	0	5	2
7:00 PM	60	4	60	6	60	45	60	2	60	29	0	0	5	1
8:00 PM	60	7	60	4	59	33	60	12	60	0	0	0	5	1
9:00 PM	60	0	60	0	60	4	60	5	60	4	0	0	5	0
10:00 PM	11	4	11	0	11	6	11	0	11	0	0	0	1	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	15.3	3.8	15.1	6.9	15.1	10.6	15.1	6.0	15.1	7.8	5.6	2.5		
Average Use (min/hr)	38.2	9.5	37.7	17.2	37.6	26.6	37.7	15.0	37.7	19.4	14.1	6.3		

The pattern of lighting use

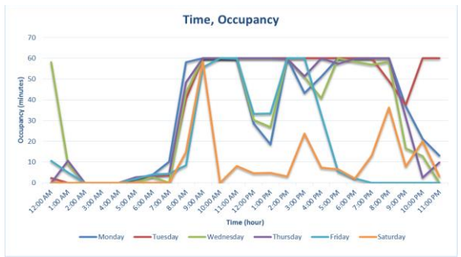


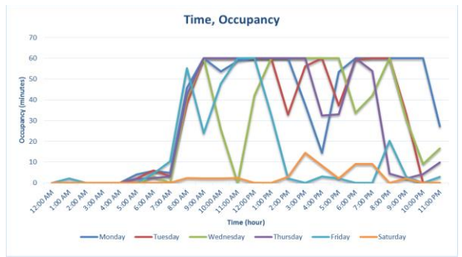


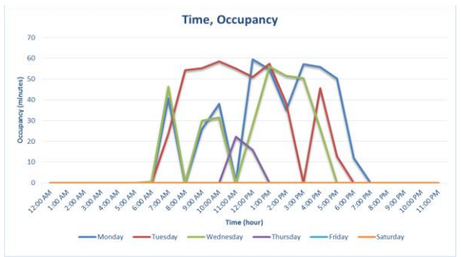


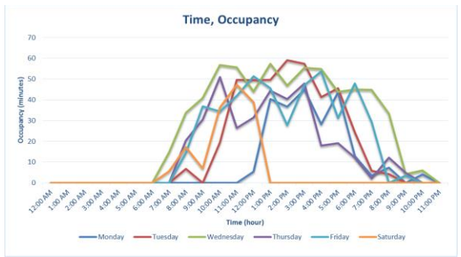


The pattern of occupancy

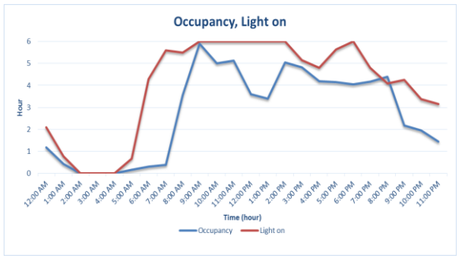


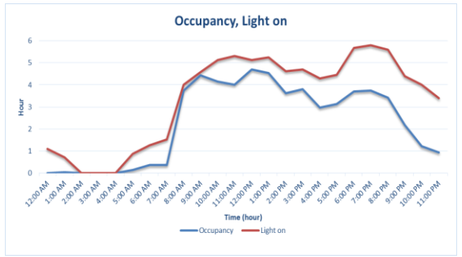


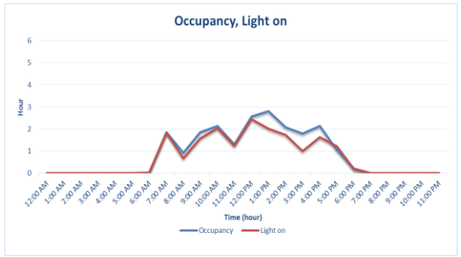


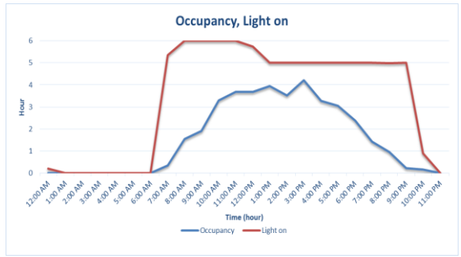


Average hour of daily space & lighting









SAVERY HALL

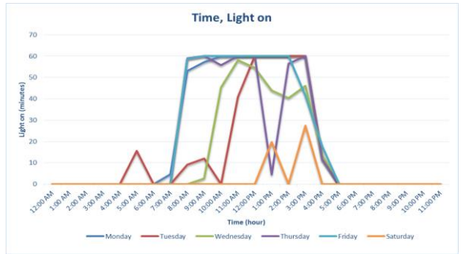
Summary of occupancy & light use

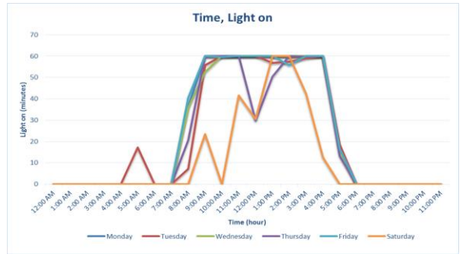
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	16	3	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	5	5	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	53	32	9	7	0	0	59	48	59	45	0	0	3	2
9:00 AM	57	39	12	0	3	0	60	45	60	49	0	0	3	2
10:00 AM	60	55	0	0	45	0	56	50	60	49	0	0	4	3
11:00 AM	60	44	41	28	58	0	60	54	60	52	0	0	5	3
12:00 PM	60	4	60	46	55	0	60	58	60	53	0	0	5	3
1:00 PM	60	50	60	58	44	0	5	8	60	52	20	0	4	3
2:00 PM	60	49	60	42	40	0	57	48	60	54	0	0	5	3
3:00 PM	60	51	60	40	46	0	60	51	42	30	28	0	5	3
4:00 PM	12	12	13	15	13	0	12	11	18	16	0	0	1	1
5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	8.1	5.7	5.5	4.0	5.1	0.0	7.1	6.2	8.0	6.7	0.8	0.0		
Average Use (min/hr)	20.3	14.2	13.8	9.9	12.7	0.0	17.8	15.5	19.9	16.7	2.0	0.0		

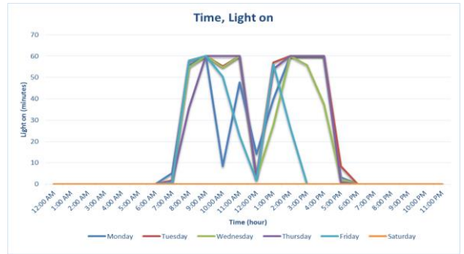
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	17	4	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	37	33	7	27	36	22	21	33	41	22	0	0	2	2
9:00 AM	60	23	56	26	53	4	60	24	60	42	23	0	5	2
10:00 AM	60	26	60	52	60	33	60	27	60	24	0	0	5	3
11:00 AM	60	41	60	48	60	27	60	49	60	25	42	0	6	3
12:00 PM	60	32	60	26	60	31	30	14	60	52	31	0	5	3
1:00 PM	60	33	57	21	60	24	50	23	60	18	60	0	6	2
2:00 PM	60	11	57	9	60	7	60	26	56	6	60	0	6	1
3:00 PM	60	19	59	22	60	35	60	31	60	29	42	0	6	2
4:00 PM	60	37	60	10	60	36	60	24	60	27	13	0	5	2
5:00 PM	16	17	18	13	15	0	13	10	17	19	0	0	1	1
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	8.9	4.5	8.5	4.3	8.7	3.7	7.9	4.4	8.9	4.4	4.5	0.0		
Average Use (min/hr)	22.2	11.3	21.3	10.8	21.8	9.2	19.7	10.9	22.2	11.0	11.3	0.0		

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	5	16	2	15	1	1	1	10	1	1	0	0	0	1
8:00 AM	56	30	58	41	55	34	36	30	58	31	0	0	4	3
9:00 AM	60	25	60	47	60	39	60	20	60	36	0	0	5	3
10:00 AM	9	11	55	39	55	32	60	29	50	31	0	0	4	2
11:00 AM	48	34	60	36	60	16	60	42	23	24	0	0	4	3
12:00 PM	14	16	3	17	3	7	3	16	2	21	0	0	0	1
1:00 PM	40	32	57	40	28	20	54	33	56	43	0	0	4	3
2:00 PM	60	49	60	38	60	34	60	25	27	20	0	0	4	3
3:00 PM	60	31	60	31	56	28	60	28	0	0	0	0	4	2
4:00 PM	60	31	60	20	37	15	60	41	0	0	0	0	4	2
5:00 PM	3	12	9	18	2	10	1	14	0	0	0	0	0	1
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	6.9	4.8	8.1	5.7	6.9	3.9	7.6	4.8	4.6	3.5	0.0	0.0		
Average Use (min/hr)	17.3	12.0	20.1	14.2	17.3	9.9	19.0	12.1	11.5	8.6	0.0	0.0		

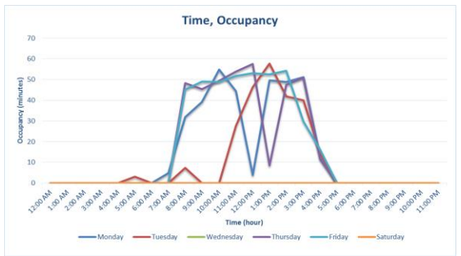
The pattern of lighting use

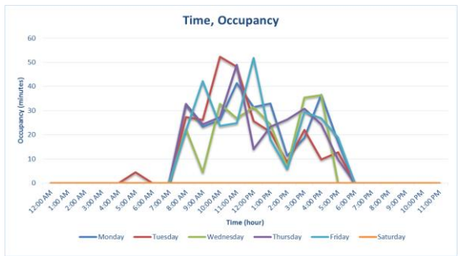


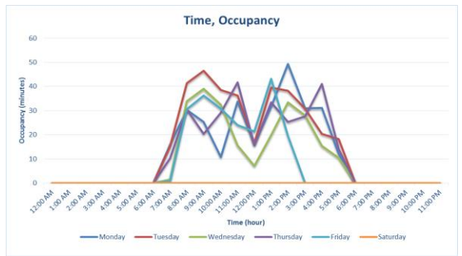




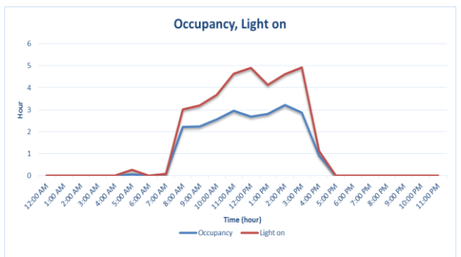
The pattern of occupancy

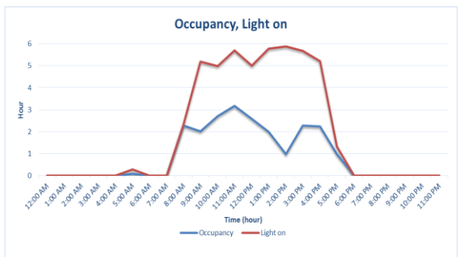


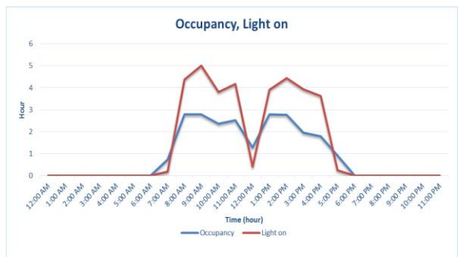




Average hour of daily space & lighting



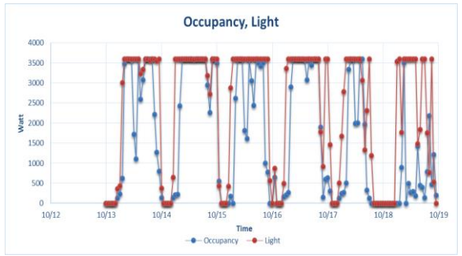




SAVERY HALL

Classroom 1

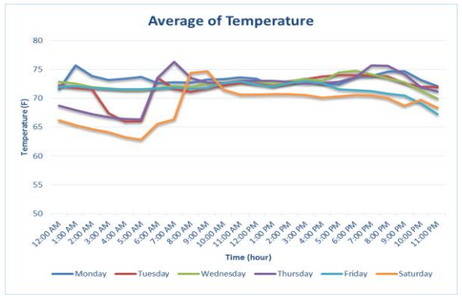
Comparison of occupancy & light on



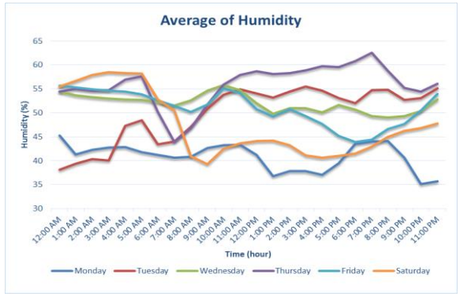
Summary of room temperature

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	72	45	72	38	73	54	69	54	72	56	66	56
1:00 AM	76	41	72	39	73	54	68	55	72	55	65	57
2:00 AM	74	42	72	40	72	53	67	55	72	55	65	58
3:00 AM	73	43	67	40	72	53	67	55	72	55	64	59
4:00 AM	73	43	66	47	71	53	66	57	72	54	63	58
5:00 AM	74	42	66	48	72	53	66	58	72	54	63	58
6:00 AM	73	41	74	43	72	52	74	50	72	53	66	53
7:00 AM	73	41	72	44	72	52	76	44	72	51	66	51
8:00 AM	73	41	71	47	72	53	74	47	72	50	74	41
9:00 AM	73	43	72	51	73	55	73	52	72	52	75	39
10:00 AM	73	43	72	54	73	56	73	56	73	55	72	42
11:00 AM	74	43	73	55	73	55	73	58	73	54	71	44
12:00 PM	73	41	73	54	73	52	73	59	72	51	71	44
1:00 PM	72	37	72	53	73	50	73	58	72	49	71	44
2:00 PM	73	38	72	54	73	51	73	58	73	51	71	43
3:00 PM	73	38	73	55	73	51	73	59	73	49	71	41
4:00 PM	73	37	74	55	73	50	73	60	73	48	70	41
5:00 PM	72	40	74	53	74	52	73	60	72	45	70	41
6:00 PM	74	44	74	52	75	51	74	61	71	44	71	42
7:00 PM	74	44	74	55	74	49	76	63	71	44	71	43
8:00 PM	75	44	74	55	73	49	76	59	71	47	70	45
9:00 PM	75	41	73	53	73	49	74	55	71	48	69	46
10:00 PM	73	35	72	53	71	50	72	54	69	50	70	47
11:00 PM	72	36	72	55	70	53	71	56	67	54	68	48
Average	73.3	40.9	71.9	49.8	72.6	52.0	71.8	55.9	71.6	51.0	68.8	47.5

Average room temperature

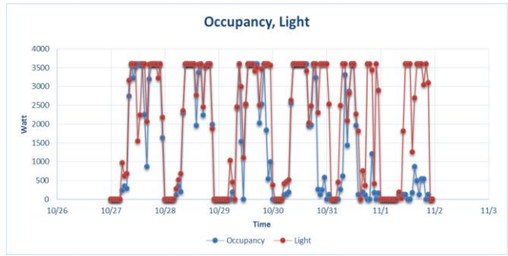


Average room humidity



Classroom 2

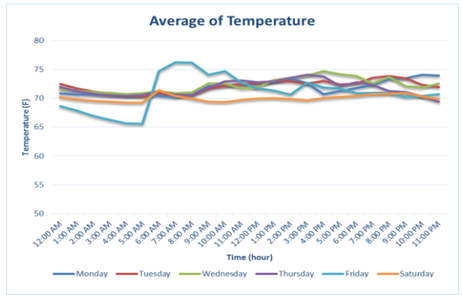
Comparison of occupancy & light on



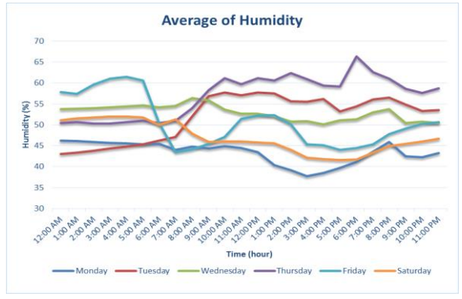
Summary of room temperature

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	71	46	72	43	72	54	72	50	69	58	70	51
1:00 AM	71	46	72	43	71	54	71	51	68	57	70	52
2:00 AM	71	46	71	44	71	54	71	50	67	60	70	52
3:00 AM	71	46	71	44	71	54	70	50	66	61	69	52
4:00 AM	70	46	70	45	71	54	70	51	66	61	69	52
5:00 AM	70	45	70	45	71	55	71	51	66	61	69	52
6:00 AM	70	45	71	46	71	54	71	50	75	50	71	50
7:00 AM	70	44	70	47	71	54	71	51	76	43	70	51
8:00 AM	71	45	71	52	71	56	71	54	76	44	70	48
9:00 AM	72	44	72	57	73	56	72	58	74	45	69	46
10:00 AM	72	45	72	58	73	54	73	61	75	47	69	46
11:00 AM	72	45	72	57	72	53	73	60	73	51	70	46
12:00 PM	73	43	73	58	72	53	73	61	72	52	70	46
1:00 PM	73	40	73	57	73	52	73	61	71	52	70	46
2:00 PM	73	39	73	56	74	51	74	62	71	50	70	44
3:00 PM	73	38	73	55	74	51	74	61	73	45	70	42
4:00 PM	71	39	73	56	75	50	74	59	72	45	70	42
5:00 PM	71	40	72	53	74	51	72	59	72	44	70	42
6:00 PM	72	41	73	54	74	51	73	66	71	44	70	42
7:00 PM	72	44	74	56	73	53	72	63	71	45	71	43
8:00 PM	73	46	74	57	74	54	71	61	71	48	71	45
9:00 PM	73	42	73	55	72	50	71	59	70	49	71	46
10:00 PM	74	42	72	53	72	51	70	58	70	50	70	46
11:00 PM	74	43	72	54	73	50	69	59	71	51	70	47
Average	71.8	43.3	72.1	51.9	72.3	52.9	71.8	56.9	71.0	50.7	70.0	46.9

Average room temperature

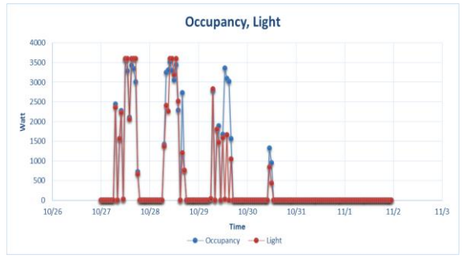


Average room humidity



Faculty Office

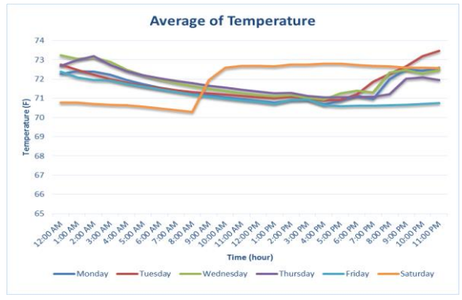
Comparison of occupancy & light on



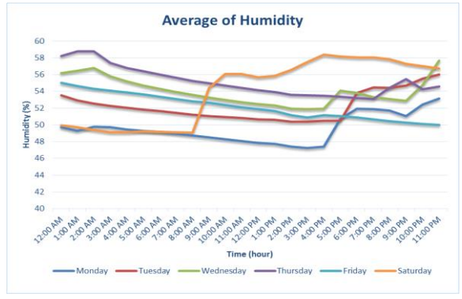
Summary of room temperature

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	72	50	73	54	73	56	73	58	72	55	71	50
1:00 AM	72	49	72	53	73	56	73	59	72	55	71	50
2:00 AM	72	50	72	53	73	57	73	59	72	54	71	49
3:00 AM	72	50	72	52	73	56	73	57	72	54	71	49
4:00 AM	72	49	72	52	72	55	72	57	72	54	71	49
5:00 AM	72	49	72	52	72	55	72	56	72	54	71	49
6:00 AM	72	49	72	52	72	54	72	56	71	53	70	49
7:00 AM	71	49	71	51	72	54	72	56	71	53	70	49
8:00 AM	71	49	71	51	72	54	72	55	71	53	70	49
9:00 AM	71	49	71	51	72	53	72	55	71	53	72	54
10:00 AM	71	48	71	51	71	53	72	55	71	52	73	56
11:00 AM	71	48	71	51	71	53	71	54	71	52	73	56
12:00 PM	71	48	71	51	71	52	71	54	71	52	73	56
1:00 PM	71	48	71	51	71	52	71	54	71	52	73	56
2:00 PM	71	47	71	50	71	52	71	54	71	51	73	57
3:00 PM	71	47	71	50	71	52	71	54	71	51	73	57
4:00 PM	71	47	71	51	71	52	71	53	71	51	73	58
5:00 PM	71	51	71	50	71	54	71	53	71	51	73	58
6:00 PM	71	52	71	54	71	54	71	53	71	51	73	58
7:00 PM	71	52	72	54	71	53	71	53	71	51	73	58
8:00 PM	72	52	72	54	72	53	71	54	71	50	73	58
9:00 PM	72	51	73	55	72	53	72	55	71	50	73	57
10:00 PM	72	52	73	56	72	55	72	54	71	50	73	57
11:00 PM	73	53	73	56	72	58	72	55	71	50	73	57
Average	71.5	49.6	71.7	52.2	71.9	54.0	71.8	55.2	71.1	52.2	71.9	54.1

Average room temperature

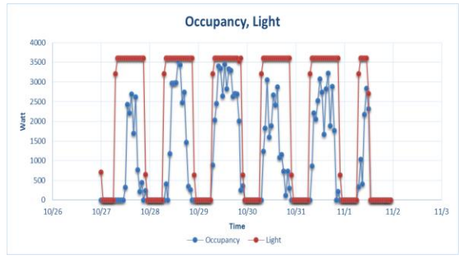


Average room humidity



Grad Student Office

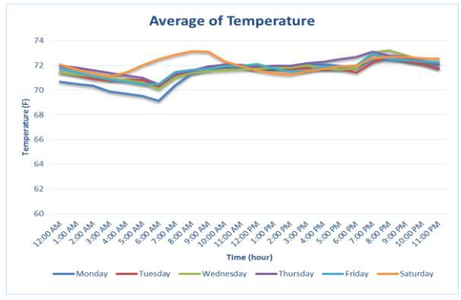
Comparison of occupancy & light on



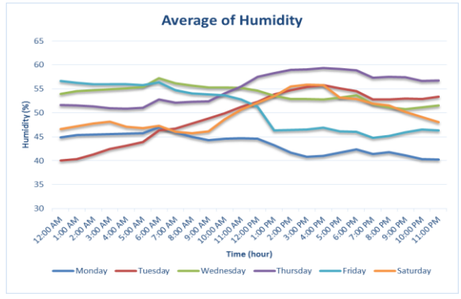
Summary of room temperature

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	71	45	71	40	71	54	72	52	72	57	72	47
1:00 AM	71	45	71	40	71	55	72	52	71	56	72	47
2:00 AM	70	45	71	41	71	55	72	51	71	56	71	48
3:00 AM	70	46	71	42	71	55	71	51	71	56	71	48
4:00 AM	70	46	71	43	71	55	71	51	71	56	71	47
5:00 AM	70	46	71	44	71	55	71	51	70	56	72	47
6:00 AM	69	47	70	46	70	57	70	53	70	56	72	47
7:00 AM	70	46	71	47	71	56	71	52	71	55	73	46
8:00 AM	71	45	72	48	71	56	72	52	72	54	73	46
9:00 AM	72	44	72	49	72	55	72	52	72	54	73	46
10:00 AM	72	45	72	50	72	55	72	54	72	54	72	49
11:00 AM	72	45	72	51	72	55	72	56	72	53	72	51
12:00 PM	72	45	72	52	72	55	72	58	72	51	72	52
1:00 PM	72	43	72	54	72	54	72	58	72	46	71	53
2:00 PM	72	42	72	55	72	53	72	59	72	46	71	55
3:00 PM	72	41	72	55	72	53	72	59	72	46	72	56
4:00 PM	72	41	72	56	72	53	72	59	72	47	72	56
5:00 PM	72	42	72	55	72	53	73	59	72	46	72	53
6:00 PM	72	42	71	54	72	54	73	59	72	46	72	53
7:00 PM	72	41	72	53	73	52	73	57	73	45	73	52
8:00 PM	72	42	73	53	73	51	73	58	73	45	73	52
9:00 PM	72	41	72	53	73	51	73	57	72	46	73	50
10:00 PM	72	40	72	53	72	51	72	57	72	46	73	49
11:00 PM	72	40	72	53	72	52	72	57	72	46	73	48
Average	71.3	43.5	71.6	49.5	71.7	53.9	71.9	55.2	71.7	50.9	72.1	49.9

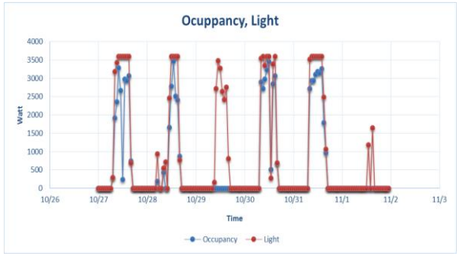
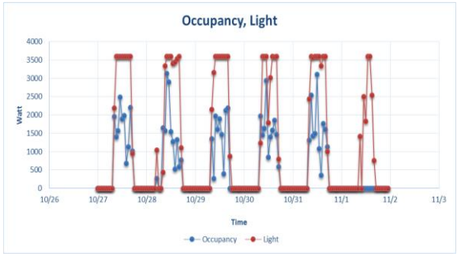
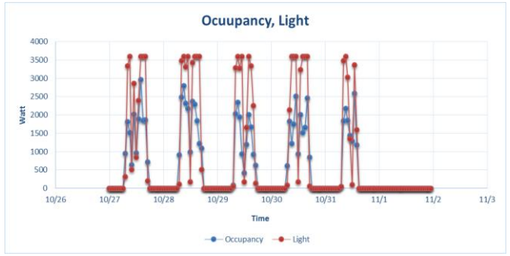
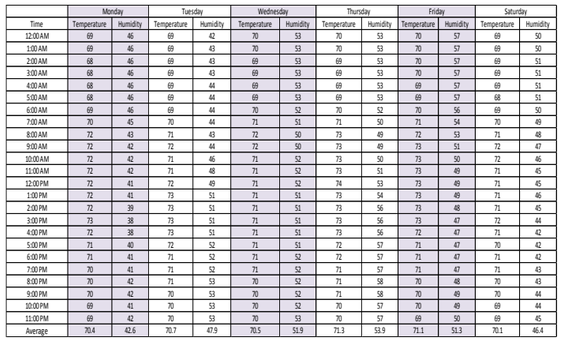
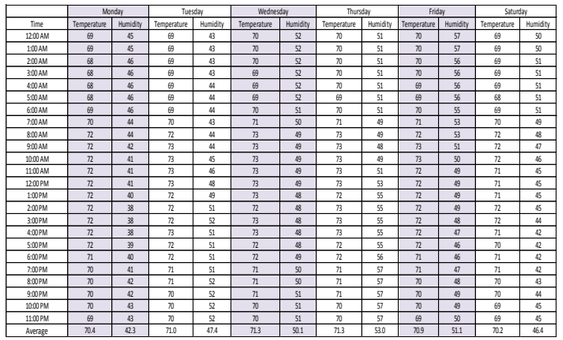
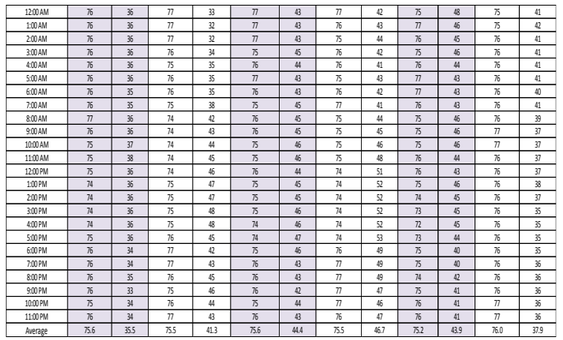
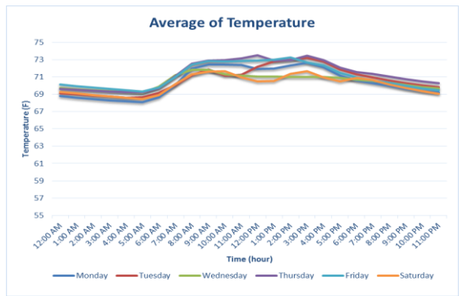
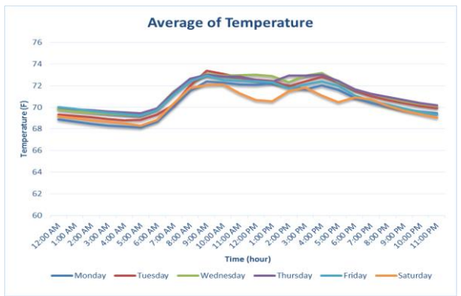
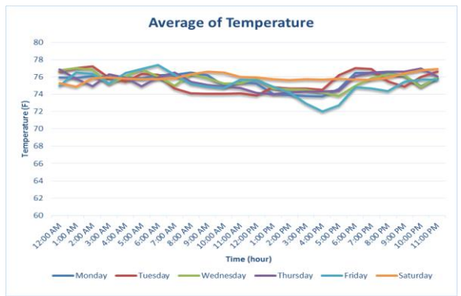
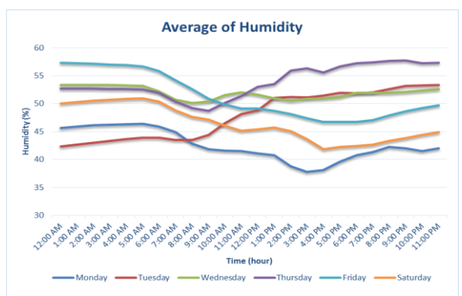
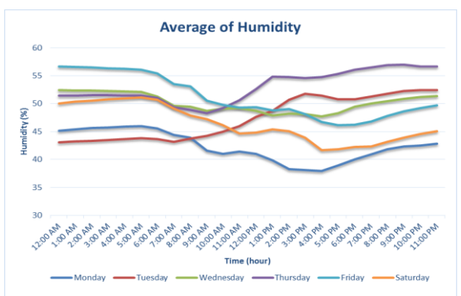
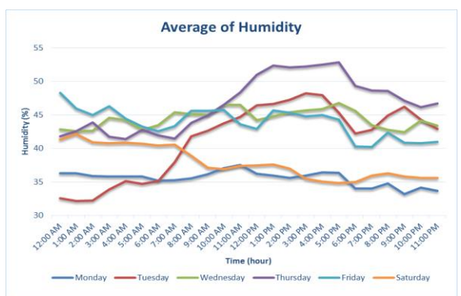
Average room temperature



Average room humidity



SAVERY HALL

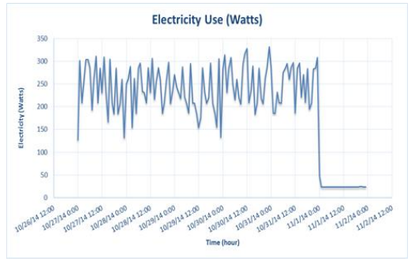
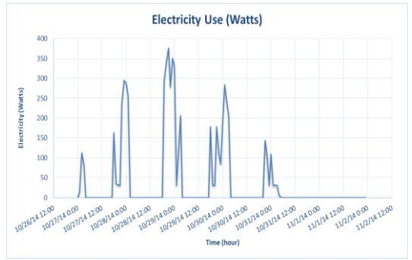
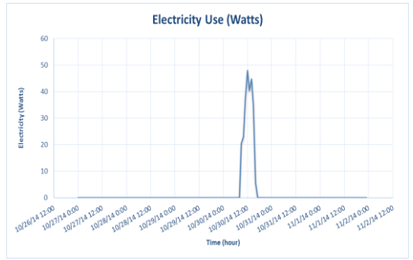
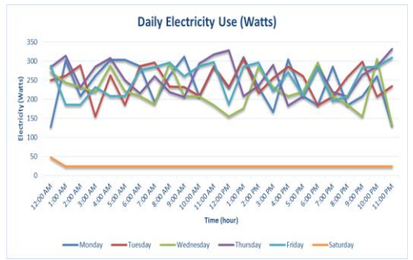
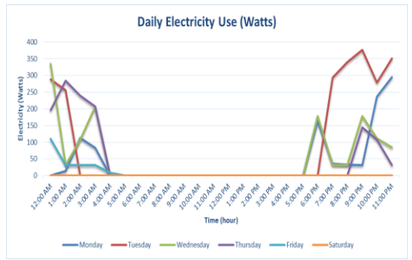
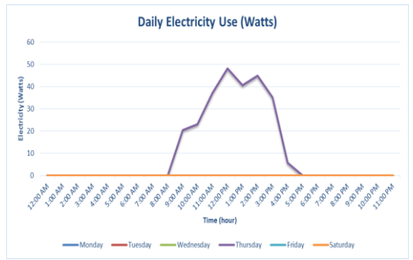
	Staff Office 1	Staff Office 2	Staff Office 3
Comparison of occupancy & light on			
Summary of room temperature			
Average room temperature			
Average room humidity			

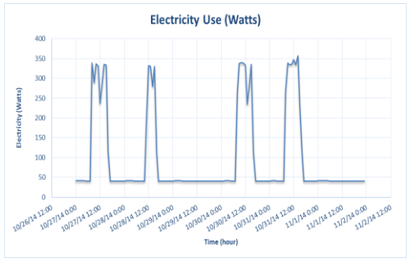
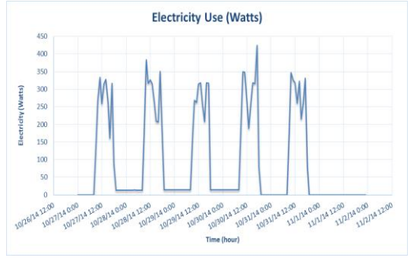
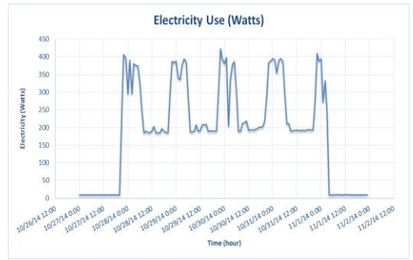
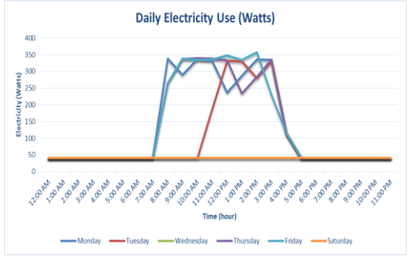
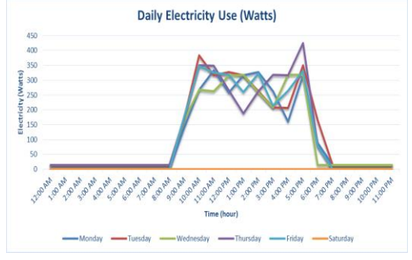
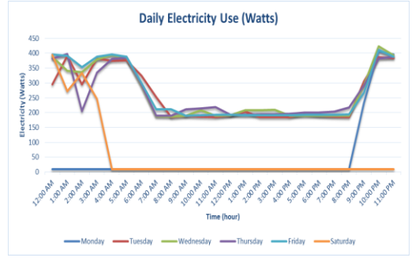
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	69	46	69	42	70	53	70	53	70	57	69	50
1:00 AM	69	46	69	43	70	53	70	53	70	57	69	50
2:00 AM	68	46	69	43	69	53	69	53	70	57	69	51
3:00 AM	68	46	69	43	69	53	69	53	70	57	69	51
4:00 AM	68	46	69	44	69	53	69	53	69	57	69	51
5:00 AM	68	46	69	44	69	53	69	53	69	57	68	51
6:00 AM	69	46	69	44	70	52	70	52	70	56	69	50
7:00 AM	70	45	70	44	71	51	71	50	71	54	70	49
8:00 AM	72	43	71	43	72	50	73	49	72	53	71	48
9:00 AM	72	42	72	44	72	50	73	49	73	51	72	47
10:00 AM	72	42	71	46	71	52	73	50	73	50	72	46
11:00 AM	72	42	71	48	71	52	73	51	73	49	71	45
12:00 PM	72	41	72	49	71	52	74	53	73	49	71	45
1:00 PM	72	41	73	51	71	51	73	54	73	49	71	46
2:00 PM	72	39	73	51	71	51	73	56	73	48	71	45
3:00 PM	73	38	73	51	71	51	73	56	73	47	72	44
4:00 PM	72	38	73	51	71	51	73	56	72	47	71	42
5:00 PM	71	40	72	52	71	51	72	57	71	47	70	42
6:00 PM	71	41	71	52	71	52	72	57	71	47	71	42
7:00 PM	70	41	71	52	71	52	71	57	71	47	71	43
8:00 PM	70	42	71	53	70	52	71	58	70	48	70	43
9:00 PM	70	42	70	53	70	52	71	58	70	49	70	44
10:00 PM	69	41	70	53	70	52	70	57	70	49	69	44
11:00 PM	69	42	70	53	70	53	70	57	69	50	69	45
Average	70.4	42.6	70.7	47.9	70.5	51.9	71.3	53.9	71.1	51.3	70.1	46.4

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	69	45	69	43	70	52	70	51	70	57	69	50
1:00 AM	69	45	69	43	70	52	70	51	70	57	69	50
2:00 AM	68	46	69	43	70	52	70	51	70	56	69	51
3:00 AM	68	46	69	43	69	52	70	51	70	56	69	51
4:00 AM	68	46	69	44	69	52	70	51	69	56	69	51
5:00 AM	68	46	69	44	69	52	69	51	69	56	68	51
6:00 AM	69	46	69	44	70	51	70	51	70	55	69	51
7:00 AM	70	44	70	43	71	50	71	49	71	53	70	49
8:00 AM	72	44	72	44	73	49	73	49	72	53	72	48
9:00 AM	72	42	73	44	73	49	73	48	73	51	72	47
10:00 AM	72	41	73	45	73	49	73	49	73	50	72	46
11:00 AM	72	41	73	46	73	49	73	51	72	49	71	45
12:00 PM	72	41	73	48	73	49	73	53	72	49	71	45
1:00 PM	72	40	72	49	73	48	72	55	72	49	71	45
2:00 PM	72	38	72	51	72	48	73	55	72	49	72	45
3:00 PM	72	38	72	52	73	48	73	55	72	48	72	44
4:00 PM	72	38	73	51	73	48	73	55	72	47	71	42
5:00 PM	72	39	72	51	72	48	72	55	72	46	70	42
6:00 PM	71	40	72	51	72	49	72	56	71	46	71	42
7:00 PM	70	41	71	51	71	50	71	57	71	47	71	42
8:00 PM	70	42	71	52	71	50	71	57	70	48	70	43
9:00 PM	70	42	70	52	71	51	71	57	70	49	70	44
10:00 PM	70	43	70	52	70	51	70	57	70	49	69	45
11:00 PM	69	43	70	52	70	51	70	57	69	50	69	45
Average	70.4	42.3	71.0	47.4	71.3	50.1	71.3	53.0	70.9	51.1	70.2	46.4

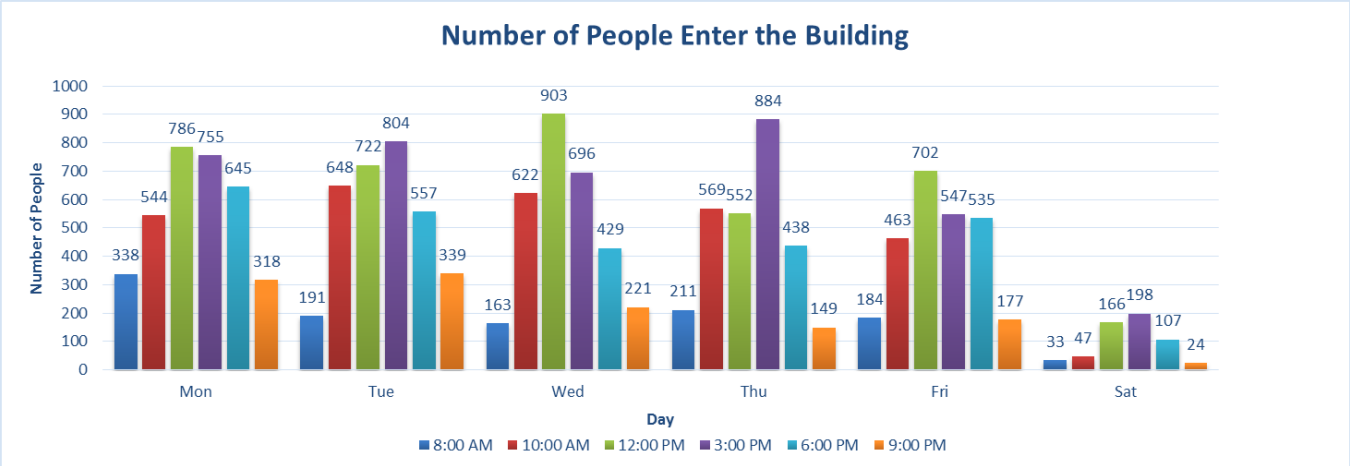
12:00 AM	76	36	77	33	77	43	77	42	75	48	75	41
1:00 AM	76	36	77	32	77	43	76	43	77	46	75	42
2:00 AM	76	36	77	32	77	43	75	44	76	45	76	41
3:00 AM	76	36	76	34	75	45	76	42	75	46	76	41
4:00 AM	76	36	75	35	76	44	76	41	76	44	76	41
5:00 AM	76	36	76	35	77	43	75	43	77	43	76	41
6:00 AM	76	35	76	35	76	43	76	42	77	43	76	40
7:00 AM	76	35	75	38	75	45	77	41	76	43	76	41
8:00 AM	77	36	74	42	76	45	75	44	75	46	76	39
9:00 AM	76	36	74	43	76	45	75	45	75	46	77	37
10:00 AM	75	37	74	44	75	46	75	46	75	46	77	37
11:00 AM	75	38	74	45	75	46	75	48	76	44	76	37
12:00 PM	75	36	74	46	76	44	74	51	76	43	76	37
1:00 PM	74	36	75	47	75	45	74	52	75	46	76	38
2:00 PM	74	36	75	47	75	45	74	52	74	45	76	37
3:00 PM	74	36	75	48	75	46	74	52	73	45	76	35
4:00 PM	74	36	75	48	74	46	74	52	72	45	76	35
5:00 PM	75	36	76	45	74	47	74	53	73	44	76	35
6:00 PM	76	34	77	42	75	46	76	49	75	40	76	35
7:00 PM	76	34	77	43	76	43	77	49	75	40	76	36
8:00 PM	76	35	76	45	76	43	77	49	74	42	76	36
9:00 PM	76	33	75	46	76	42	77	47	75	41	76	36
10:00 PM	75	34	76	44	75	44	77	46	76	41	77	36
11:00 PM	76	34	77	43	76	43	76	47	76	41	77	36
Average	75.6	35.5	75.5	41.3	75.6	44.4	75.5	46.7	75.2	43.9	76.0	37.9

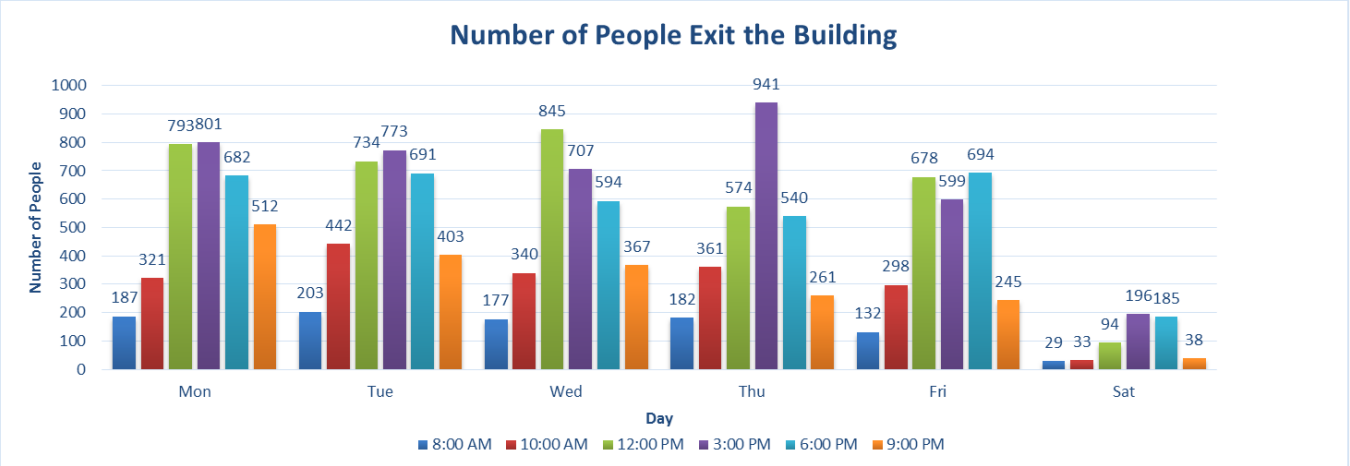
SAVERY HALL

	Computer Lab	Faculty Office	Grad Student Office
Electricity use			
The pattern of daily electricity use			

	Staff Office 1	Staff Office 2	Staff Office 3
Electricity use			
The pattern of daily electricity use			

Profile of Building Occupancy (People Counters)





First Floor

	In	Out
Mon	370	397
Tue	241	265
Wed	332	295
Thu	346	358
Fri	212	326
Sat	74	67
AVG	301	328

	In	Out
Mon	283	364
Tue	337	343
Wed	259	247
Thu	310	290
Fri	178	225
Sat	4	50
AVG	273	294

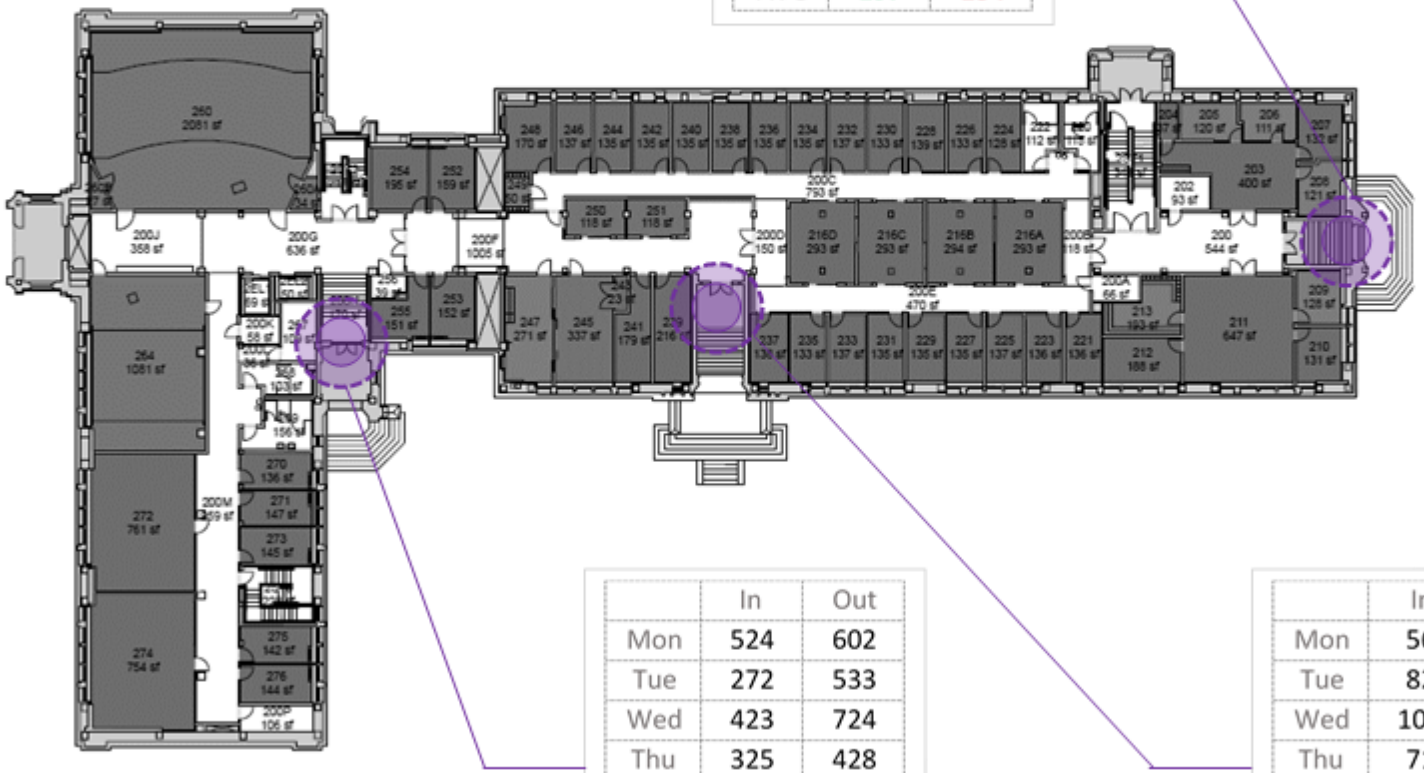
	In	Out
Mon	1045	1081
Tue	1189	991
Wed	1123	1214
Thu	1014	1133
Fri	958	847
Sat	254	286
AVG	863	1053

	In	Out
Mon	56	107
Tue	82	51
Wed	104	76
Thu	71	58
Fri	91	39
Sat	48	2
AVG	81	66

	In	Out
Mon	1094	794
Tue	833	1109
Wed	877	816
Thu	928	867
Fri	641	982
Sat	113	99
AVG	874	913

Second Floor

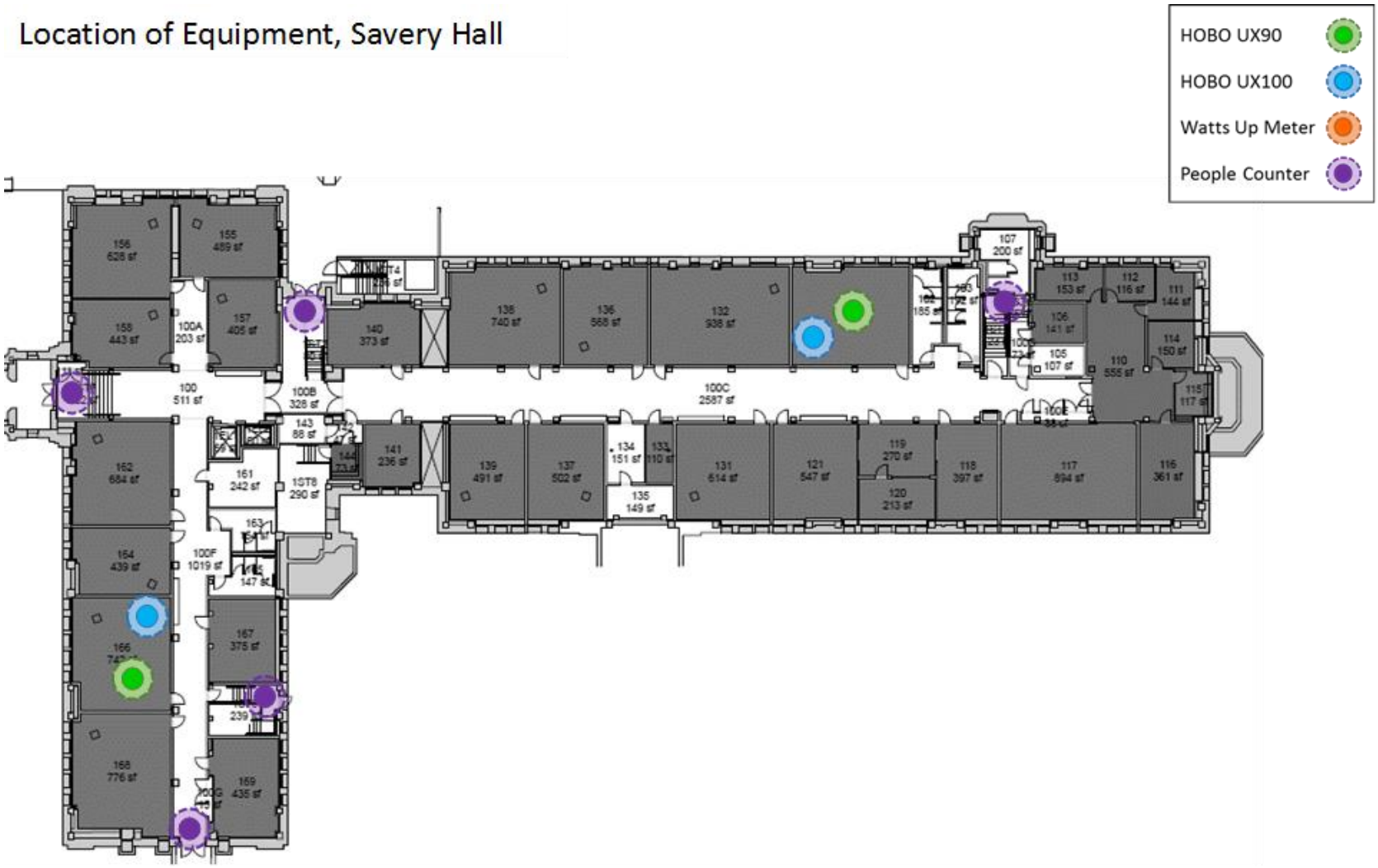
	In	Out
Mon	101	97
Tue	235	132
Wed	188	217
Thu	254	115
Fri	208	108
Sat	52	30
AVG	197	134



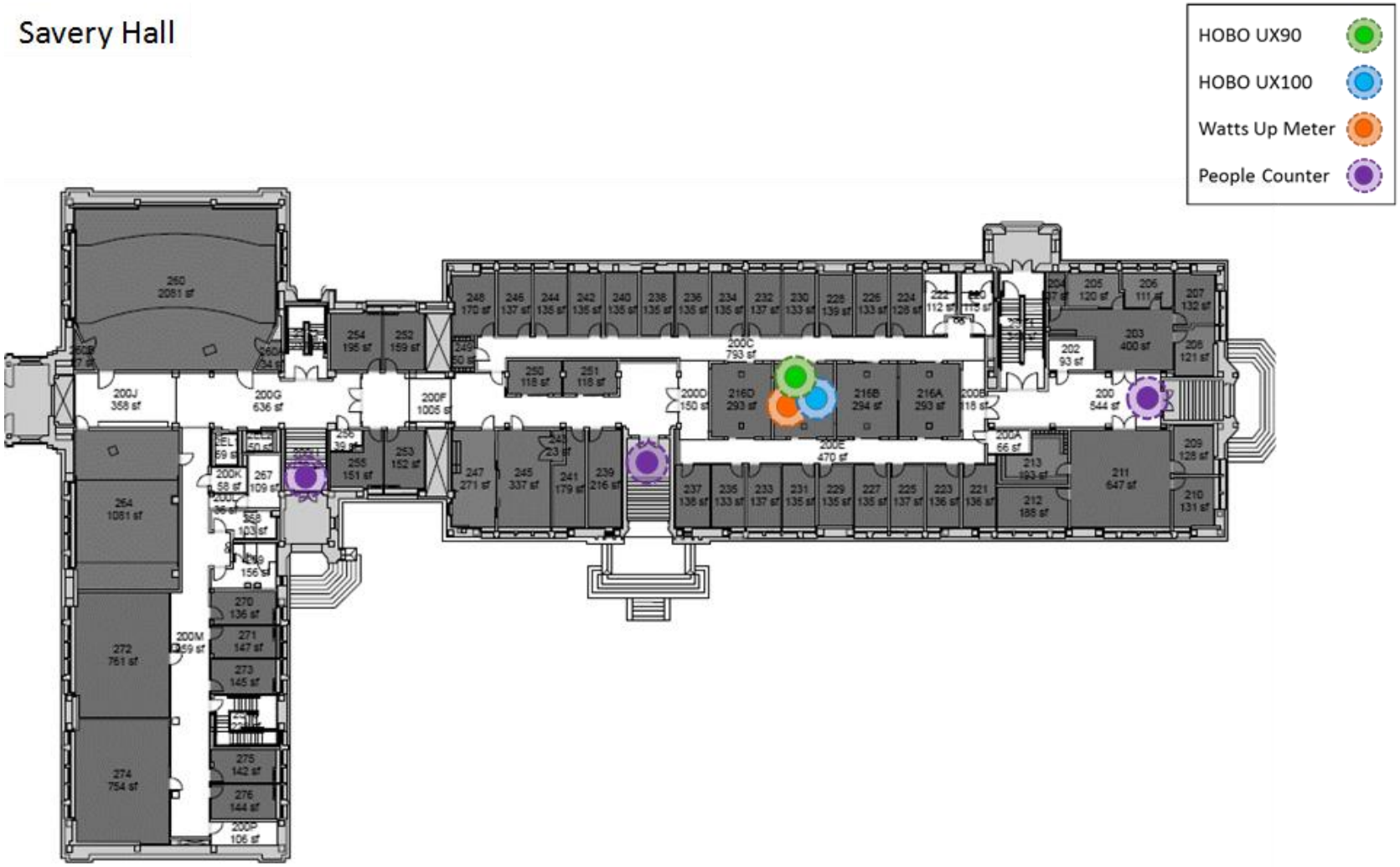
	In	Out
Mon	524	602
Tue	272	533
Wed	423	724
Thu	325	428
Fri	381	443
Sat	13	77
AVG	385	546

	In	Out
Mon	56	31
Tue	82	42
Wed	104	58
Thu	71	30
Fri	92	78
Sat	48	15
AVG	81	48

Location of Equipment, Savery Hall

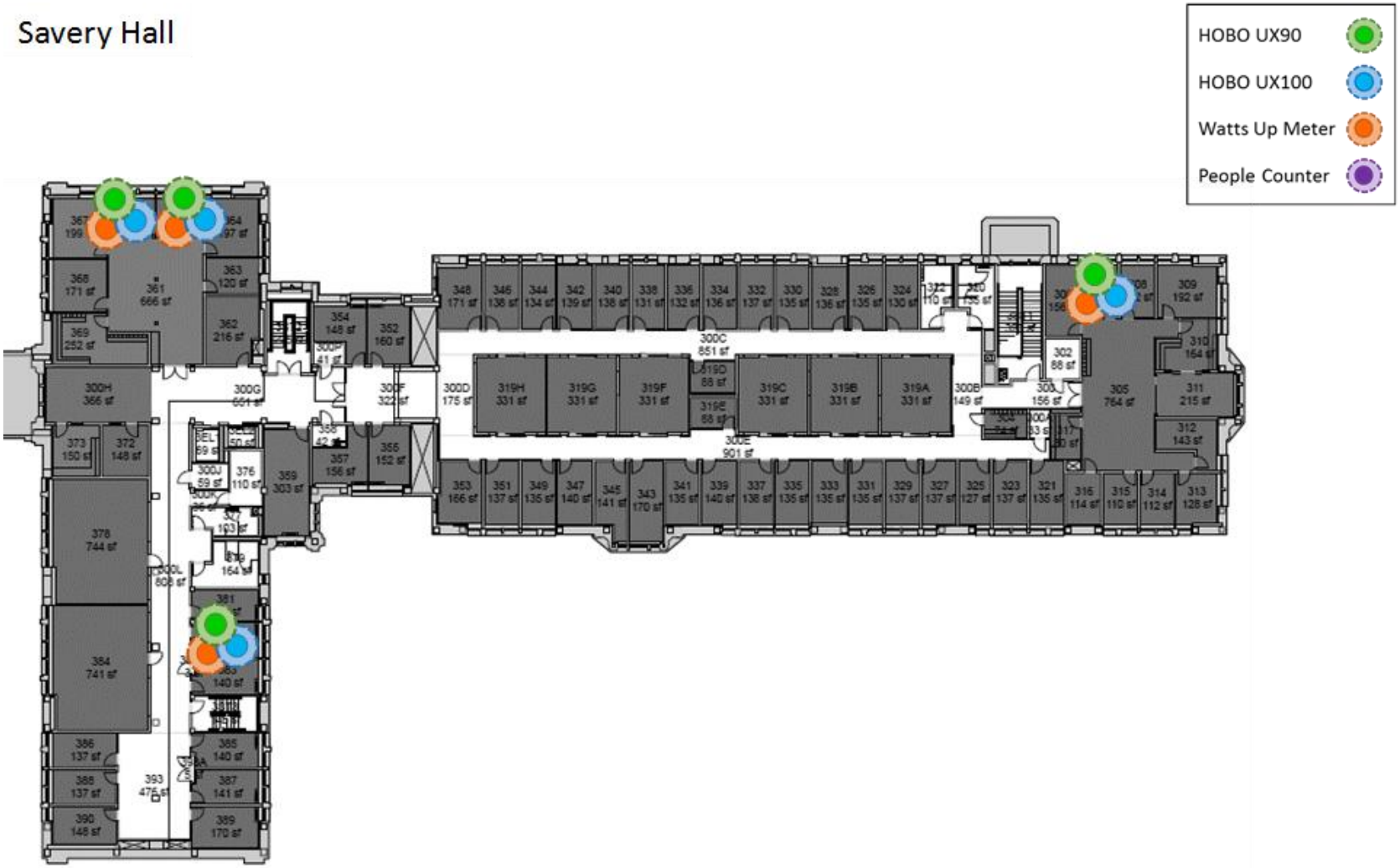


Savery Hall



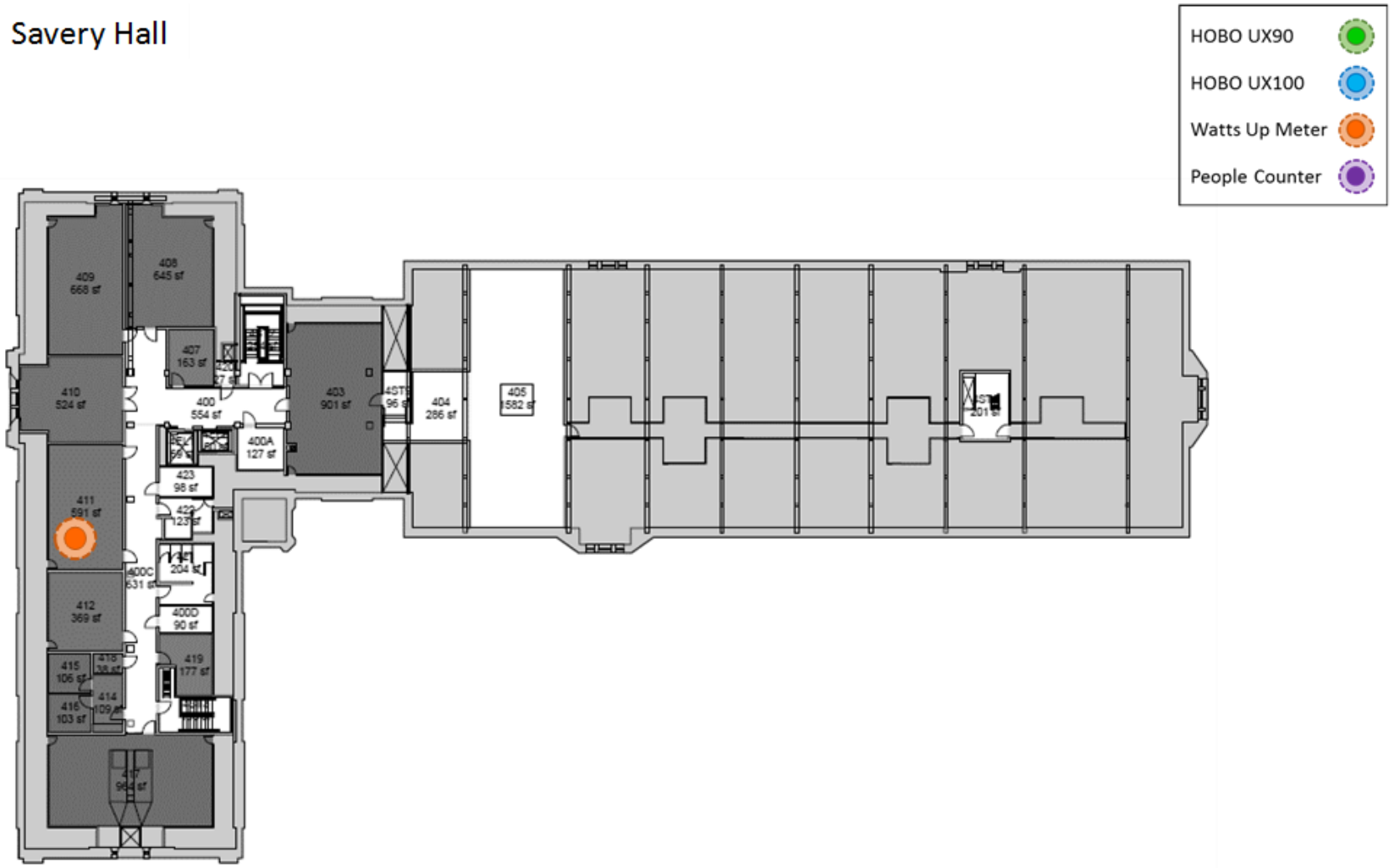
Second Floor

Savery Hall



Third Floor

Savery Hall



Fourth Floor

Appendix IV

Building Factsheet: Dempsey Hall

DEMPSEY HALL

The summary sheets provide the results of manual observation and automated monitoring:

1. An overview of the building information
2. Quick facts from the data summarization & analysis
3. A summary data collected through the manual observation. First table organizes data based on different days of the week. Second table organizes data based on different hours per day.
4. The extent & pattern of building occupancy, desktops use, and lighting use (indicated in graphs).
5. Number of laptops present and plugged in
6. The results of automated monitoring (HOBO devices) in the selected rooms including extent & pattern of room occupancy, light use, and average room temperature & humidity.
7. The results of automated monitoring (Watts Up meters) in the selected rooms including the extent & pattern of electricity use.

Building Overview	
Number of Stories	1 Basement + 3 stories
Departments of	Michael G. Foster School of Business
Number of Offices	74
Number of Classrooms	10
Number of Computer labs	0
Number of Rooms with Operable Windows	82

Building Fact Sheet

Manual Observation & Automated Monitoring Quick Facts	
Time period of audit	**12 – 18 November 2014**
Audit time slots	**8am, 10am, 12pm, 3pm, 6pm, 9pm**
10 AM and 3 PM are the peak hours of the building use (Number of people present, desktops in use, and rooms with light on)	
In average, the number of rooms with opened windows is less than 1% of the total number of rooms with operable windows.	
In average, the number of rooms with opened blinds/drapes is about 22% of the total number of rooms with windows.	
Almost, 27% of building users bring their laptops to the building and 39% of laptops are plugged in.	
Range of indoor temperature	65 – 75 °F (Standard range: 68-76 °F)
Range of indoor humidity	15 – 35 % (Standard range: 30-50 %)
Total number of equipment in the building	
Printer/Scanner/Copier : 25	Projector : 18 (very much in use)
TV : 8 (not much in use)	Personal heater/fan : 6 (much in use)
Desktop : 76	Refrigerator : 8 Microwave : 14

The tables show a summary of data collected through the manual observation

Type of Data	Mon.						Tue.						Wed.						Thu.						Fri.						Sat.					
	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM	8 AM	10 AM	12 PM	3 PM	6 PM	9 PM
Total number of people present	90	104	126	144	85	30	216	154	92	201	127	63	163	43	109	121	83	45	194	154	202	213	154	50	29	67	47	76	15	0	0	9	19	0	0	0
Total number of room with light on	35	45	16	59	24	9	44	51	15	50	19	6	37	57	14	49	25	10	43	42	18	52	31	11	29	44	9	32	12	0	10	8	4	0	0	0
Total number of rooms with opened windows	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of rooms with opened blinds/drapes	14	21	7	40	7	1	17	22	7	37	21	1	14	10	8	35	3	1	13	14	8	34	4	1	12	17	2	23	0	0	7	1	1	0	0	0
Average rooms temperature	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total number of desktops on	21	68	21	73	11	5	34	60	16	57	14	3	33	45	25	32	8	2	29	24	30	48	14	1	18	49	7	30	5	0	0	3	2	0	0	0
Total number of laptops present	14	17	32	42	37	19	5	9	24	85	41	22	11	15	21	59	66	29	6	17	20	73	34	22	7	7	20	29	16	0	1	0	7	0	0	0
Total number of laptops plugged in	3	10	10	20	8	5	4	5	10	59	24	7	1	7	8	24	18	15	0	6	7	52	6	9	2	3	9	26	3	0	0	0	1	0	0	0
Total number of projectors in use	1	0	4	6	0	8	4	6	5	6	0	4	2	2	1	10	9	2	4	7	4	9	3	1	0	0	3	1	0	0	0	0	2	0	0	0
Total number of TV's in use	2	1	0	0	1	0	5	2	0	0	0	0	3	1	0	0	4	0	3	1	0	0	4	0	4	2	0	0	0	0	2	0	0	0	0	0
Total number of desk/floor lamps	3	5	4	2	0	0	7	9	4	2	0	0	4	0	4	2	3	0	4	2	5	2	2	0	2	4	0	2	0	0	0	0	0	0	0	0
Total number of personal fans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of personal heaters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of cell phones plugged in	1	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Total number of tablets plugged in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

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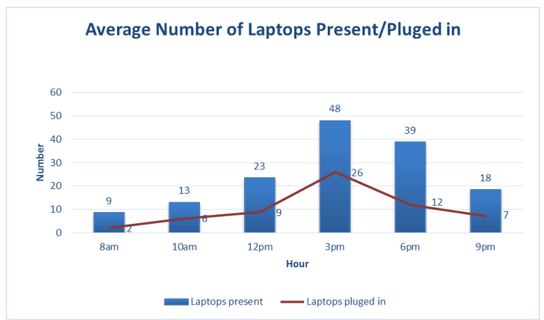
Type of Data	8 AM						10 AM						12 PM						3 PM						6 PM						9 PM					
	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
Total number of people present	90	216	163	194	29	0	104	154	43	154	67	9	126	92	109	202	47	19	144	201	121	213	76	0	85	127	83	154	15	0	30	63	45	50	0	0
Total number of room with light on	35	44	37	43	29	10	45	51	57	42	44	8	16	15	14	18	9	4	59	50	49	52	32	0	24	19	25	31	12	0	9	6	10	11	0	0
Total number of rooms with opened windows	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of rooms with opened blinds/drapes	14	17	14	13	12	7	21	22	10	14	17	1	7	7	8	8	2	1	40	37	35	34	23	0	7	21	3	4	0	0	1	1	1	1	0	0
Average rooms temperature	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total number of desktops on	21	34	33	29	18	0	68	60	45	24	49	3	21	16	25	30	7	2	73	57	32	48	30	0	11	14	8	14	5	0	5	3	2	1	0	0
Total number of laptops present	14	5	11	6	7	1	17	9	15	17	7	0	32	24	21	20	20	7	42	85	59	73	29	0	37	41	66	34	16	0	19	22	29	22	0	0
Total number of laptops plugged in	3	4	1	0	2	0	10	5	7	6	3	0	10	10	8	7	9	1	20	59	24	52	26	0	8	24	18	6	3	0	5	7	15	9	0	0
Total number of projectors in use	1	4	2	4	0	0	0	6	2	7	0	0	4	5	1	4	3	2	6	6	10	9	1	0	0	0	9	3	0	0	8	4	2	1	0	0
Total number of TV's in use	2	5	3	3	4	2	1	2	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	4	0	0	0	0	0	0	0	0
Total number of desk/floor lamps	3	7	4	4	2	0	5	9	0	2	4	0	4	4	4	5	0	0	2	2	2	2	2	0	0	0	3	2	0	0	0	0	0	0	0	0
Total number of personal fans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of personal heaters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of cell phones plugged in	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0
Total number of tablets plugged in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0

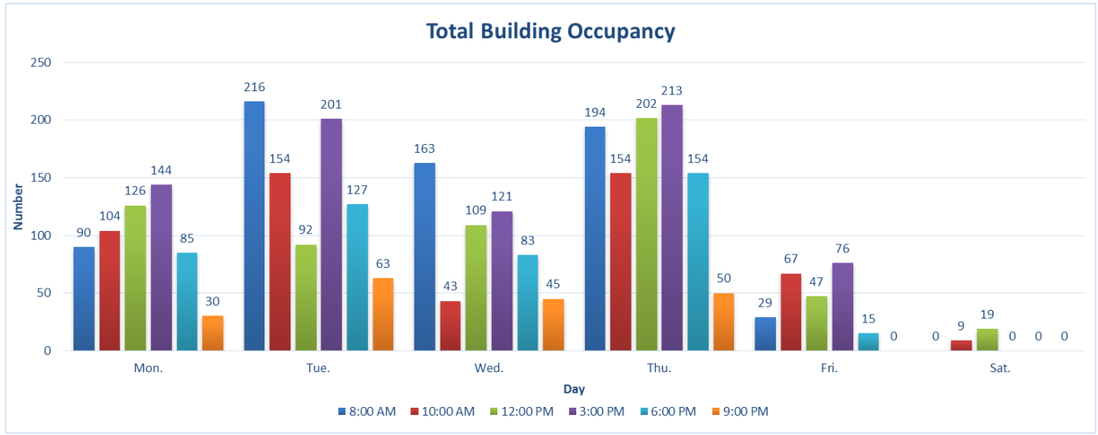
DEMPSEY HALL

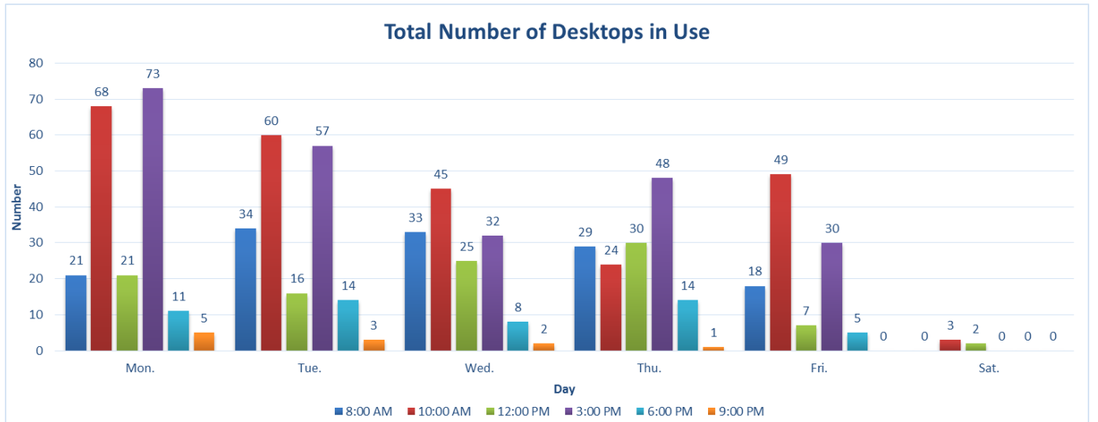
These graphs summarizes the results of **Manual Observation**.

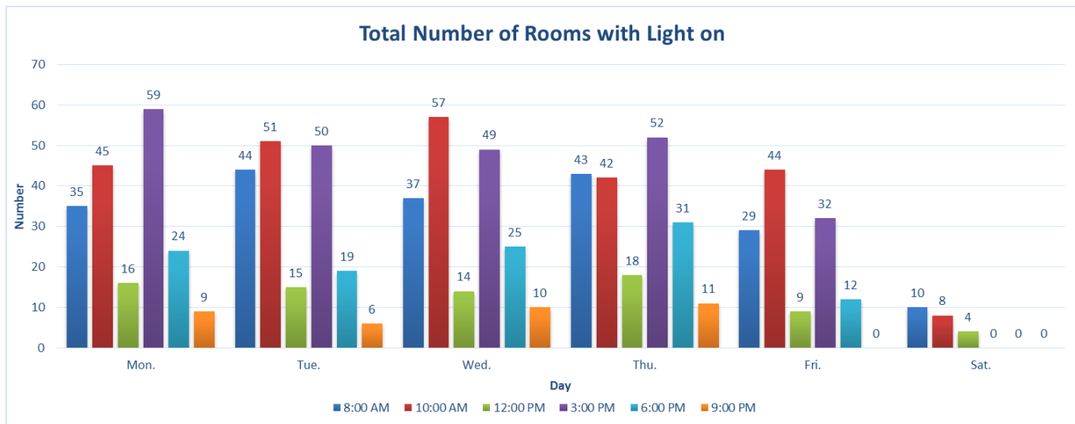
The graphs show the total number of people present, desktops in use, and rooms with light on. The amounts can be compared between different days of a week and different hours of a day.

The graph below shows the average number of laptops present and the numbers of them that were plugged in.









Staff Office 1

Staff Office 2

Staff Office 3

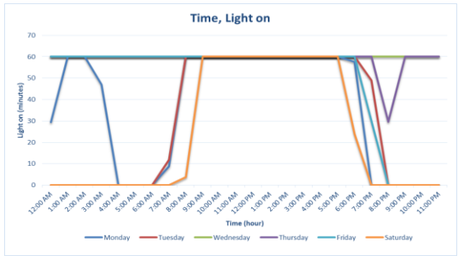
Summary of occupancy & light use

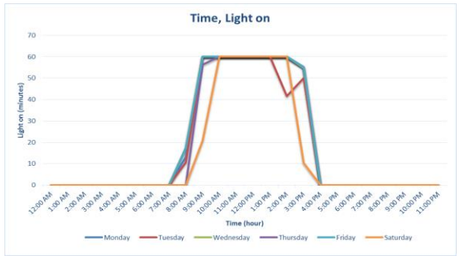
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	29	0	0	0	60	0	60	0	60	0	0	0	3	0
1:00 AM	60	0	0	0	60	0	60	0	60	0	0	0	4	0
2:00 AM	60	0	0	0	60	0	60	0	60	0	0	0	4	0
3:00 AM	47	0	0	0	60	0	60	0	60	0	0	0	4	0
4:00 AM	0	0	0	0	60	0	60	0	60	0	0	0	3	0
5:00 AM	0	0	0	0	60	0	60	0	60	0	0	0	3	0
6:00 AM	0	0	0	0	60	0	60	2	60	2	0	0	3	0
7:00 AM	9	9	12	13	60	10	60	4	60	6	0	0	3	1
8:00 AM	60	44	60	42	60	22	60	34	60	24	4	3	5	3
9:00 AM	60	38	60	34	60	48	60	39	60	48	60	1	6	3
10:00 AM	60	43	60	40	60	31	60	34	60	43	60	2	6	3
11:00 AM	60	45	60	49	60	32	60	42	60	52	60	2	6	4
12:00 PM	60	32	60	42	60	42	60	35	60	40	60	0	6	3
1:00 PM	60	30	60	55	60	34	60	44	60	45	60	5	6	4
2:00 PM	60	28	60	49	60	27	60	28	60	44	60	0	6	3
3:00 PM	60	39	60	52	60	26	60	16	60	46	60	0	6	3
4:00 PM	60	22	60	36	60	32	60	25	60	35	60	0	6	2
5:00 PM	60	15	60	20	60	16	60	28	60	24	60	0	6	2
6:00 PM	58	0	60	6	60	0	60	2	60	0	24	0	5	0
7:00 PM	0	0	49	2	60	0	60	2	30	0	0	0	3	0
8:00 PM	0	0	0	0	60	0	30	0	0	0	0	0	1	0
9:00 PM	0	0	0	0	60	0	60	0	0	0	0	0	2	0
10:00 PM	0	0	0	0	60	0	60	0	0	0	0	0	2	0
11:00 PM	0	0	0	0	60	0	60	0	0	0	0	0	2	0
Total Use (hrs/d)	14.4	5.7	12.0	7.4	24.0	5.4	23.5	5.6	19.5	6.8	9.5	0.2		
Average Use (min/hr)	36.0	14.3	30.0	18.4	60.0	13.4	58.7	14.0	48.7	17.0	23.7	0.6		

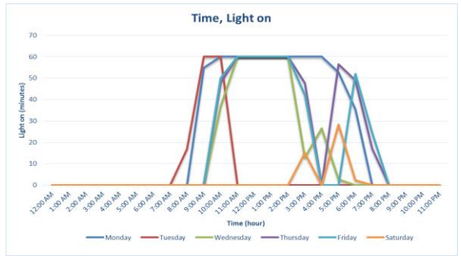
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	15	0	0	0	0	0	5	0	0	0	0
8:00 AM	13	26	11	13	17	26	0	17	17	27	0	0	1	2
9:00 AM	60	24	60	40	60	48	56	58	60	41	21	0	5	4
10:00 AM	60	27	60	38	60	50	60	37	60	45	60	0	6	3
11:00 AM	60	35	60	29	60	46	60	35	60	32	60	0	6	3
12:00 PM	60	49	60	53	60	30	60	37	60	44	60	0	6	4
1:00 PM	60	42	60	48	60	35	60	31	60	51	60	0	6	3
2:00 PM	60	27	42	45	60	37	60	40	60	39	60	0	6	3
3:00 PM	55	29	50	47	55	37	55	26	55	51	10	0	5	3
4:00 PM	0	32	0	41	0	39	0	25	0	29	0	0	0	3
5:00 PM	0	21	0	31	0	27	0	31	0	9	0	0	0	2
6:00 PM	0	0	0	2	0	7	0	6	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	4	0	5	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	4	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	7.1	5.2	6.7	6.7	7.2	6.4	6.9	5.9	7.2	6.2	5.5	0.0		
Average Use (min/hr)	17.8	13.0	16.8	16.7	18.0	16.1	17.1	14.7	18.0	15.5	13.8	0.0		

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			
Time	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy	Light	Occupancy
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	17	0	0	0	0	0	0	0	0	0	0	0
9:00 AM	55	29	60	2	0	0	0	0	0	0	0	0	2	1
10:00 AM	60	19	60	0	37	0	48	0	50	5	0	0	4	0
11:00 AM	60	8	0	0	60	0	60	0	60	49	0	0	4	1
12:00 PM	60	20	0	0	60	0	60	0	60	60	0	0	4	1
1:00 PM	60	46	0	0	60	0	60	16	60	39	0	0	4	2
2:00 PM	60	46	0	0	60	0	60	29	60	49	0	0	4	2
3:00 PM	60	57	0	0	13	0	48	3	42	14	15	0	3	1
4:00 PM	60	25	0	0	27	2	0	0	0	0	0	0	1	0
5:00 PM	53	17	0	0	3	0	56	40	0	0	28	3	2	1
6:00 PM	36	21	0	0	0	0	49	9	52	37	2	0	2	1
7:00 PM	0	0	0	0	0	0	17	0	24	0	0	0	1	0
8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Use (hrs/d)	9.4	4.8	2.3	0.0	5.3	0.0	7.6	1.6	6.8	4.2	0.8	0.1		
Average Use (min/hr)	23.5	12.0	5.7	0.1	13.3	0.1	19.1	4.0	17.0	10.5	1.9	0.1		

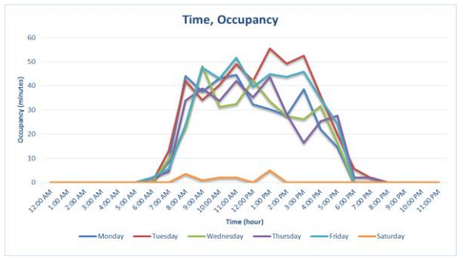
The pattern of lighting use

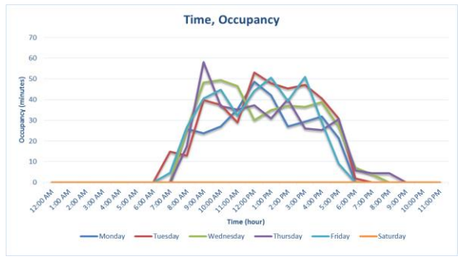


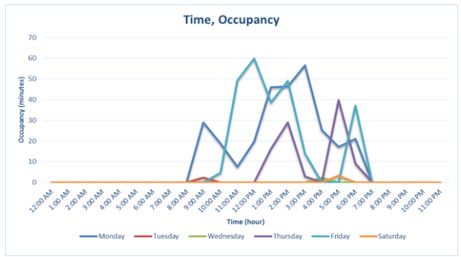




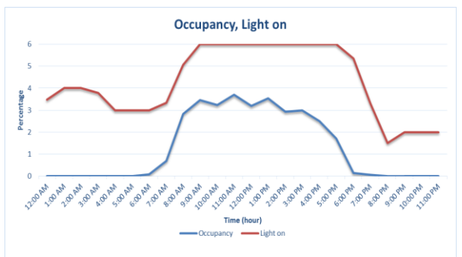
The pattern of occupancy

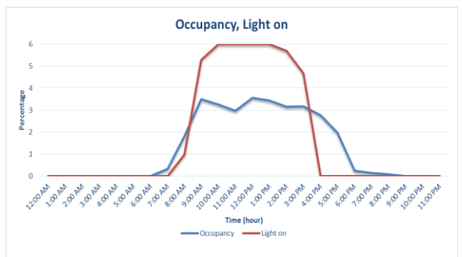


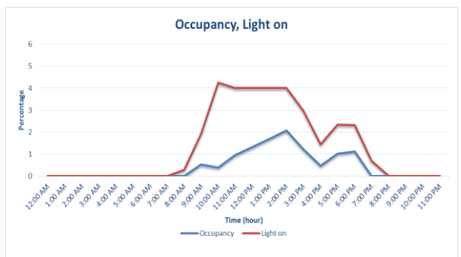




Average percent of daily space &







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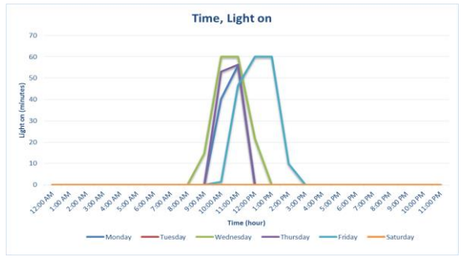
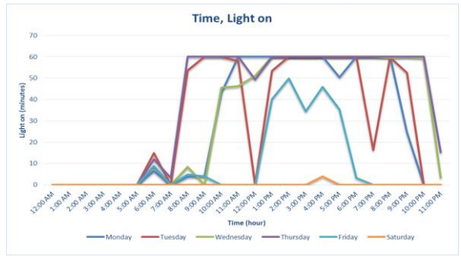
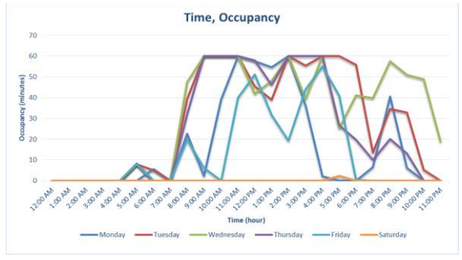
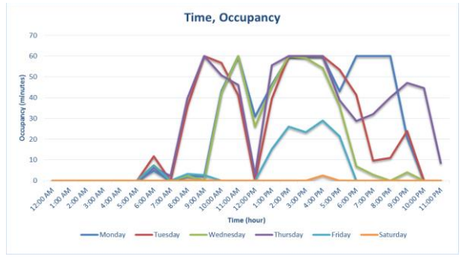
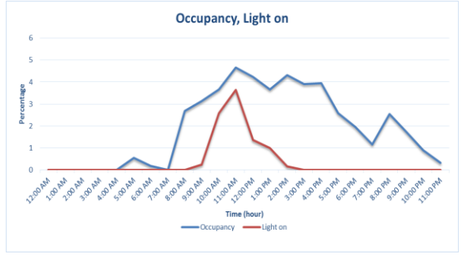
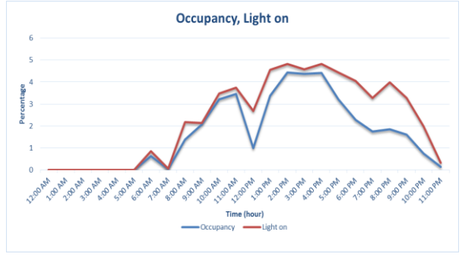
	Classroom 1	Classroom 2
Summary of occupancy & light use		
The pattern of lighting use		
The pattern of occupancy		
Average percent of daily space &		

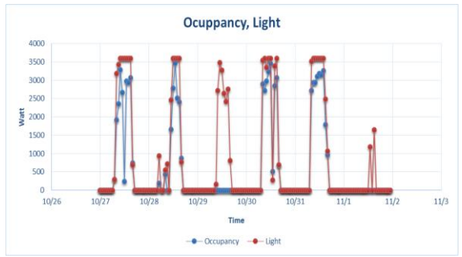
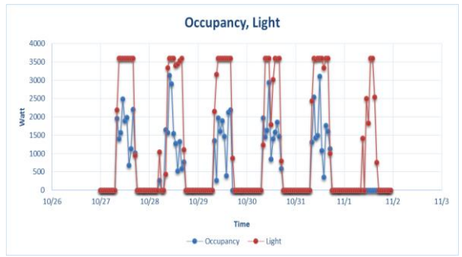
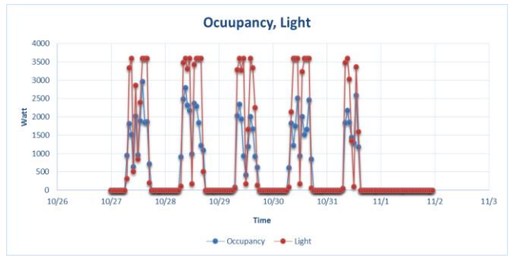
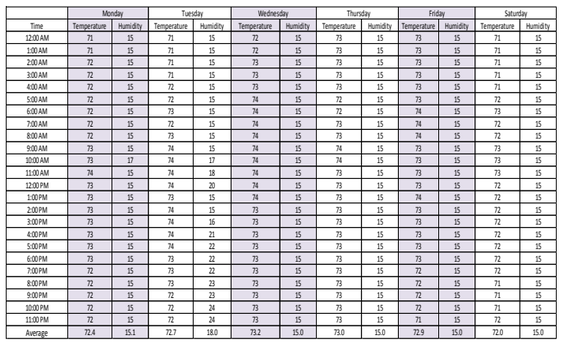
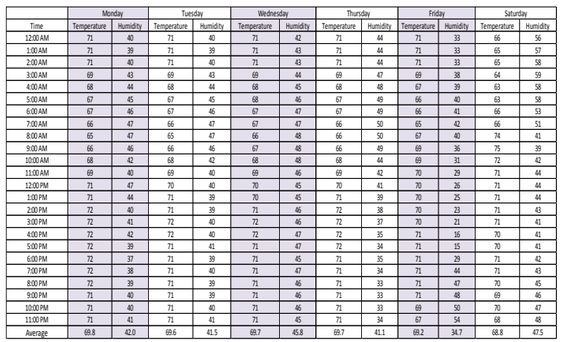
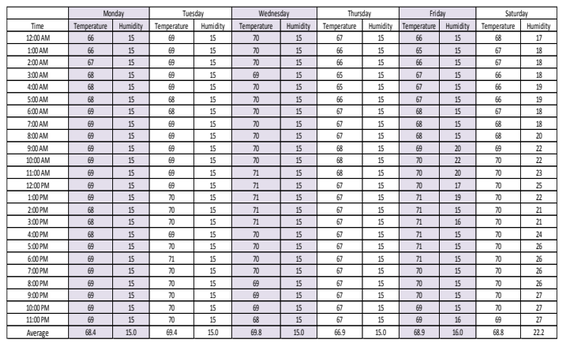
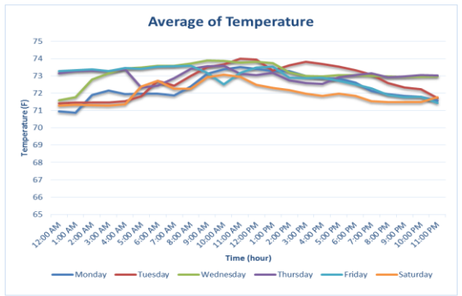
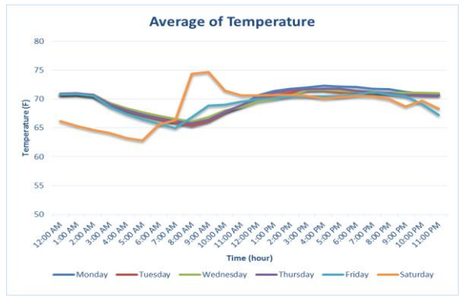
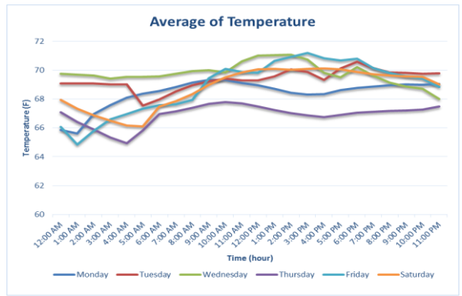
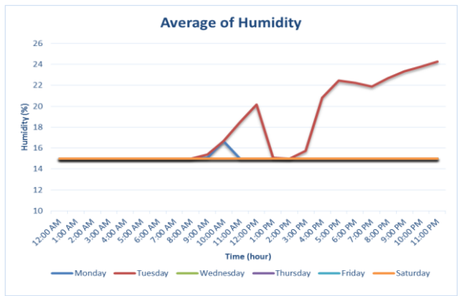
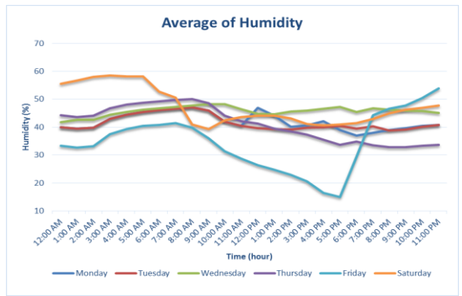
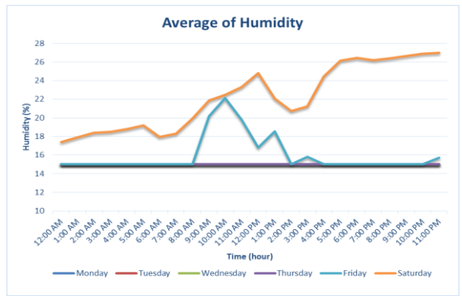
Classroom 1

Time	Monday Light	Monday Occupancy	Tuesday Light	Tuesday Occupancy	Wednesday Light	Wednesday Occupancy	Thursday Light	Thursday Occupancy	Friday Light	Friday Occupancy	Saturday Light	Saturday Occupancy		
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	8	0	8	0	8	0	8	0	0	0	1
6:00 AM	0	6	0	5	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	23	0	39	0	48	0	32	0	20	0	0	0	3
9:00 AM	0	2	0	60	15	60	0	60	0	6	0	0	0	3
10:00 AM	40	39	0	60	60	60	53	60	1	0	0	0	3	4
11:00 AM	56	60	0	60	60	60	56	60	47	40	0	0	4	5
12:00 PM	0	57	0	45	22	42	0	58	60	51	0	0	1	4
1:00 PM	0	55	0	39	0	48	0	46	60	32	0	0	1	4
2:00 PM	0	60	0	60	0	60	0	60	10	19	0	0	0	4
3:00 PM	0	36	0	55	0	39	0	60	0	44	0	0	0	4
4:00 PM	0	2	0	60	0	60	0	60	0	55	0	0	0	4
5:00 PM	0	0	0	60	0	25	0	27	0	41	0	2	0	3
6:00 PM	0	0	0	56	0	41	0	20	0	0	0	0	0	2
7:00 PM	0	7	0	14	0	40	0	10	0	0	0	0	0	1
8:00 PM	0	41	0	35	0	58	0	20	0	0	0	0	0	3
9:00 PM	0	6	0	33	0	51	0	13	0	0	0	0	0	2
10:00 PM	0	0	0	5	0	49	0	0	0	0	0	0	0	1
11:00 PM	0	0	0	0	0	19	0	0	0	0	0	0	0	0
Total Use (hrs/d)	1.6	6.6	0.0	11.6	2.6	12.8	1.8	9.9	3.0	5.3	0.0	0.0		
Average Use (min/hr)	4.0	16.4	0.0	28.9	6.5	32.0	4.6	24.8	7.4	13.2	0.0	0.1		

Classroom 2

Time	Monday Light	Monday Occupancy	Tuesday Light	Tuesday Occupancy	Wednesday Light	Wednesday Occupancy	Thursday Light	Thursday Occupancy	Friday Light	Friday Occupancy	Saturday Light	Saturday Occupancy		
12:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:00 AM	7	5	15	12	9	7	12	6	9	7	0	0	1	1
7:00 AM	0	0	0	0	0	0	3	2	0	0	0	0	0	0
8:00 AM	4	2	54	36	8	2	60	40	5	3	0	0	2	1
9:00 AM	4	2	60	60	0	0	60	60	4	3	0	0	2	2
10:00 AM	43	43	60	57	46	42	60	51	0	0	0	0	3	3
11:00 AM	60	60	58	41	46	60	60	46	0	0	0	0	4	3
12:00 PM	60	31	0	0	51	26	49	3	0	0	0	0	3	1
1:00 PM	60	46	53	40	60	45	60	56	40	15	0	0	5	3
2:00 PM	60	60	60	60	60	60	60	60	50	26	0	0	5	4
3:00 PM	60	60	60	60	60	59	60	60	34	23	0	0	5	4
4:00 PM	60	60	60	60	60	54	60	60	46	29	4	2	5	4
5:00 PM	50	43	60	54	60	36	60	39	35	21	0	0	4	3
6:00 PM	60	60	60	41	60	7	60	29	3	0	0	0	4	2
7:00 PM	60	60	16	10	60	3	60	32	0	0	0	0	3	2
8:00 PM	60	60	60	11	60	0	60	40	0	0	0	0	4	2
9:00 PM	25	21	52	24	60	4	60	47	0	0	0	0	3	2
10:00 PM	0	0	0	0	59	0	60	45	0	0	0	0	2	1
11:00 PM	0	0	0	0	4	0	15	8	0	0	0	0	0	0
Total Use (hrs/d)	11.2	10.2	12.1	9.4	12.7	6.8	15.3	11.4	3.8	2.1	0.1	0.0		
Average Use (min/hr)	28.0	25.5	30.3	23.5	31.8	17.0	38.3	28.5	9.4	5.3	0.2	0.1		

DEMPSEY HALL

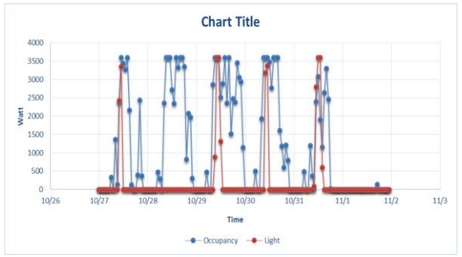
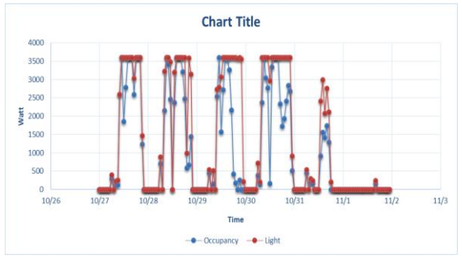
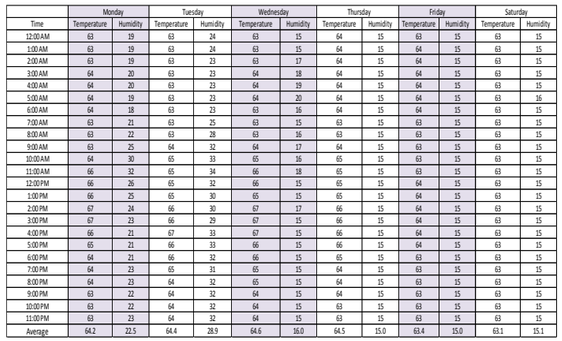
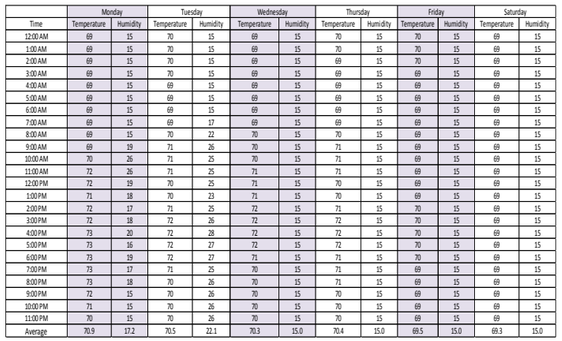
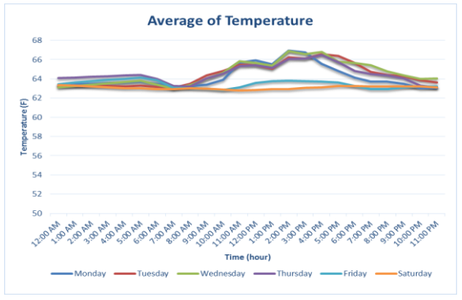
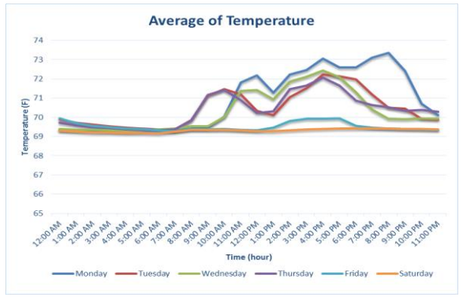
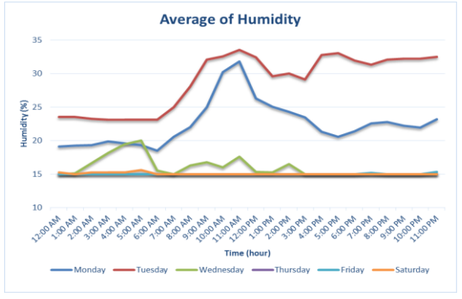
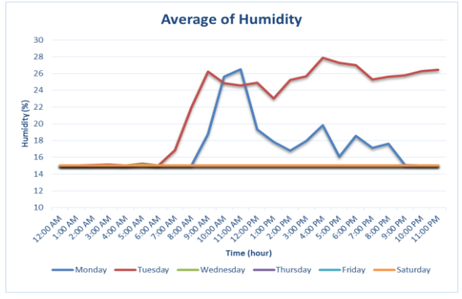
	Staff Office 1	Staff Office 2	Staff Office 3
Comparison of occupancy & light on			
Summary of room temperature			
Average room temperature			
Average room humidity			

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	71	15	71	15	72	15	73	15	73	15	71	15
1:00 AM	71	15	71	15	72	15	73	15	73	15	71	15
2:00 AM	72	15	71	15	73	15	73	15	73	15	71	15
3:00 AM	72	15	71	15	73	15	73	15	73	15	71	15
4:00 AM	72	15	72	15	73	15	73	15	73	15	71	15
5:00 AM	72	15	72	15	74	15	72	15	73	15	72	15
6:00 AM	72	15	73	15	74	15	72	15	74	15	73	15
7:00 AM	72	15	72	15	74	15	73	15	74	15	72	15
8:00 AM	72	15	73	15	74	15	73	15	74	15	72	15
9:00 AM	73	15	74	15	74	15	74	15	73	15	73	15
10:00 AM	73	17	74	17	74	15	74	15	73	15	73	15
11:00 AM	74	15	74	18	74	15	73	15	73	15	73	15
12:00 PM	73	15	74	20	74	15	73	15	73	15	72	15
1:00 PM	73	15	73	15	74	15	73	15	74	15	72	15
2:00 PM	73	15	74	15	73	15	73	15	73	15	72	15
3:00 PM	73	15	74	16	73	15	73	15	73	15	72	15
4:00 PM	73	15	74	21	73	15	73	15	73	15	72	15
5:00 PM	73	15	74	22	73	15	73	15	73	15	72	15
6:00 PM	73	15	73	22	73	15	73	15	73	15	72	15
7:00 PM	72	15	73	22	73	15	73	15	72	15	72	15
8:00 PM	72	15	73	23	73	15	73	15	72	15	71	15
9:00 PM	72	15	72	23	73	15	73	15	72	15	71	15
10:00 PM	72	15	72	24	73	15	73	15	72	15	71	15
11:00 PM	72	15	72	24	73	15	73	15	73	15	72	15
Average	72.4	15.1	72.7	18.0	73.2	15.0	73.0	15.0	72.9	15.0	72.0	15.0

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	71	40	71	40	71	42	71	44	71	33	66	56
1:00 AM	71	39	71	39	71	43	71	44	71	33	65	57
2:00 AM	71	40	71	40	71	43	71	44	71	33	65	58
3:00 AM	69	43	69	43	69	44	69	47	69	38	64	59
4:00 AM	68	44	68	44	68	45	68	48	67	39	63	58
5:00 AM	67	45	67	45	68	46	67	49	66	40	63	58
6:00 AM	67	46	67	46	67	47	67	49	66	41	66	53
7:00 AM	66	47	66	47	67	47	66	50	65	42	66	51
8:00 AM	65	47	65	47	66	48	66	50	67	40	74	41
9:00 AM	66	46	66	46	67	48	66	49	69	36	75	39
10:00 AM	68	42	68	42	68	48	68	44	69	31	72	42
11:00 AM	69	40	69	40	69	46	69	42	70	29	71	44
12:00 PM	71	47	70	40	70	45	70	41	70	26	71	44
1:00 PM	71	44	71	39	70	45	71	39	70	25	71	44
2:00 PM	72	40	71	39	71	46	72	38	70	23	71	43
3:00 PM	72	41	72	40	72	46	72	37	70	21	71	41
4:00 PM	72	42	72	40	72	47	72	35	71	16	70	41
5:00 PM	72	39	71	41	71	47	72	34	71	15	70	41
6:00 PM	72	37	71	39	71	45	71	35	71	29	71	42
7:00 PM	72	38	71	40	71	47	71	34	71	44	71	43
8:00 PM	72	39	71	39	71	46	71	33	71	47	70	45
9:00 PM	71	40	71	39	71	46	71	33	71	48	69	46
10:00 PM	71	40	71	40	71	46	71	33	69	50	70	47
11:00 PM	71	41	71	41	71	45	71	34	67	54	68	48
Average	69.8	42.0	69.6	41.5	69.7	45.8	69.7	41.1	69.2	34.7	68.8	47.5

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	66	15	69	15	70	15	67	15	66	15	68	17
1:00 AM	66	15	69	15	70	15	66	15	65	15	67	18
2:00 AM	67	15	69	15	70	15	66	15	66	15	67	18
3:00 AM	68	15	69	15	69	15	65	15	67	15	66	18
4:00 AM	68	15	69	15	70	15	65	15	67	15	66	19
5:00 AM	68	15	68	15	70	15	66	15	67	15	66	19
6:00 AM	69	15	68	15	70	15	67	15	68	15	67	18
7:00 AM	69	15	69	15	70	15	67	15	68	15	68	18
8:00 AM	69	15	69	15	70	15	67	15	68	15	68	20
9:00 AM	69	15	69	15	70	15	68	15	69	20	69	22
10:00 AM	69	15	69	15	70	15	68	15	70	22	70	22
11:00 AM	69	15	69	15	71	15	68	15	70	20	70	23
12:00 PM	69	15	69	15	71	15	67	15	70	17	70	25
1:00 PM	69	15	70	15	71	15	67	15	71	19	70	22
2:00 PM	68	15	70	15	71	15	67	15	71	15	70	21
3:00 PM	68	15	70	15	71	15	67	15	71	16	70	21
4:00 PM	68	15	69	15	70	15	67	15	71	15	70	24
5:00 PM	69	15	70	15	70	15	67	15	71	15	70	26
6:00 PM	69	15	71	15	70	15	67	15	71	15	70	26
7:00 PM	69	15	70	15	70	15	67	15	70	15	70	26
8:00 PM	69	15	70	15	69	15	67	15	70	15	70	26
9:00 PM	69	15	70	15	69	15	67	15	70	15	70	27
10:00 PM	69	15	70	15	69	15	67	15	69	15	70	27
11:00 PM	69	15	70	15	68	15	67	15	69	16	69	27
Average	68.4	15.0	69.4	15.0	69.8	15.0	66.9	15.0	68.9	16.0	68.8	22.2

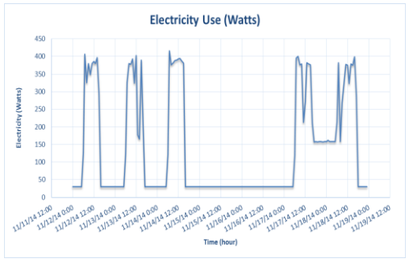
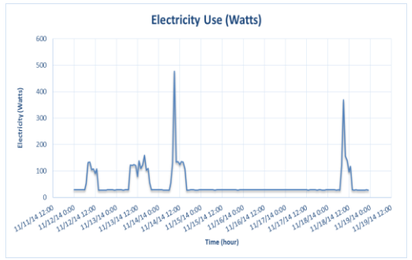
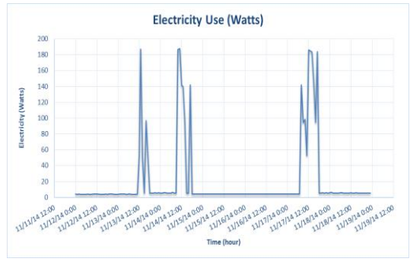
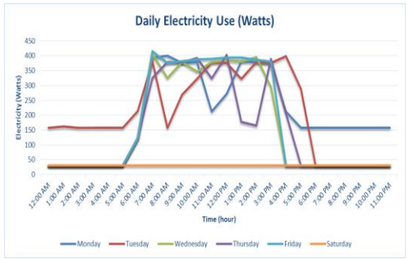
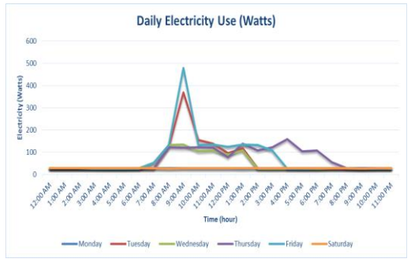
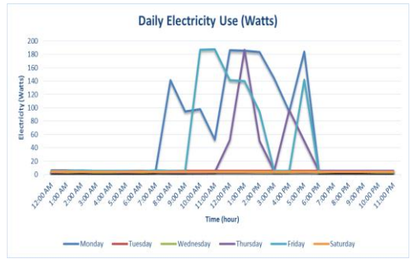
DEMPSEY HALL

	Classroom 1	Classroom 2
Comparison of occupancy & light on		
Summary of room temperature		
Average room temperature		
Average room humidity		

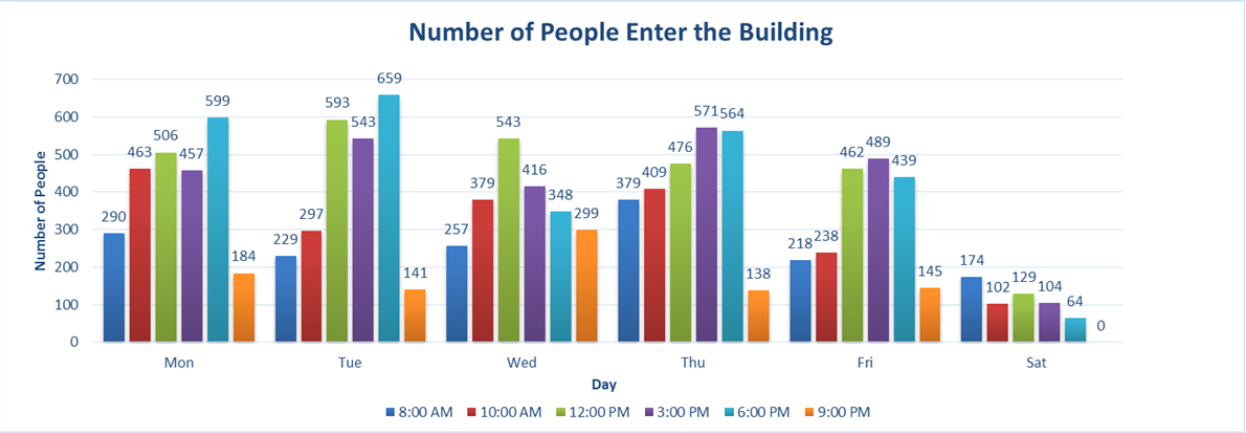
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	63	19	63	24	63	15	64	15	63	15	63	15
1:00 AM	63	19	63	24	63	15	64	15	64	15	63	15
2:00 AM	63	19	63	23	63	17	64	15	64	15	63	15
3:00 AM	64	20	63	23	64	18	64	15	64	15	63	15
4:00 AM	64	20	63	23	64	19	64	15	64	15	63	15
5:00 AM	64	19	63	23	64	20	64	15	64	15	63	16
6:00 AM	64	18	63	23	63	16	64	15	64	15	63	15
7:00 AM	63	21	63	25	63	15	63	15	63	15	63	15
8:00 AM	63	22	63	28	63	16	63	15	63	15	63	15
9:00 AM	63	25	64	32	64	17	64	15	63	15	63	15
10:00 AM	64	30	65	33	65	16	65	15	63	15	63	15
11:00 AM	66	32	65	34	66	18	65	15	63	15	63	15
12:00 PM	66	26	65	32	66	15	65	15	64	15	63	15
1:00 PM	66	25	65	30	65	15	65	15	64	15	63	15
2:00 PM	67	24	66	30	67	17	66	15	64	15	63	15
3:00 PM	67	23	66	29	67	15	66	15	64	15	63	15
4:00 PM	66	21	67	33	67	15	66	15	64	15	63	15
5:00 PM	65	21	66	33	66	15	66	15	64	15	63	15
6:00 PM	64	21	66	32	66	15	65	15	63	15	63	15
7:00 PM	64	23	65	31	65	15	64	15	63	15	63	15
8:00 PM	64	23	64	32	65	15	64	15	63	15	63	15
9:00 PM	63	22	64	32	64	15	64	15	63	15	63	15
10:00 PM	63	22	64	32	64	15	63	15	63	15	63	15
11:00 PM	63	23	64	32	64	15	63	15	63	15	63	15
Average	64.2	22.5	64.4	28.9	64.6	16.0	64.5	15.0	63.4	15.0	63.1	15.1

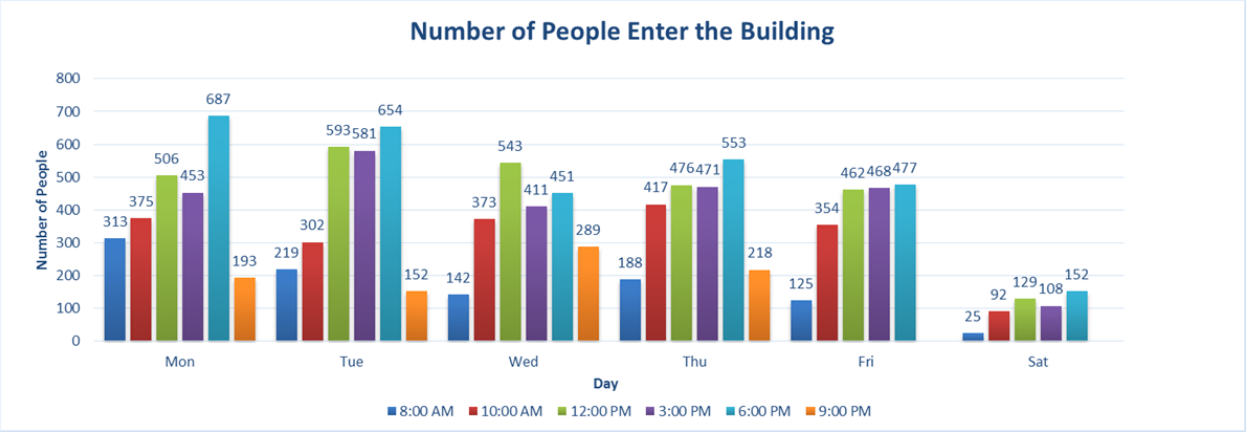
	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Time	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity	Temperature	Humidity
12:00 AM	69	15	70	15	69	15	70	15	70	15	69	15
1:00 AM	69	15	70	15	69	15	70	15	70	15	69	15
2:00 AM	69	15	70	15	69	15	69	15	70	15	69	15
3:00 AM	69	15	70	15	69	15	69	15	69	15	69	15
4:00 AM	69	15	69	15	69	15	69	15	69	15	69	15
5:00 AM	69	15	69	15	69	15	69	15	69	15	69	15
6:00 AM	69	15	69	15	69	15	69	15	69	15	69	15
7:00 AM	69	15	69	17	69	15	69	15	69	15	69	15
8:00 AM	69	15	70	22	70	15	70	15	69	15	69	15
9:00 AM	69	19	71	26	70	15	71	15	69	15	69	15
10:00 AM	70	26	71	25	70	15	71	15	69	15	69	15
11:00 AM	72	26	71	25	71	15	71	15	69	15	69	15
12:00 PM	72	19	70	25	71	15	70	15	69	15	69	15
1:00 PM	71	18	70	23	71	15	70	15	69	15	69	15
2:00 PM	72	17	71	25	72	15	71	15	70	15	69	15
3:00 PM	72	18	72	26	72	15	72	15	70	15	69	15
4:00 PM	73	20	72	28	72	15	72	15	70	15	69	15
5:00 PM	73	16	72	27	72	15	72	15	70	15	69	15
6:00 PM	73	19	72	27	71	15	71	15	70	15	69	15
7:00 PM	73	17	71	25	70	15	71	15	69	15	69	15
8:00 PM	73	18	70	26	70	15	71	15	69	15	69	15
9:00 PM	72	15	70	26	70	15	70	15	69	15	69	15
10:00 PM	71	15	70	26	70	15	70	15	69	15	69	15
11:00 PM	70	15	70	26	70	15	70	15	69	15	69	15
Average	70.9	17.2	70.5	22.1	70.3	15.0	70.4	15.0	69.5	15.0	69.3	15.0

DEMPSEY HALL

	Staff Office 1	Staff Office 2	Staff Office 3
Electricity use			
The pattern of daily electricity use			

Profile of Building Occupancy (People Counters)

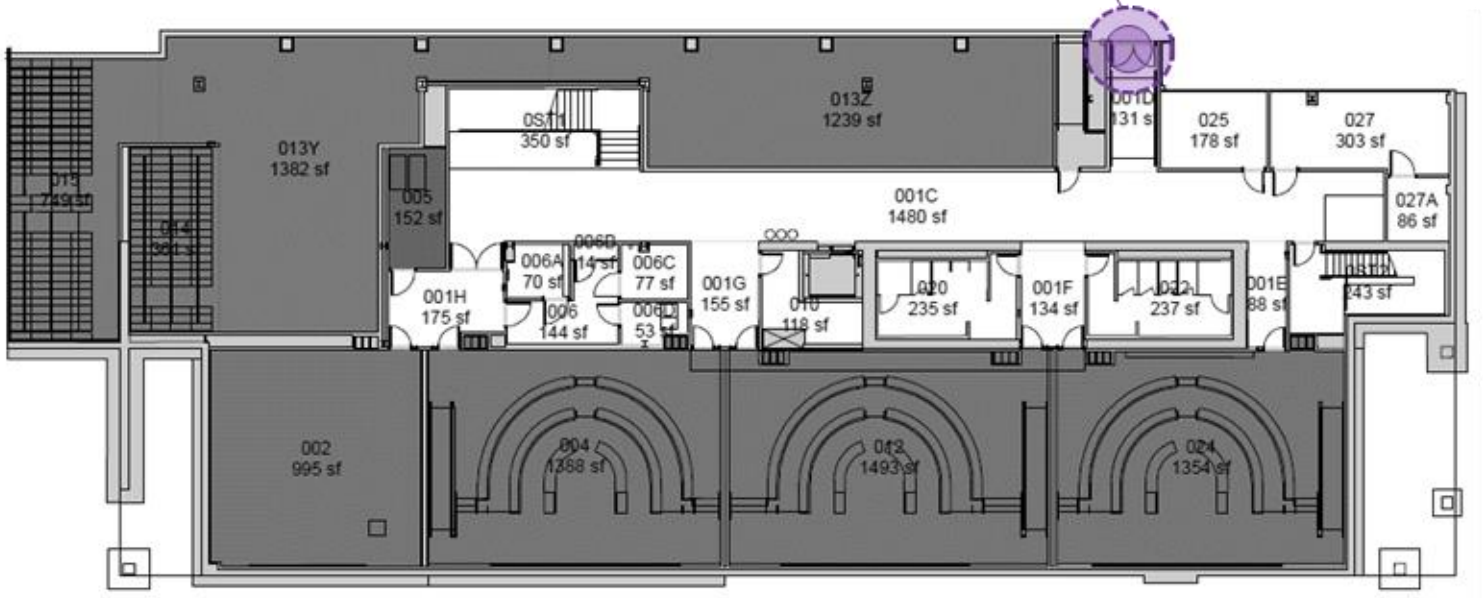




Total Number of People In/Out	
Mon	2499
Tue	2462
Wed	2208
Thu	2474
Fri	2059
Sat	573

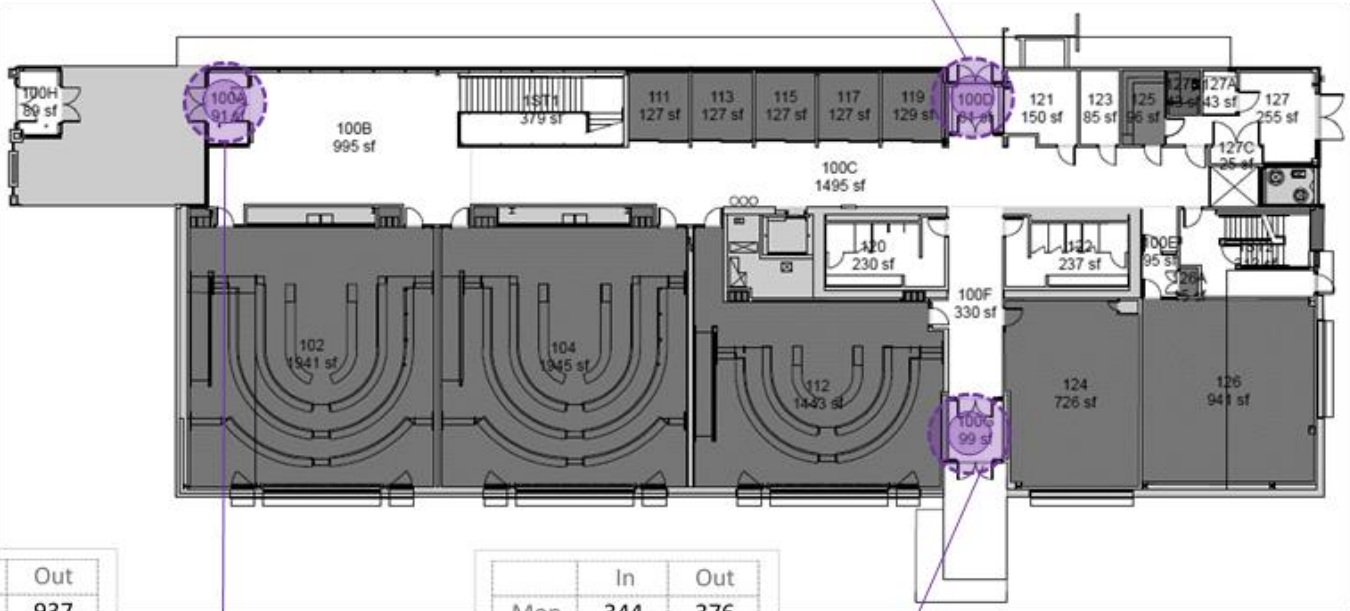
Basement

	In	Out
Mon	156	274
Tue	175	128
Wed	233	162
Thu	197	146
Fri	56	211
Sat	16	36
AVG	163	184



First Floor

	In	Out
Mon	311	334
Tue	505	355
Wed	363	376
Thu	459	328
Fri	250	222
Sat	58	37
AVG	378	323

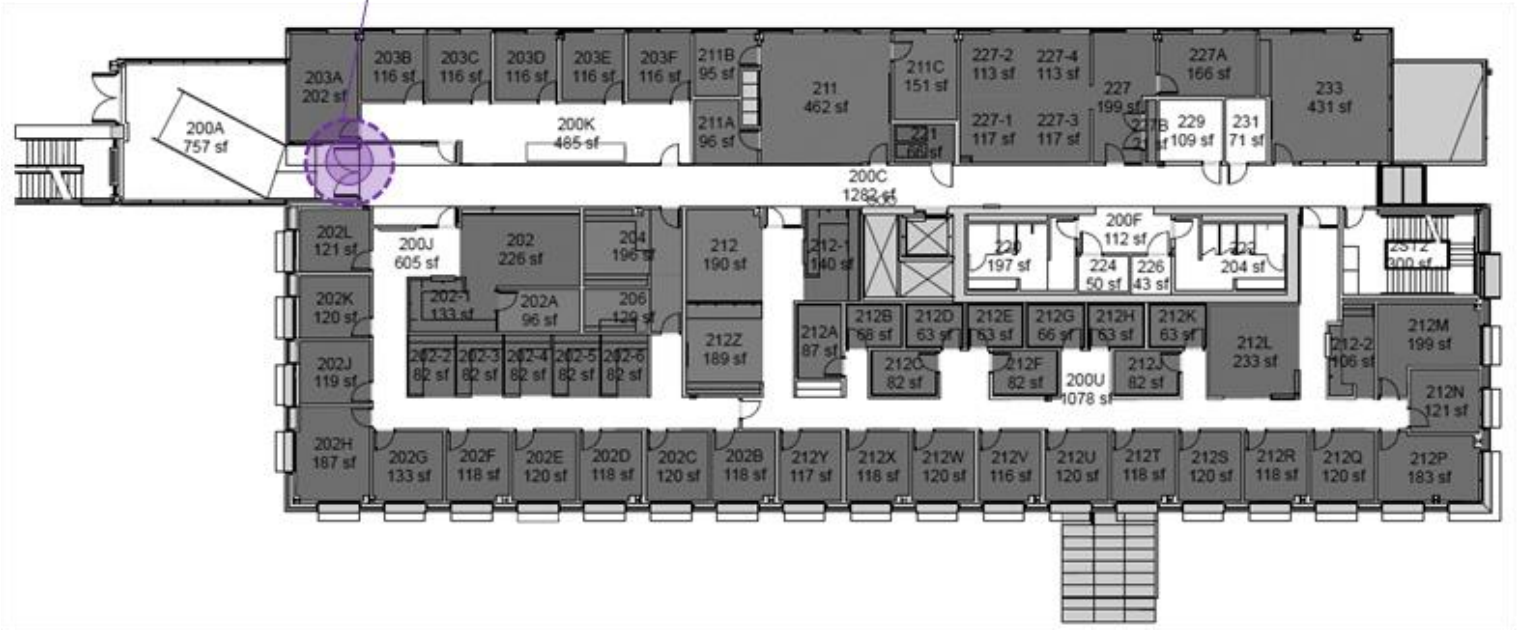


	In	Out
Mon	1080	937
Tue	1129	1287
Wed	966	1060
Thu	1192	1116
Fri	791	665
Sat	124	68
AVG	1031	1012

	In	Out
Mon	344	376
Tue	389	233
Wed	378	267
Thu	229	253
Fri	299	242
Sat	42	49
AVG	328	274

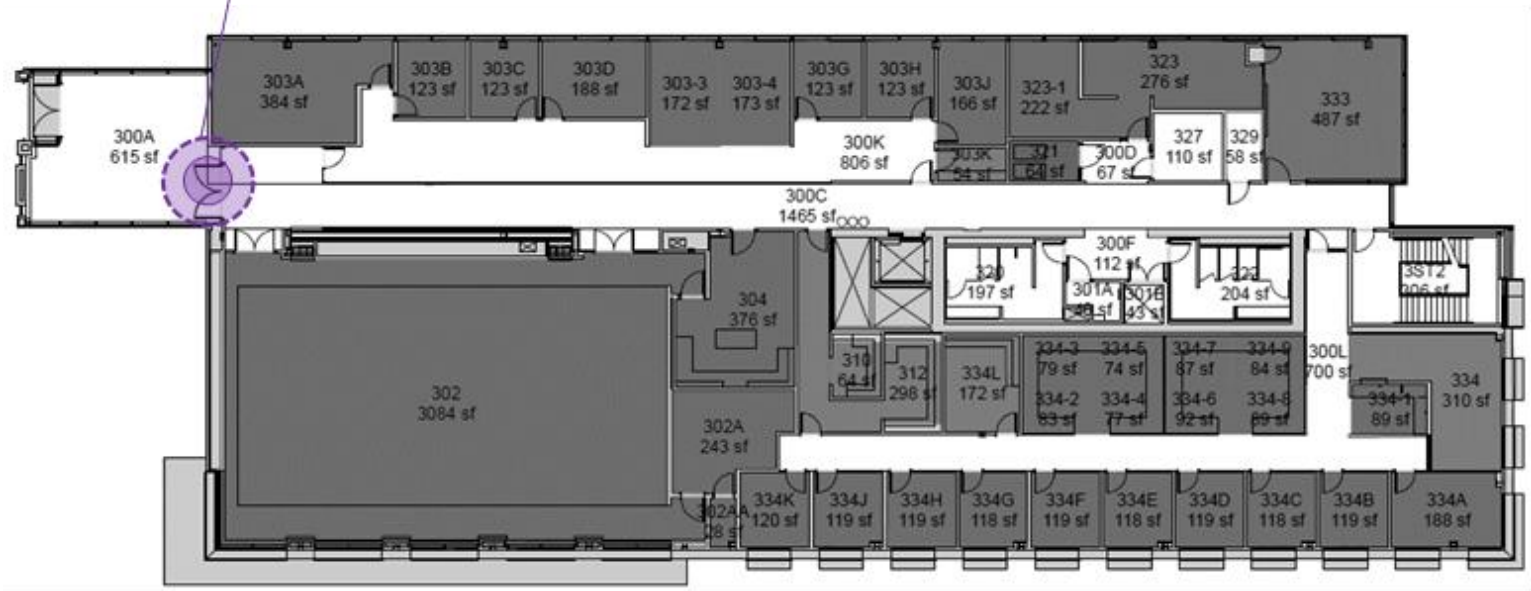
Second Floor

	In	Out
Mon	408	381
Tue	572	489
Wed	361	453
Thu	420	507
Fri	334	376
Sat	54	97
AVG	419	442



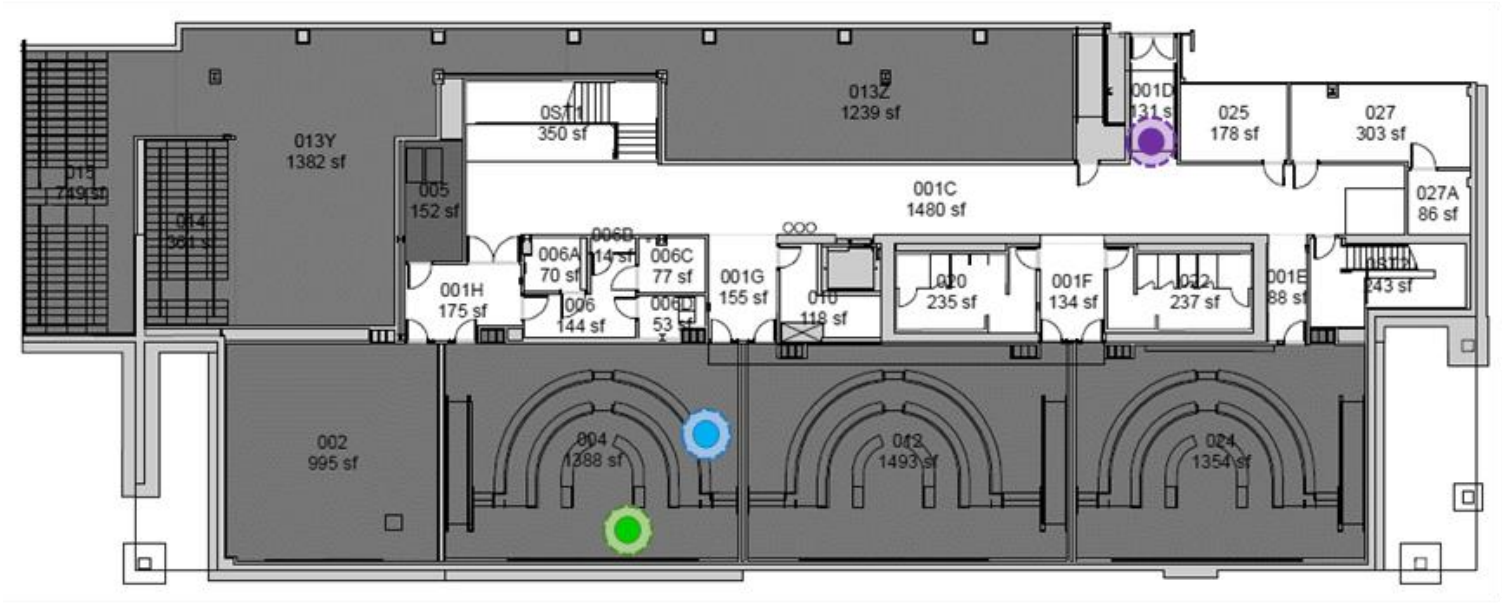
Third Floor

	In	Out
Mon	435	366
Tue	313	427
Wed	342	383
Thu	307	429
Fri	216	403
Sat	38	76
AVG	322	401



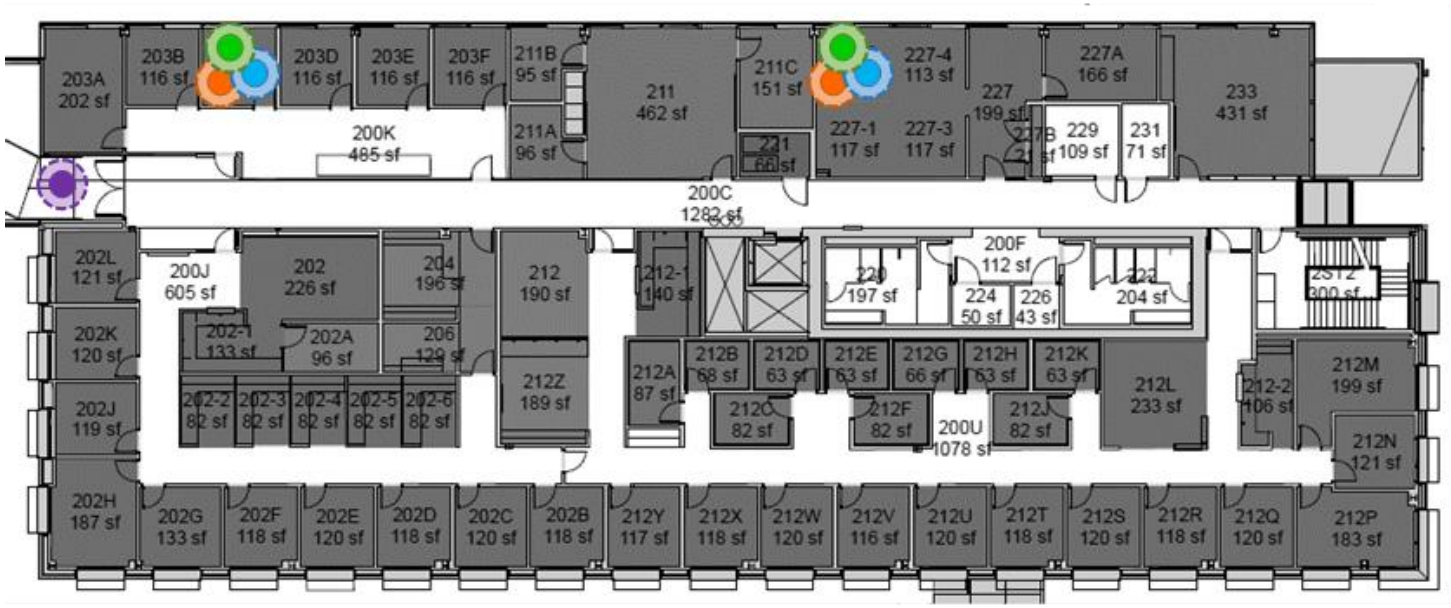
Location of Equipment, Dempsey Hall

HOBO UX90
HOBO UX100
Watts Up Meter
People Counter



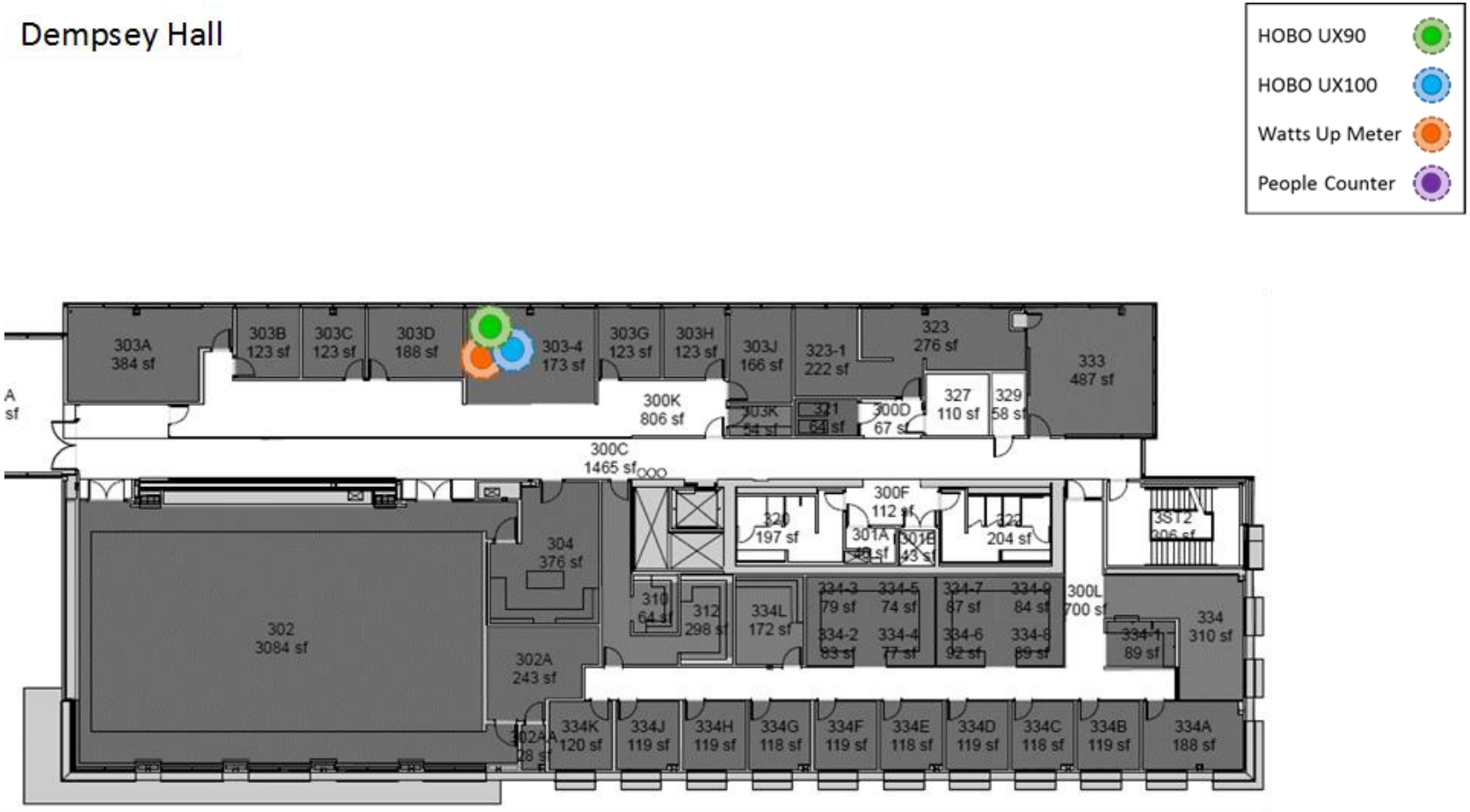
Basement

Dempsey Hall



Second Floor

Dempsey Hall



Third Floor

Appendix V

Building Audit Materials

(Building Managers Handouts, Invitation Letters, Audit Flyer)

GREEN SEED FUND

Dear Building Manager,

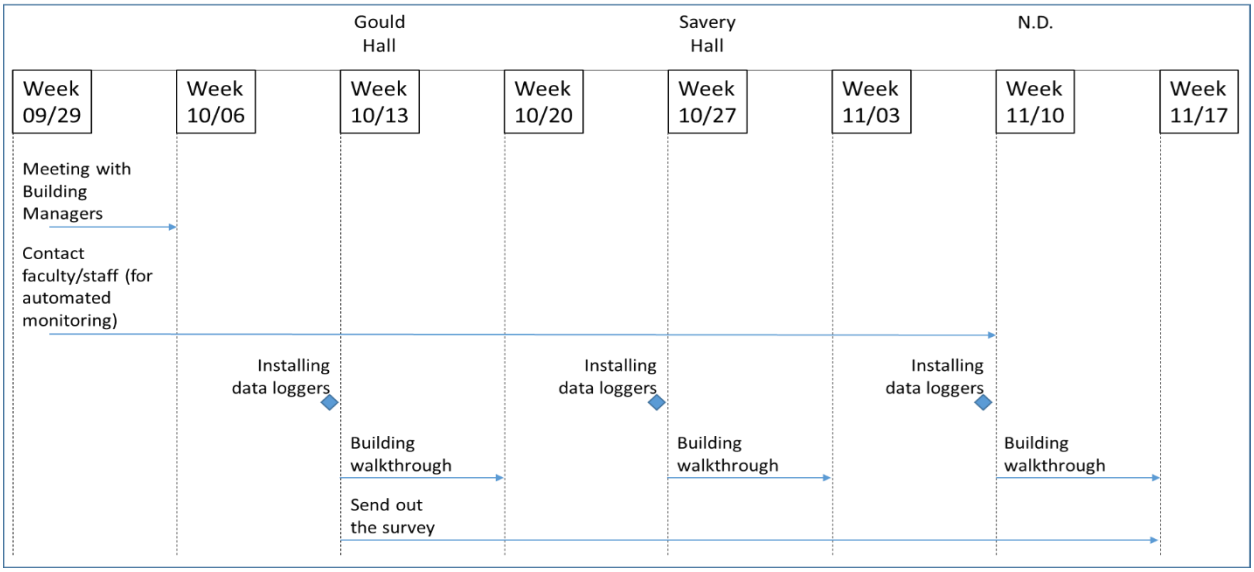
We would like to appreciate for your interest in the "Building Use Audit" project. We believe a strong collaboration and communication between the building managers and research team is necessary for the success of this project. Therefore, we asked for this meeting to share our last achievements with you and discuss the next key times and steps in the project.

Key activities for the "manual observation" and "automated monitoring":

- Facilitating access to the building for observation/auditing (building permit)
- Informing building occupants of the presence of the research team (auditors)
- Contacting faculties & staffs for conducting the automated monitoring (installing data loggers in the selected offices)
- Facilitating access to the selected rooms (faculty/staff/grad. student offices, classrooms, computer labs) for installing the equipment
- Sending the invitation (email) to the building occupants for participating in the survey.

Building audit timeline:

- The building audit will be performed during the October- November 2014.
- The building audit will be conducted 1 week (Mon-Sat) for each building and 6 times per day (8am, 10am, 12pm, 3pm, 6pm, and 9pm).



UW GREEN SEED FUND

Dear Building Faculty;

The University of Washington Green Seed Fund Research Team is developing an energy use audit tool to analyze people's understanding of energy and how their actions affect its use in campus offices, classrooms, and buildings. In the spring of 2014, you were invited to participate in this audit because you were a regular building user in one of the three buildings of interest to the study. In the fall of 2014, the team will be conducting a second round of the survey and the monitoring sessions to fine-tune the audit tool. As in round one, there are two parts to the audit in round two and we hope that you will continue your support of the project and participate in the second and final round.

Part one:
A 10 to 15-minute, 20 question survey on energy use, behavior, and awareness. As a professor and frequent user of Gould Hall, Savery Hall, or Dempsey Hall we would appreciate your participation in this anonymous survey.

As of October 14, 2014 students, faulty, and staff will have access to the survey until midnight on November 24, 2014. One week before the close of the survey, a reminder notice will be emailed to all users of the subject buildings.
Access URL: https://catalyst.uw.edu/webq/survey/jak33/250029

Please direct any questions with regard to the survey to Julie Kriegh, College of the Built Environments, at jak33@u.washington.edu

Part two:
A session on monitoring and direct observation of energy use in classrooms, offices and general building areas will be conducted over several days during fall quarter 2014. Because faculty offices are not accessible without permission, we are reaching out to specific faculty who may be supportive of our project and wish to contribute to the development of the user behavior energy audit tool by allowing our team to monitor energy use in their offices.

We hope that you will accept our invitation to participate in this study by taking the survey and allowing energy monitoring of your office. This monitoring consists of installing a light monitor and a watts meter to evaluate power usage. The monitoring will also involve a checklist of equipment being used in the office, such as, printer, computers, lights, and fans or heaters.

Please let us know if you are willing to participate and our field manager will contact you directly to answer questions and set up an appointment to install monitors. **At that time, we will ask you to sign a consent form to verify your permission**. Please direct any questions with regard to the field monitoring to Alireza Borhani, College of the Built Environments, at a.borhani@yahoo.com. Thank you for your support of the UW Green Seed People + Energy Audit project, we look forward to your participation.

Green Seed Team
Alireza Borhani, CBE field manager Julie Kriegh, CBE survey development

UW GREEN SEED FUND

Dear Building Faculty, Staff and Students;

The University of Washington Green Seed Fund Research Team is developing an energy use audit tool to analyze people's understanding of energy and how their actions affect its use in campus offices, classrooms, and buildings. In the spring of 2014, you were invited to participate in this audit because you were a regular building user in one of the three buildings of interest to the study. In the fall of 2014, the team will be conducting a second round of the survey and the monitoring sessions to fine-tune the audit tool. As in round one, there are two parts to the audit in round two and we hope that you will continue your support of the project and participate in the second and final round.

Part one:
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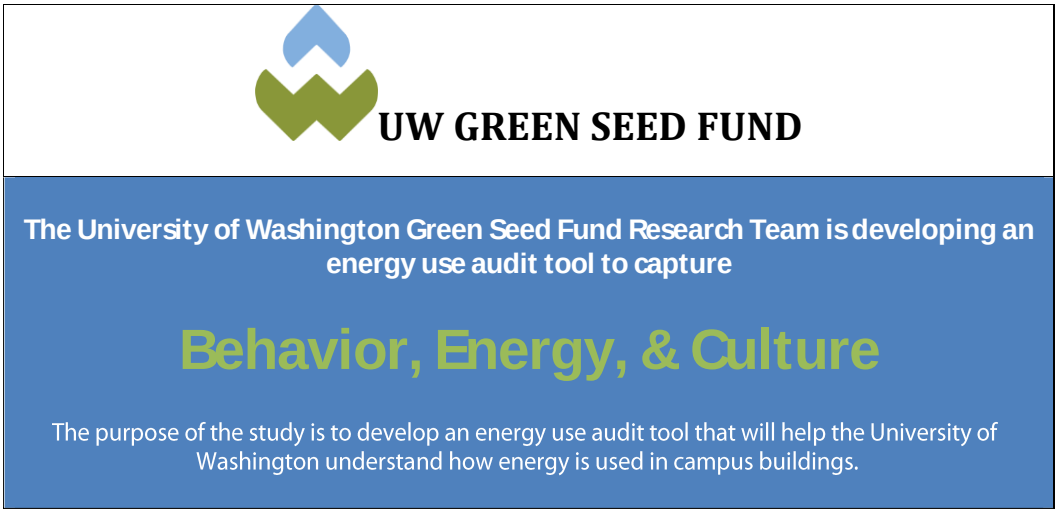
Access URL: https://catalyst.uw.edu/webq/survey/jak33/250029

Please direct any questions with regard to the survey to Julie Kriegh, College of the Built Environments, at jak33@u.washington.edu

Part two:
A session on monitoring and direct observation of energy use in classrooms, offices and general building areas will be conducted over several days during fall quarter 2014. Our team of observers will not interfere with any events, operations, or classroom instruction. They will be completing a checklist of energy use behaviors such as plugging in computers, printers, or cell phones as well as counting the number of occupants in the public areas and classrooms being observed. Please direct any questions with regard to the field monitoring to our field manager, Alireza Borhani, College of the Built Environments, at a.borhani@yahoo.com

Thank you for your support of the UW Green Seed People + Energy Audit project, we look forward to your participation.

Best regards,
Alireza Borhani, CBE field manager
Julie Kriegh, CBE survey development



Fall 2014 Energy Use Survey

As a frequent user of Gould Hall, Savery Hall, or Dempsey Hall we would appreciate your participation in an anonymous, 10 to 15-minute survey. The survey was first offered in the spring of 2014. It has undergone some changes to streamline the instrument and we would like to invite you to take the survey for the first time or a second time in the fall of 2014. Please take a few minutes to complete the survey online at URL: https://catalyst.uw.edu/webq/survey/jak33/250029

Fall 2014 Energy Use Monitoring

A session on monitoring and direct observation of energy use in classrooms, offices and general building areas will be conducted over several days during fall quarter 2014. Our team of observers will not interfere with any events, operations, or classroom instruction. They will be completing a checklist of energy use behaviors, such as plugging in computers, printers, or cell phones as well as counting the number of occupants in the public areas and classrooms being observed.

Please direct any questions with regard to the field monitoring to our field manager Alireza Borhani, College of the Built Environments, at a.borhani@yahoo.com and questions with regard to the survey to our survey developer, Julie Kriegh, College of the Built Environments, at jak33@u.washington.edu