Energize Worcester Phase II

Analysis of Consumer Energy Behavior in Homes of Multiple Occupancy near the University of Worcester

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Abstract

Our project focused on student and landlord opinions about and behaviors towards heat use in student homes of multiple occupancy (HMOs) in the St. John's Campus of the University of Worcester in Worcester, England. We reconnoitered 350 residences, identified 196 HMOs, and interviewed 40 student tenants. We also interviewed three landlords and a manager of student properties at a letting agency. We found that students have limited knowledge of thermostatic controls, energy consumption, and utility costs; landlords are much more knowledgeable on these issues and many have retrofitted their properties to make them more energy efficient. We recommend that students be better educated about thermostatic controls and heat use in order to become more energy efficient.

Acknowledgements

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Executive Summary

Energy efficiency and CO_2 emissions within the United Kingdom are largely impacted by the current condition of the housing stock. UK properties are among the least thermally efficient in Western Europe; they are responsible for 28% of UK's total CO_2 emissions each year. In its efforts to reduce energy consumption and CO_2 emissions, the University of Worcester promotes sustainability in its curriculum and operations, and incorporates student programs, such as Energize Worcester, which has earned funding from the National Union of Students (NUS). The NUS, Worcester Student Union, Energize Worcester, and the University of Worcester Office of Sustainability are increasingly focusing on homes of multiple occupancy (HMOs), which are the dominant form of housing for students living off-campus.

The goal of this project was to assist Energize Worcester in determining the most efficient solutions for promoting energy conservation by analyzing consumer behavior regarding thermostatic and boiler controls in HMOs around the University of Worcester. We reconnoitered 350 residences, identified 196 HMOs, and interviewed 40 student tenants and observed the heating systems and conditions in their accommodations. We also interviewed three landlords and a manager of student properties at a letting agency. Based on our interviews and observations we evaluated the attitudes, opinions, and knowledge of students and landlords regarding thermostatic and boiler systems and identified current heating and energy consumption practices and behaviors.

Findings on Students

We received survey responses from 40 second year and third year University of Worcester students living in off-campus accommodations. We found that 20% of students paid for their utilities separately from their rent, while the remainder (80%) pay for heat, electricity, Wi-Fi, and cable as part of the rent they pay their landlord. Of these students who have inclusive bills, we found that about half (48%) have a cap on their heat. This means that if these students exceed the cap (usually based on cost of heating) they have to pay extra. Surprisingly, only 36% of these students knew the amount of their heating cap. We also found that 69% of students

believed that they consciously controlled the heat: 52% solely to save money, 30% to protect the environment, 13% for both environmental reasons and money, and 5% did not specify. However, based on our observational survey, we noticed that out of the twenty thermostats we observed, the thermostats were set between 15°C and above 30°C (with an average temperature of 23.8°C). Fifty five percent of thermostats that we observed were set at or above 20°C, which is normal room temperature.

It is interesting to compare the survey responses to the observational checklist to differentiate students' opinions from their behaviors on their energy consumption. We found that most students who believe they are energy efficient do not actually behave accordingly.

Findings on Landlords

We contacted five landlords and received four responses and conducted a total of three landlord interviews. We contacted two letting agencies and interviewed the manager of student HMOs at one of these. We found that the landlords we talked to were very informed and concerned about the efficiency of the energy consumption in their properties. We did not gather much useful information from the letting agency.

The landlords we interviewed said they did not generally take advantage of government reimbursement programs. The general consensus was that they are not feasible because of the time and effort that they take. However, from the government's perspective there is still an allure for offering incentives, despite this lack of participation. This is because it makes the government appear as if they are actively attempting to improve the housing stock, when, in reality, very few take advantage of the offerings.

As previously mentioned, some students pay an inclusive bill to their landlord, and some pay for heat and utilities separately. Both scenarios produce problems. When students pay their own bills, they generally try to reduce the energy consumption in an effort to save money, which leads to cold homes. This can lead to an increased risk of mold growth, which poses a health risk to tenants and damages the building. However, in most cases, all bills are included in rent because students usually look for all-inclusive rent payments. From the landlord perspective, as

well as a sustainability perspective, this approach presents a few issues, as well. In properties with all-inclusive rent, a trend of a lack of caring and overuse of heat can be observed. This is not an energy efficient practice; students turn the heat up as much as they desire because they are not paying for it. This not only costs the landlord more money, but it also taxes the environment. In either case, the root of the problem is that students do not treat the house as their own, which produces lackluster results.

Nest, Hive, and other similar systems that allow a landlord to control a home's heating over Wi-Fi from anywhere can lead to a greater degree of control over heating, as well as produce data related to energy usage in an HMO. Landlords can enforce a temperature range that the tenants must operate within, but it is illegal to fully restrict a tenant's control of the heating. One landlord commented, "For my liking that's a bit too big brother, I don't want to be that controlling." For this reason, more basic programmable thermostats seem to be ideal for landlords. With these, a landlord can set specific times of the day that the boiler is on and off, as well as the maximum temperature to which the thermostat can be set, which could help limit the amount of heating energy the students use.

Conclusion

Primarily, from our survey responses, we found that 2nd and 3rd year students in the St. John's area are relatively uninformed about energy consumption, as well as thermostatic and boiler controls in their accommodations. By comparing our survey responses and our observations, we found that there is a significant disconnect between students' opinions and their behaviors on energy efficiency. Many students have limited awareness of their own heat usage or of the cost that is associated with it and little understanding of how better to control energy use and expenses. The minority of students who are knowledgeable and mindful of their heat use focus primarily on the monetary impacts rather than the impacts to the environment. It is apparent from our in-home observations and interviews that many landlords in this area put in effort upfront to make homes more energy efficient and overall more livable for students by retrofitting the homes with various upgrades, such as new boilers, windows, and thermostats. Overall, landlords found it most frustrating that student tenants were not

knowledgeable about living independently, using thermostatic controls, paying utility bills, and conserving energy.

Recommendations

Based on our background research and findings, we recommend that various parties (such as the University of Worcester, the National Union of Students (NUS), individual landlords, and landlord associations) develop a coordinated strategy to better educate students and their parents about how to manage energy use in off-campus housing. It is important that students are taught this before they begin living independently. We suggest that:

1. The University of Worcester and the NUS develop educational materials that are:

    a. Distributed to students and parents at the beginning of the academic year;
    b. Made available online and at key locations on campus, such as in student accommodations, the University Accommodations Office, the Pierson Center, Main Reception, and the Student Union; and
    c. Distributed to 2nd and 3rd year students when they move out of university accommodations.
2. The University of Worcester and the NUS develop assistive materials and advice for negotiating with roommates regarding energy consumption and bills.
3. Landlord associations work with landlords to develop materials for posting in rental properties regarding the use of thermostatic controls and boilers and include this information in rental agreements/contracts.
4. Landlords include details about heating caps in rental agreements/contracts and send this information to students and to parents, or whomever is paying the bills.
5. Landlords meet with student tenants at the beginning of the rental period and periodically during the year to review thermostatic controls, boilers, heating caps, and utility payments.
6. The University of Worcester and the NUS continue to research conditions and behaviors regarding energy use in HMOs.

7. Landlords and the University of Worcester continue to explore uses of new technologies (such as smart meters, and Hive and Nest thermostats) in better controlling energy in HMOs.

We also have recommendations for future Energize Worcester projects. We recommend that the next project group use the "University Accredited Rental Properties" database that we have updated, expand beyond the original eight zones on the Student House Zones map, interview more landlords in the area within their rental properties, as well as interview the head of the local Landlords Association to gain insight on the opinions of landlords as a whole. We also recommend that the students conduct an online survey to supplement house visits (if the project entails this), and that the students further test the iPad Phase One software and try to upload the results of this to the University of Worcester's GIS software.

Through these recommendations, we aim to alter student opinions and attitudes towards energy efficiency and improve knowledge and awareness about these issues. By attempting to better educate students, we hope to decrease overall heat usage, lower energy costs for students and landlords, improve student comfort, and reduce environmental impacts.

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Glossary of Terms

Terms	Definitions
CO_2	Carbon Dioxide
DCLG	Department for Communities and Local Government
DECC	Department of Energy and Climate Change
EPC	Energy Performance Certificate
EU	European Union
HMOs	Homes of Multiple Occupancy
NLA	National Landlords Association
NUS	National Union of Students
SAP	Standard Assessment Procedure
UN	United Nations
UK	United Kingdom
UTAUT	United Theory of Acceptance and Use of Technology

Chapter 1. Introduction

The current condition of the housing stock in the UK has a large impact on the energy efficiency and CO_2 emissions of the nation, specifically in homes of multiple occupancy (HMOs). UK properties are among the least thermally efficient in Western Europe. These properties are responsible for 28% of the UK's total CO_2 emissions each year. Under various EU and UN agreements, the UK is committed to reducing its energy use from fossil fuels and cutting carbon emissions by 80% by 2050. The UK is promoting a variety of programs and policies to reach this goal, among them various efforts to reduce energy consumption in housing. Various policies have been tried at the national and local level, but effective policies and programs remain elusive.

In its efforts to contribute to the reduction of energy consumption, the University of Worcester has been promoting sustainability in its curriculum, operations, and facility construction. To work towards this goal, the University of Worcester has created student programs such as Energize Worcester, which have earned funding from the National Union of Students (NUS). A recent report by the NUS found that "half of respondents (52 per cent) reported that they have felt uncomfortably cold in their home and, related to this, 48 per cent felt that their accommodation was poorly insulated and/or draughty." In order to assist Energize Worcester in determining the most efficient solutions for promoting energy conservation this project analyzed consumer behavior regarding thermostat and boiler controls in HMOs around the University of Worcester. HMOs are part of the housing sector that poses a particular problem because of tenant-landlord relations and responsibilities. This problem is called the "split incentive"; if landlords pay the utilities, then the tenants potentially have less incentive to practice energy saving behaviors, while, vice versa, when tenants pay for their utilities, the landlords have less incentive to improve the thermal efficiency of their properties.

We reconnoitered more than 350 houses in the residential neighborhoods within 15 minutes of the St. John's Campus of the University of Worcester in order to identify student-occupied HMOs. We successfully completed in-home inspections and in-person questionnaire surveys in 40 student HMOs between 22 March and 18 April 2016. We also interviewed three landlords and a manager of student HMOs at one letting agency[1]. We used the surveys and interviews to evaluate landlords' and tenants' attitudes, opinions, and behaviors regarding thermostatic and boiler systems in their homes. Based on the data collected, we recommend that students be better educated on thermostatic and boiler controls, energy consumption, paying utility bills, and the connections among these. We also recommend revised methods for more detailed in-home surveys that will be conducted by other student teams in the next winter heating season.

[1] A letting agency facilitates an agreement between a landlord and tenant for the rental of a residential property, essentially a real estate agent for rentals.

Chapter 2. Literature Review

2.1 Introduction

In this section we will discuss Energize Worcester, housing stock, consumer behavior, and policies related to the efficiency of boiler use and thermostatic control. We first detail the history of Energize Worcester and the organizations from which it originated, as well as some of the issues that drove its creation and currently drive its operation. We will then investigate the current condition of UK housing stock and background on energy and heat use. We then discuss the relationship between consumer behaviors and technology and how these relate to conscious actions on heating and boiler control. Finally, we will talk about current energy policies in the UK.

2.2 University of Worcester and Origins of Energize Worcester

The NUS represents over seven million students in the UK and has promoted students' welfare and interests since its inception in 1922 ("University of Worcester's Student Union," 2008). The NUS has had a long interest in promoting environmental stewardship. For example, two ongoing campaigns called "Snap It Off" and "Switch Off" ("SU Sustainability," 2009) are designed to encourage students to 'go green' and use energy responsibly in residence halls and in private accommodations.

With funding from the NUS Students' Green Fund, Energize Worcester was created to provide tips and helpful resources that reduce the overall energy bill of student residences while protecting the environment. The overall mission is to improve and maintain an individual's health, especially during the colder months, while simultaneously saving money and conserving energy. Not only does this program contribute to the University's overall goal of going green by promoting sustainable communities and services, it also allows the students to help spread awareness of energy efficiency and demonstrate their sustainability skills to businesses and employers.

The NUS Students' Green Fund is a program that began as a way to fund projects of individual member unions within the NUS that focus on sustainability and energy consciousness ("About," 2013). The Green Fund helps with 26 student unions on 25 environmentally conscious projects, "ranging from greening student homes, to creating growing spaces on campuses; from up-cycling cafes, to developing sustainable transport for physically disabled students" ("About," 2013). Specifically, the Green Fund has been helping Energize Worcester with substantive funding since 2013.

The efforts of the student union are embedded in the larger efforts to promote environmental sustainability at the University of Worcester. The University has been systematically promoting sustainability in its curriculum, operations, and facility construction. The students, faculty, and staff at the University of Worcester "have worked positively to promote sustainable working and living [environments] by reducing water use, cutting private car journeys, segregating waste streams, including food, re-using and repairing, [and] reducing energy use" ("First Class Sustainable University," 2010). As a result of these efforts, the university has received many accolades and was ranked as the second most environmentally sustainable university out of 151 universities in the 2015 People & Planet University League ("People & Planet University League 2015 Tables," 2015).

The NUS, Worcester Student Union, Energize Worcester, and the University of Worcester Sustainability Office are increasingly focusing on HMOs, which are the dominant form of housing for students living off-campus. In 2013, the NUS conducted a survey of 2,870 student residents in privately rented homes titled, "Homes Fit for Study." The study found that just under 45% of respondents said that their doors and windows were draughty, 48% said they felt that their homes were poorly insulated, and 20% said that their roofs and windows leaked (National Union of Students, 2013). The survey inquired about mold growth, the presence of slugs, mice, or other infestations, and safety hazards including electrical hazards and gas related hazards. A near majority of 47% of residents stated that their homes had mold growth, while 24% reported infestations (National Union of Students, 2013). As a result of poor construction and inadequate heating and ventilation, molds begin to grow in homes; these molds may pose a risk to the health and safety of residents (Fung & Hughson, 2003).

2.3 Housing Stock Condition and Energy Consumption in the UK

The current condition of the housing stock in the UK has a large impact on the energy consumption and CO_2 emissions of the nation. According to the Department of Energy & Climate Change, the two most important factors for heat efficiency of a home are insulation and effectiveness of the heating system, both of which relate to the age of the house (Palmer & Cooper, 2013). Approximately 40% of homes in the current housing stock have been built since 1965, but most are much older; of this 40%, only 13% are considered to be "modern homes" (Palmer & Cooper, 2013). These modern homes are more energy and thermally efficient because they are built to more rigorous standards. For example, in 1976 the Building Regulations made insulation a legal requirement (Dowson, Poole, Harrison, & Susman, 2012). Additionally, most homes are now built using double glazed windows, or windows with two layers of glass with gas in-between, to reduce heat loss from the home ("Double-Glazing Insulation," 2013).

In 1965, Building Regulations were created to regulate new construction; Part L of the Building Regulations addresses energy conservation in both dwellings and non-dwellings ("Planning Portal," 2012). In regard to this, all buildings must undergo a Standard Assessment Procedure (SAP). The SAP is the methodology used by the government to rate a home's energy efficiency and produce an Energy Performance Certificate (EPC) ("SAP Calculations Explained," 2005). The building's EPC contains information pertaining to its property's energy use and associated costs. The SAP is based on the structure of the building (construction process, insulation, etc.), lighting system, heating and hot water system, and renewable technologies used ("SAP Calculations Explained," 2005). The higher the rating is, the lower the operating cost of the building. An EPC is required prior to construction, upon the sale of the building, and upon renting the building (United Kingdom Government, 2013). As evident from Figure 1, a continually growing percentage of new homes receive high SAP ratings and the number of new homes with lower SAP ratings has been reduced significantly (Dowson et al., 2012). This reflects continual changes and improvements to the Building Regulations and shows that Part L of the Building Regulations has had a positive impact on the energy efficiency of

newly constructed dwellings. These SAP ratings also provide a comparison between new homes and older homes, once again displaying the influence of the regulations.

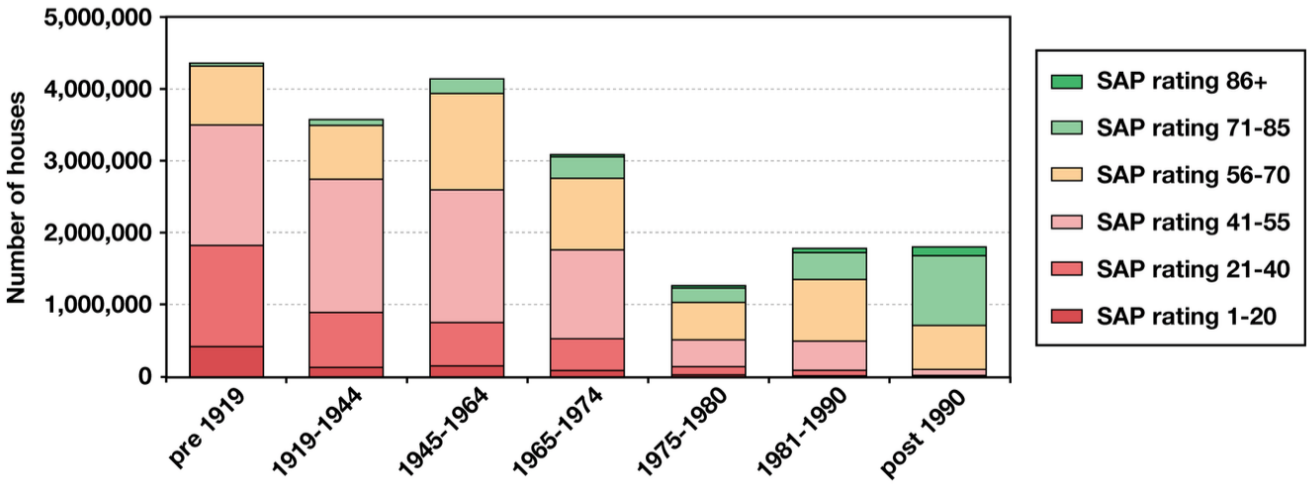

Figure 1: SAP Ratings of Homes

(Dowson et al., 2012)

However, older homes comprise the vast majority of the housing stock, a portion of which even predates the 20th century. These homes are far less efficient than those built to current standards. About 80% of today's homes will still be in use in 2050 (Dowson et al., 2012). For this reason, the retrofitting of older homes is crucial. One of the most common retrofits is to insulate old homes; this increases the thermal efficiency of the home and reduces energy costs. However, there are many challenges to retrofitting existing homes, especially older ones, and it is often difficult and very costly. The industry is not capable of retrofitting all of the homes that need to be retrofitted because there are simply too many (Dowson et al., 2012). Additionally, there is a distinct gap between projected savings and actual savings; one study predicted 49% savings, when in reality savings were less than 20% (Dowson et al., 2012), so the payback periods on investments might be very long.

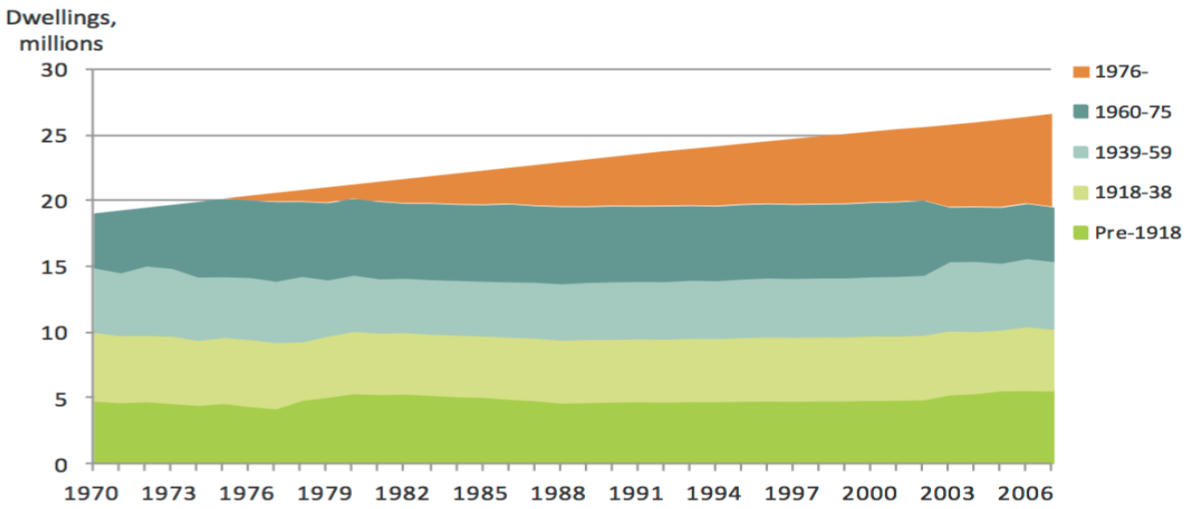

Figure 2: Age of Housing Stock

(Palmer & Cooper, 2013)

In the average UK household, historically and currently, heating accounts for the largest portion of energy consumption (see Figure 2). Currently about 62% of household energy goes towards heating; however, this varies depending on the severity of the winter (Palmer & Cooper, 2013). The past 40 years have only seen a 10% increase in energy required for heating across all residences despite the fact that there has been a 44% increase in total number of residences (Palmer & Cooper, 2013). This reflects improved insulation, as well as heating systems, of modern homes. There has also been an overall reduction in CO_2 emissions, once again, despite the increase in number of residences (Figure 3). This is the product of a switch in source of electricity and a switch to gas for home heating; in the 1990s, electric companies began using natural gas fired power stations, instead of traditional coal fired systems (Palmer & Cooper, 2013). The age of homes, the age of heating systems, and the effectiveness of insulation also directly affect CO_2 emissions. Currently there is on average about 1.75 metric tons of CO_2 released per person in the UK from all energy sources; about 45% of this originates from energy use in homes and buildings (Stafford, Gorse, & Shao, 2011). Additionally, according to Palmer & Cooper (2013), "average CO_2 emissions per household have fallen by nearly half since 1970." This is, again, due to improvements in insulation and heating systems of modern homes, but is also in part due to retrofitting older homes.

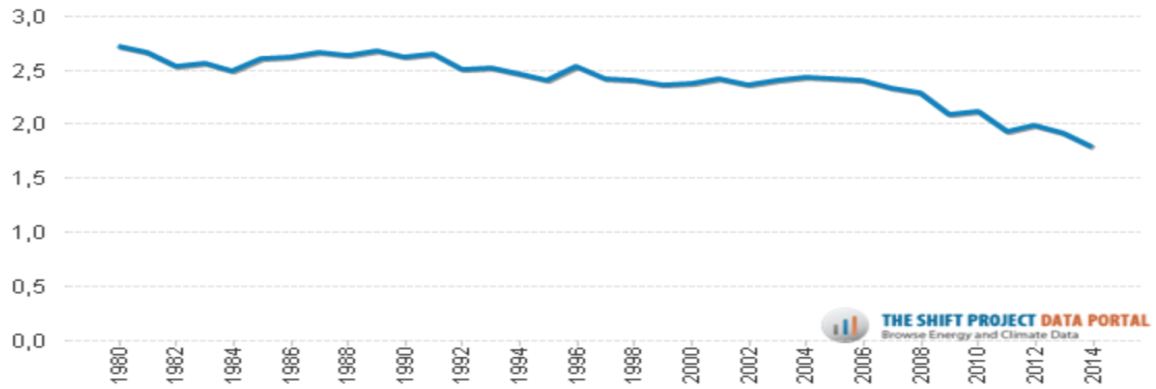

Figure 3: CO2 Emission in the United Kingdom, MtCO2 per million people

(The Shift Project, 2012)

However, despite this reduction in CO_2 emissions, current energy use in homes still accounts for almost one third of the total energy consumption in the UK (Figure 4). The orange line (total energy consumption) represents energy used in homes, transportation, and industry in all forms. This number has increased over the years from about 25% in 1970 (Palmer & Cooper, 2013). These findings relate directly to the mission of Energize Worcester; each statistic identifies an opportunity for improvements to be made to save money, improve health by increasing home temperatures, and protect the environment (Energize Worcester, 2013).

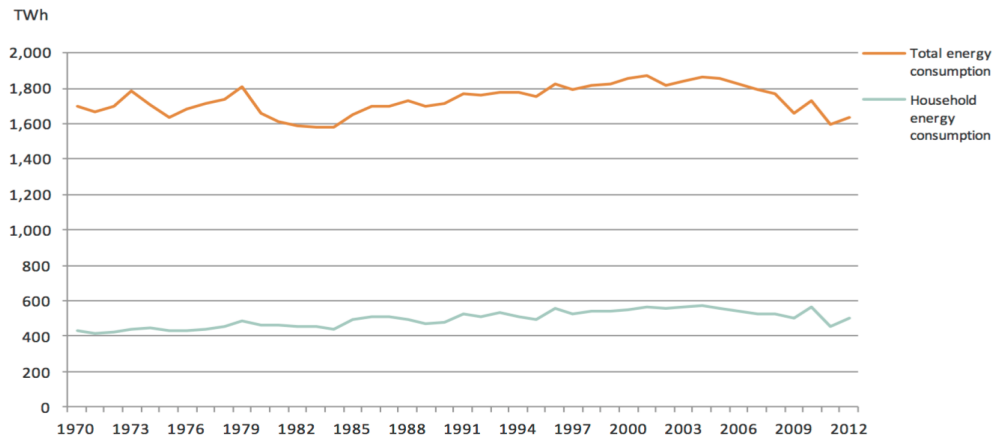

Figure 4: Total Energy Consumption and Energy Consumption of Homes

(Palmer & Cooper, 2013)

Most homes in the UK have central heating, which "allows the households to simultaneously heat all the spaces of their home, [and] is found in 90% of UK homes" (Beizaee, Allinson, Lomas, Foda, and Loveday, 2015). Condensing combination boilers are most common in HMOs. They are gas fired boilers that reuse the waste gas to increase the starting temperature of the incoming fluid before it is actually received by the heating mechanism. This design helps to improve the efficiency and very much reduces the amount of waste harmful to the atmosphere. These are commonly known as "combi" boilers. Of this 90% of UK homes, "nearly one third… have condensing combi gas boilers, which is the fastest growing type of boilers installed in the UK" (Beizaee, Allinson, Lomas, Foda, and Loveday, 2015). These boilers supply on-demand hot water both for radiators to heat the home and hot water for domestic use. The main benefit of these boilers is that a water storage tank is not required so they can easily fit into tight spaces, and the system is cheaper to install.

One approach to increasing the temperature of the house while also conserving energy is to upgrade the boiler. When old boilers fail they are typically replaced with newer, more efficient boilers; "[t]he efficiencies of gas and oil-fired boilers have improved enormously over the past 30 years, from about 65% to over 90%" (Roberts, 2008). Additionally, rental properties must have their boilers annually certified, increasing the rate of identification of issues, thus increasing boiler replacement and reducing strain on the environment (Hamilton, Steadman, Bruhns, Summerfield, and Lowe, 2013). This success is in part due to UK policy changes to implement new, efficient technologies.

2.4 Energy Conservation Approaches: Technical and Behavioral

According to Poortinga, Steg, Vlek, and Wiersma (2003), there are two distinct approaches to reducing energy consumption: behavioral and technical. Technical measures require an individual to implement the use of energy saving technology in order to decrease energy consumption, while behavioral measures require a change in the individual's daily actions towards efficiency in energy usage (Poortinga et al., 2003). For example, many energy conservation programs in the past have encouraged homeowners and renters to turn off lights and adjust thermostats when leaving their homes. Unfortunately, many people refuse or merely

forget to do so on a regular basis. Increasingly, however, technical fixes have been developed to limit the need for such behavioral changes; thus, many energy conservation programs encourage the installation of motion sensitive lights or programmable thermostats (Tang & Bhamra, 2008; Lu, J., Sookoor, T., Srinivasan, V., Gao, G., Holben, B., Stankovic, J., ... & Whitehouse, K., November 2010). Moreover, according to Midden, Kaiser, and McCalley (2007), the efficiency of eco-technologies greatly depends on the way handlers interact with them. In other words, it would be best to implement a combination of these two measures. For instance, smart meters will gather information on household energy use daily and will present it to the user, while providing further energy saving tips. Nonetheless, the ability of a smart meter to affect energy consumption will greatly depend on how well the consumer uses such information and tips. Three energy saving strategies have been drawn out by Poortinga et al. (2003) and grouped in a table (Table 1).

Table 1: Energy Saving Measures and Strategies

(Poortinga, Steg, Vlek and Wiersma, 2003)

Energy Saving Strategies	Technical, Behavioral, both?	Example
Energy Efficiency Improvement of Products	Technical	Glazing of windows
Different use of Products	Behavioral	Manually adjusting thermostat or lighting
Shifts in Consumption	Both	Purchase of less energy-intense products

There are many different technological advancements that can increase the energy efficiency of HMOs. Some of these include: smart meters, efficient boilers, solar power panels, insulation, and newer, more effective windows. Smart technologies are on the forefront of

energy conservation ideas for residential settings. However, technology is not the only factor in reducing energy consumption.

2.5 General Consumer Behavior

Behavioral psychology plays a sizable role in how people react to and use these new technologies. It is possible that people could be against new ideas and technologies for saving energy if they previously had negative experiences with these. Attitudes towards energy consumption may depend on many other parameters, such as: socioeconomic status, category of residence (house, apartment, or condominium), and beliefs about energy consumption (Gadenne, Sharma, Kerr, & Smith, 2011). Many studies have been completed that explore attitudes and behaviors towards new energy saving methods.

In their United Theory of Acceptance and Use of Technology (UTAUT), Venkatesh, Morris, Davis, and Davis, (2003) describe four factors that affect behavioral intentions with regard to use of a technology (Figure 5). People are more likely to adopt a new technology if there is strong social support or pressure (Social Influence), a sufficient support network (Facilitating Conditions), if the technology is believed to be easy to use (Effort Expectancy), and if it performs as expected (Performance Expectancy). Social Influence is the degree that others important to the individual think the system is good to adopt (p. 451). Facilitating Conditions is the degree to which the person believes that there is an ample support network for which they can receive help with use of the system (p.453). Effort Expectancy is related to the belief that the system is easy to use (p. 450). Performance Expectancy is a person's belief that the individual will be more efficient in nature because of the technological system (p. 447).

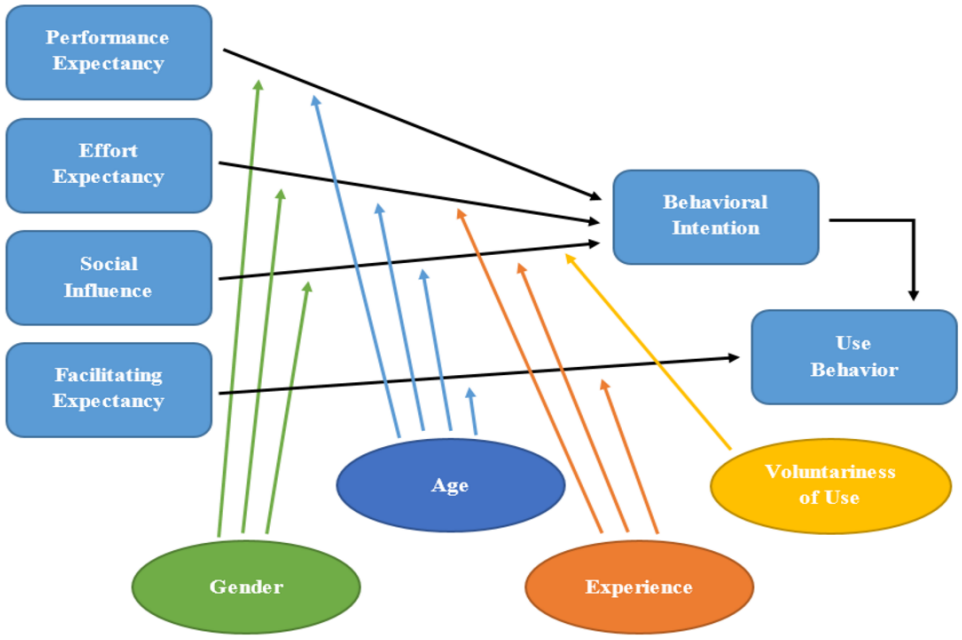

Figure 5: Psychological Constraints to Consumer Behavior

Hedonic Expectancy is heavily related to a consumer's view of a new idea or technology. This behavioral construct is based on the belief that a system will make one's life more enjoyable/interesting (Venkatesh & Brown, 2001). Research has shown that Hedonic Expectancy has an effect on the Behavioral Intentions of a consumer. Other constructs that may affect intentions are the system's Price Value and the consumer's pre-existing Habits (Holbrook & Hirschman, 1982). Consumers are more likely to adopt a system if it is at a low cost to them; however, consumers will pay more for quality (Zeithaml, 1988).

Older consumers tend to experience difficulties in processing newer complex systems. Older consumers will consider the availability of good tech support very important, compared to younger consumers (Hall & Mansfield, 1975). Men tend to be more motivated to spend effort and time to overcome new constraints and difficulties that come with learning a new system. This ideology can be seen as the do it yourself attitude. Women tend to focus on the amount of "…effort involved and the process to achieve their objectives" (Henning & Jardim, 1977; Rotter & Portugal, 1969; Venkatesh & Morris, 2000). Thus, men will end up relying less on a support structure compared to women.

Young men will be more likely to seek novelty and innovativeness in early stages of using new systems (Chau & Hui, 1998). Under social influence, men tend to act more "…independent, cooperative, and make decisions based on selective information and heuristic, while women are more interdependent, cooperative, and consider more details" (Bakan, 1966; Deaux & Kite, 1987). Women tend to be more cost conscious than men, typically being more involved with purchasing and more responsible with money than men (Slama & Taschian, 1985). Men seem to enjoy the idea of "playing" with technologies, and will assign a higher price value than women to products that feature new technologies. The effect of Price Value will be greater on a female's Behavioral Intention than that of a male (Venkatesh & Morris, 2000).

2.6 Consumer Behavior: The Tenant and Landlord Gap

In the multiple occupancy setting, there is a common issue called the "split incentive." This occurs when lack of cooperation between tenants and landlords leads to inefficiency of energy use. When landlords pay the utilities, tenants "have no price incentive to conserve energy" (Levinson & Niemann, 2004), but landlords are more inclined to promote energy saving measures. This is because the amount that tenants have to pay for heat is fixed and does not depend on the amount of heat they use. The study focused on the magnitude of the difference between the "extra energy" used by tenants and the energy saved by landlords in these settings. If a line is drawn at customary energy use, the difference between this and the actual energy consumption of tenants is the "extra energy." This describes the "energy efficiency gap," which is the difference between "customary" and "optimal" energy use (Jaffe & Stavins, 1994). Two questions have been raised in order to facilitate the direction of study in this area: "(1) how much extra energy is used by tenants in these apartments, and (2) what explains the persistence of this seemingly inefficient institution" (Levinson & Niemann, 2004). Levinson and Niemann (2004) concluded that the inefficient energy use of the tenants is marginally offset by the additional energy saved by the actions of landlords to conserve energy. Additionally, "in a perfectly competitive market, landlords will never include heating or cooling costs in rents" (Levinson & Niemann, 2004). However, the housing market near the University of Worcester is in high demand for all-inclusive rent. This is primarily due to convenience for the students as tenants.

In contrast, when tenants pay the heating bills they are more inclined to adopt behaviors that save energy, while the landlords are less likely to accept energy saving measures. In this case, it may become a problem where tenants demand the installation of energy saving technologies in the apartment, because they are not able to make these improvements themselves without authorization of the landlord. A study by Gillingham, Harding and Rapson (2012) showed the opposing incentives between landlords and tenants on two situations regarding energy consumption in the dwelling. The two situations are as follows: "(1) when the landlord (principal) pays the energy bill and cannot influence the choice of energy consumption by the tenant (agent), and (2) when the tenant (principal) cannot perfectly observe the prior choice of insulation by the landlord (agent)" (Gillingham et al., 2012). They concluded that landlords provide little to no incentives in having the exterior walls and ceilings well insulated. Compared to when landlords do not pay for utilities, "tenants of utility-included multi-family dwellings may be limited by the technologies in place in existing buildings and could result in constraints on fuel choice and overall energy efficiency in new buildings" (Maruejols & Young, 2011). Due to this, residences where landlords pay for utilities may be more energy efficient than those otherwise.

2.7 Implementation of Policies

In 2009, the UK government created "The UK Low Carbon Transition Plan" that details the five steps by which the government and citizens, including landlords and tenants of rental properties, can significantly reduce their energy use (Her Majesty's Government, 2009). However, in a study conducted by the Department for Communities and Local Government (DCLG), "[t]he large majority of landlords (92%) were part-time landlords," meaning that their primary income was not from their rental properties (Department for Communities and Local Government, 2011). If a landlord's primary income is not their rental property, then they are less likely to invest in energy efficient systems because "the rewards from refurbishment could be perceived as slim." In fact, "the landlord/tenant dilemma occurs when a landlord and a tenant have difficulties in agreeing upon a common strategy for energy-efficiency improvement of a property" (Hope & Booth, 2014; Ástmarsson, Jensen, & Maslesa, 2013). In this case, incentives from the government or energy companies and educational campaigns might

be useful in order for landlords to make appropriate changes to HMOs. The government has tried technological, social, and monetary incentives.

In order to meet some of these needs, in "The UK Low Carbon Transition Plan," the government has essentially used transparency as a policy. All properties, whether built, sold, or rented, must have an Energy Performance Certificate, which details the amount of energy used, the cost, and advice on how to decrease both (United Kingdom Government, 2013). These EPCs are available to tenants when looking to rent properties, and if landlords do not obtain or show EPCs they can be fined (Her Majesty's Government, 2009; United Kingdom Government, 2013). Furthermore, the government has created a registration system for landlords who comply with energy efficiency practices (Her Majesty's Government, 2009). They have decided to "ensure that all new Government funding for homes built by registered social landlords and other developers is made on the condition that they comply with Rating Level 3 of the Code for Sustainable Homes," essentially socially incentivizing the landlords by allowing them to extend their properties only if they are compliant with energy efficiency (Department of Trade and Industry, 2007).

Additionally, the government has created other incentives to reduce energy consumption. The Green Deal further promotes energy efficiency in homes and businesses using energy efficient technologies and reduction of energy cost as incentives ("Green Deal Initiative About," 2010). It was created using a reimbursement incentive approach in order to diffuse responsibility. This deal allows those who pay for their energy consumption "to get energy efficiency improvements without having to front up the cash" (Department of Energy and Climate Change, 2010). With this deal, the monthly cost of the new technology is supposed to be offset by the money saved through energy efficiency. The Green Deal was implemented because of the UK's overall goal of reducing their carbon footprint by approximately 80% by the year 2050 (Parag, 2009). The issue with energy policy in the UK overall is application and regulation. Even with these new policies in place, it is difficult for the government to implement these policies and analyze whether the policies have actually helped or not. For this reason, our goal for this project is to propose a methodology that assists Energize Worcester in determining

the most efficient technological or habitual solutions for boiler controls based on consumer behavior and habits in HMOs within 15 minutes walking distance of the St. John's Campus.

Chapter 3. Methodology

Our goal for this project is to assist Energize Worcester by identifying strategies that will reduce energy consumption and improve student comfort in HMOs through better use of thermostatic controls and home heating systems. In order to accomplish this goal we established three objectives:

1. Evaluate tenant attitudes, opinions, and beliefs regarding home heating and the use of thermostatic controls in rental properties in the St. John's area of the University of Worcester.
2. Identify current practices and behaviors of heating and energy consumption in student HMOs.
3. Evaluate landlord and letting agent attitudes, opinions, and behaviors regarding home heating and the use of thermostatic controls in rental properties in Worcester.

We conducted in-home surveys with students living off-campus in HMOs (Objective #1). We completed observational checklists to collect information about students' residences and current practices (Objective #2). We conducted in-depth interviews with local landlords and managers of HMOs at letting agents in Worcester (Objective #3).

3.1 Evaluate Tenant Attitudes, Opinions, and Beliefs Regarding Energy Saving

Our first objective was to evaluate the attitudes, opinions, and behaviors of tenants concerning energy saving technologies and habitual approaches. We consulted with our sponsor, Katy Boom, Director of Sustainability, Rachel Drayson at the NUS, and our advisor, Dominic Golding, in an iterative fashion to refine the survey in terms of content, response options, and design. Preceding our survey, we obtained a permission letter from the Worcester City Council, created a protocol for approaching houses, and obtained and amended a map with zones of houses in the WR2 postcode around the St. John's area of the University of Worcester (see Figure 6, Appendices A and B, respectively). Our survey focused in four areas: (1) basic

information about the house; (2) information about energy consumption and billing; (3) information about heating systems; and (4) information about the practice of energy saving behaviors in relation to heating.

After we created the initial survey we performed a trial run to make sure it was clear and easy to follow, and then edited the survey accordingly. Initially we used a paper survey and canvassed a small area around the University of Worcester to try to find student accommodations to test our survey. We successfully tested our survey at three student residences; these were more difficult to find than expected. We also decided that it would be appropriate to include first year students living in HMOs in our research, as this would not impact our pool of potential survey participants in our final survey. From these preliminary participants we were able to determine if the survey was easy to work through, if the questions and response options made sense, and if there were any colloquial phrases that should or should not be incorporated. We wrote and included a preamble for our survey explaining the nature of our research as well as the confidentiality and anonymity of the surveys (see Appendix C). We then revised the survey based on the feedback received. A copy of the final survey script can be found in Appendix D. Results from the entire survey can be found in Appendix E.

Once we finalized our questions, we built the survey online in Qualtrics and downloaded them onto tablets. This allowed us to collect responses offline while we were out in the 'field' without access to the internet. A copy of the first page of the Qualtrics view of our survey can be found in Appendix F. We also created instructions for future projects on how to create surveys in Qualtrics and use them offline on tablets (see Appendix G). We uploaded the survey responses once we returned to our office. Our primary method for collecting responses was canvassing door to door in neighborhoods. Our safety was of the utmost concern during our house visits. We split into two groups of two and knocked on each door of either side of a street. We had a letter which explained the nature of our research and that our research project was sanctioned by the Worcester City Council and the University of Worcester. If the students were wary of our intentions we would present this letter to clarify. When we were canvassing, we made sure that the two groups stayed in the same general vicinity. We also stayed in contact

using our cell phones between house visits to check in on each other. Additionally, we would only enter the residence with express permission from the student(s).

We recorded the status of each home; if it was a non-student residence, if there was no response, or if it was a student residence. We determined that a home was a non-student residence with two different methods, either based on a non-student respondent or based on judgment. In the case of a non-student response, we would apologize for disturbing the residence and move to the next home. In the case of judgment, a number of things stood out to us indicating non-student residents. For example, if there was clear evidence of babies or children in the home (carriage, car seats, children's toys), or if the lawn and home were extremely well cared for, we did not proceed any further with the home.

In the case of no response from a known student residence we would leave a flier with our information which asked them to contact us with a more appropriate time to return and conduct our survey. If the students contacted us we would return on the date and time that they specified. In the case of a student residence we asked if the residents were second or third year students and then, if they were, proceeded to conduct our survey. To preserve anonymity, the survey did not record any personal identifying information about individual respondents. The street address was used as the key identification for all associated data, but the address was not used to identify individual survey responses or in-home observations in any project reports or presentations.

Eventually, we received a database of student HMOs in the area, titled University Accredited Rental Properties, which increased our response rate dramatically. Along with this list we used a map, called Student House Zones, that was developed in a previous University project that displayed a 15 minute walking radius around the campus and split adjacent streets and neighborhoods into eight separate zones. The zones served to help us organize our daily canvassing as well as organize our data. In the map, the number of houses approached can be seen as “Visited” because we believed that these could be student houses, and the number of actual survey responses can be seen as “Surveys” (Figure 6). We used the map to plan our routes within the zones and the database to target known student homes. This saved us time because we

were no longer knocking on every single door within each neighborhood in order to identify those occupied by students. Unfortunately, the database was two years out of date. For this reason, some HMOs that we encountered were no longer student residences, were under renovation, or were vacant; nevertheless, most HMOs identified as student lodgings in the database were actually occupied by students. We updated the database to the best of our ability as we conducted our surveys so the University would have a more current listing of student accommodations around campus. The revised database now includes house number, street address, postcode, number of beds, zone number from the map, and whether we surveyed the house and tenants or were refused entry.

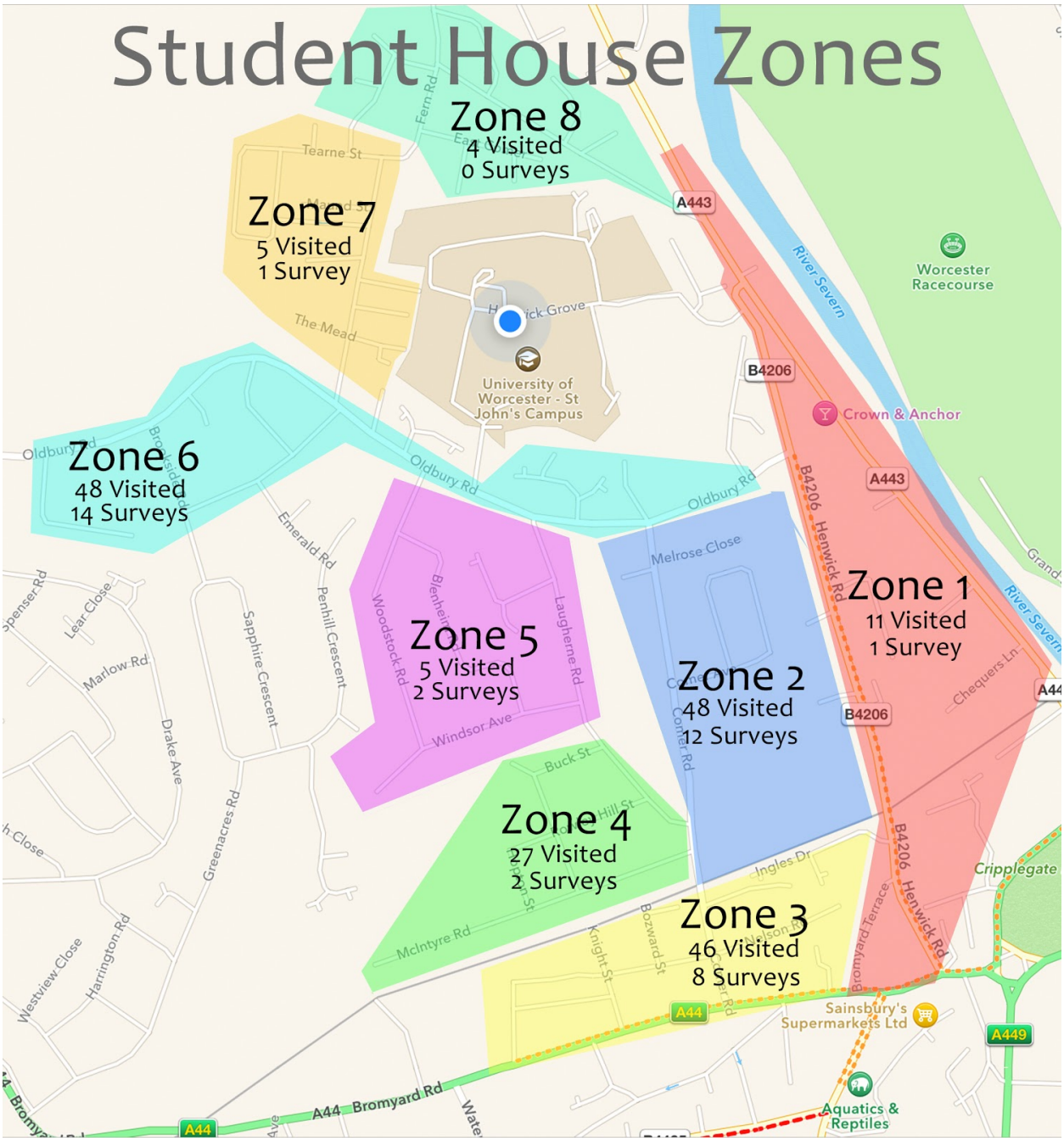

Figure 6: Annotated Zone Map

Following the acquisition of the University Accredited Rental Properties database, we visited 196 homes of multiple occupancy, 121 residents answered the door, 67 of whom were students. Of these 67 students, 40 allowed us to conduct the observational and in-person surveys (see Figure 6). We made an effort to obtain a list of student accommodations in the area from a

number of letting agencies. Our sponsor, Katy Boom, contacted several letting agencies for us requesting their known student accommodations. Although they said they would be willing to give us this information they never followed through, and, after several reminder emails, we abandoned our attempts.

We acquired iPad software called "Phase One Habitat Survey Toolkit," a tool for mapping and collecting environmental data. We planned on using this to collect photographs of boilers and link our survey results to specific addresses, but the software was not capable of including addresses in its map, so we did not use it. Additionally, the resolution of the map was too low to be practical for our project.

3.2 Identify Current Practices and Behaviors of Heating and Energy Consumption in Student Homes of Multiple Occupancy

During our in-home visits, we inquired about the condition of the house, the heating system, and students' habits that could help enhance energy efficiency. Our observations focused in three areas: (1) condition of the interior and exterior of the house; (2) personal attire compared to the temperature inside and outside of the house; and (3) control and settings of heating systems.

We developed a preliminary observational checklist in conjunction with our sponsor and based on previous Energize Worcester projects. We piloted the observational checklist during the initial in-home surveying of HMOs described above. We modified the checklist accordingly in order to ensure that we could collect the data we wanted in the most efficient and effective fashion (see Appendix H). A copy of the Qualtrics version of the observational checklist is in Appendix I. This checklist was not given to students, nor were the questions asked directly to students. One team member per group was designated to complete the observational checklist while the other member conducted the in-home survey. The purpose of the observational checklist was to collect data that we could not directly ask the students. For example, we noted whether the windows were open or closed, how the students' were dressed relative to the temperature that day, and the condition of the home. Additionally, we noted the temperature at

which the thermostat was set to and what type of boiler system was in the home. The final results from our Observational Checklist can be seen in Appendix J. The checklist and survey worked in unison, for example, when the partner conducting the survey inquired about the thermostat and boiler, the other partner would ask the respondent for permission to take a picture (when applicable). By comparing the information we received and the information that we observed we were able to analyze how students' responses to our questions compared to their actions about heat and energy control and conservation.

3.3 Evaluate Landlord and Letting Agencies Attitudes, Opinions, and Behaviors Regarding Heating and Thermostatic Controls

Building on the information from our literature review, we developed a draft of pertinent questions for landlords. We consulted with our sponsor and advisor in an iterative fashion to refine the interview scripts in terms of content, response options, and design. Our questions focused on the knowledge, opinions, and attitudes of landlords and letting agents in three areas: (1) energy saving policies and programs available to landlords; (2) the use of energy saving technologies in HMOs; and (3) landlordss opinions regarding heating, utilities, and student behavior in HMOs.

Our initial step in interviewing landlords was to contact them. In this way, if it took a while to set up an interview, we would have adequate time to actually conduct it. We identified landlords using a list that our sponsor, Katy Boom, had acquired at one of her recent landlord events. The stipulations for our interview were that they be a landlord in the St. John's area. We contacted five landlords via email explaining who we were, the nature of our project, and inquiring if they would be available for an interview (see Appendix K). If they responded, we would proceed by setting up an appropriate time and place to meet to conduct the interview. We then finalized our interview script to prepare for our first interview. The script ultimately became a guideline for the conversation and served to note key discussion points, but was not followed verbatim. Appendix L illustrates the major topic areas we addressed in the landlord interviews along with the questions that we asked. We then conducted interviews in groups of two, one interviewer and one scribe. We decided to only send two group members because we

felt that three or four members might be overwhelming to the interviewee. We received four responses to our emails and were able to conduct three interviews in total. To preserve anonymity, all quotes used from interviews in our reports were presented anonymously.

The letting agency interviews aimed to gather similar information to the landlord interviews. While we were in the field canvassing student houses, we photographed every letting agency sign that we found. We then used Google to look up each letting agency and see where it was located. We used the same interview script for the letting agencies as we did for the landlord interviews. Unlike the landlord interviews, we did not email the letting agencies to set up a time for an interview, instead we went directly to the agency building and asked to speak with the manager of student HMOs directly. We approached two letting agencies and got a response from one. This proved inconclusive for our research.

In this project our objective was to work with Energize Worcester to try to determine the best way to promote energy efficiency through a technological or habitual solution. In Chapter 4 we will discuss our findings from our interviews and surveys with landlords and students. In Chapter 5 we present a conclusion and a set of recommendations to the University of Worcester, NUS, landlords in the area, and future Energize Worcester project teams.

Chapter 4. Findings

In section 4.1, we discuss student thoughts and opinions compared to their behaviors based on our in-home surveys and observations. In Section 4.2, we discuss landlord behaviors and actions regarding heating in their properties.

4.1 Students and Heat Use

We received survey responses from 40 HMOs, 20 of which had second year students and 20 of which had third year students attending the University of Worcester. We explored student opinions based on survey responses, as well as our observations of their behaviors and habits. Through conducting in-home surveys we were able to determine that there is a lack of understanding of the cost and consumption of energy in student HMOs.

Condition of Student Homes of Multiple Occupancy

When conducting student in-home surveys, we were able to record our observations of the condition of the outside and inside of the HMOs. We were invited into the common areas (living rooms, hallways, kitchens, dining areas, and bathrooms) of students' homes to obtain photographs of the houses' boilers and thermostats. Based on our observational checklist we found that 3 student HMOs were built before 1900, 4 were built between 1900-1930, 9 were built between 1930-1950, 12 were built between 1950-1990, 6 were built from 1990-present, and 6 were not specified. Although the houses in this area were built anywhere from 10-120 years ago, all of the student HMOs that we visited were newly retrofitted. All of the boilers that we encountered were relatively new, 64% (16/25) of the thermostats that we were able to observe were digital, the walls were newly painted and well maintained, and there was no evidence of mold or draughty windows. We observed messy accommodations but these were solely due to the habits of the students, not the condition of the building itself. These renovations contribute to the overall energy efficiency of the houses.

However, despite our observation that most houses were newly renovated and in relatively good condition, most HMOs (60%, 24/40) that we surveyed had at least one identified cold area, most frequently a student's bedroom. Some HMOs had more than one cold area. A distribution of the areas in these 24 HMOs can be seen in Figure 7 below.

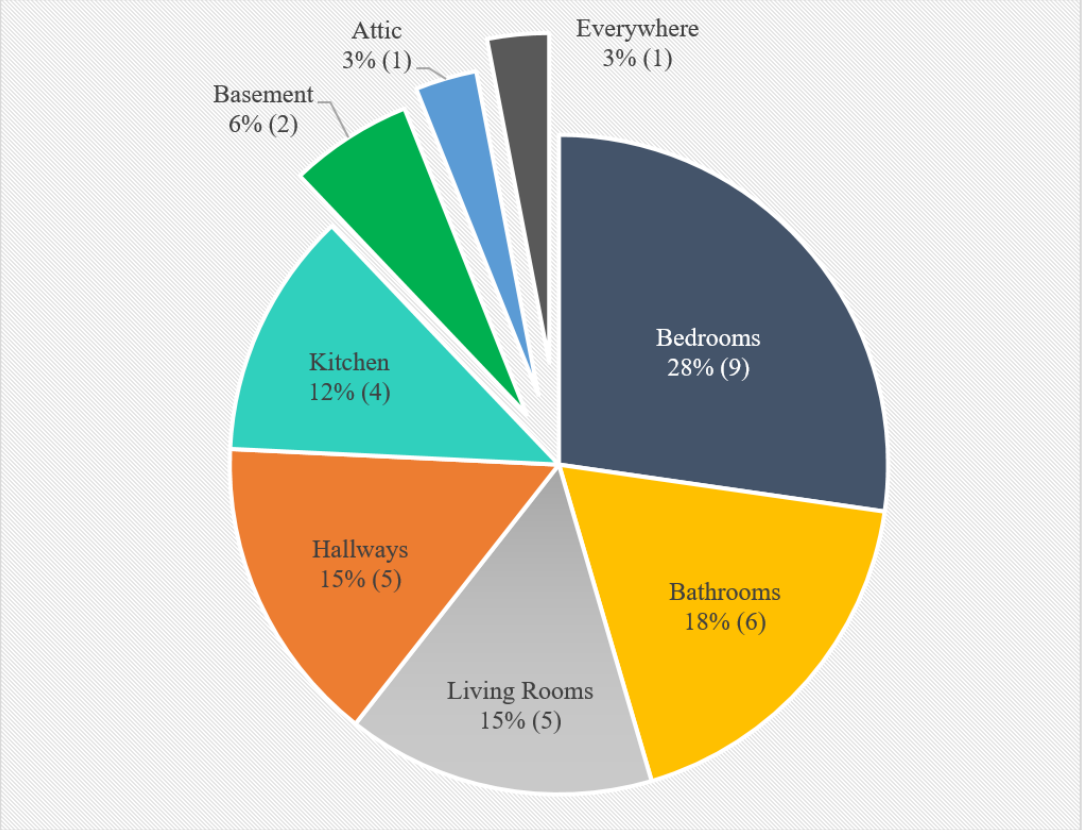

Figure 7: Survey Responses Cold Areas in Student HMOs

Demographics and Energy Consumption

We compared the demographic portion of the student survey with other responses in the survey. Our student surveys included 20 second year and 20 third year students, 17 of which were male, 14 of which were female, and 9 of which preferred not to respond. Based on the categories from the NUS, we found that 25 students are "English/ Scottish/ Welsh/ Northern Irish/British," one student is "White and Black Caribbean," three students are "any other mixed/ Multiple ethnic background," and 11 students preferred not to respond.

Seventy percent of the females and 69% of the males we surveyed consciously control the amount of heat they use (see Figure 8). We found that the 2nd and 3rd year students displayed similar behaviors in energy use (see Figure 9).

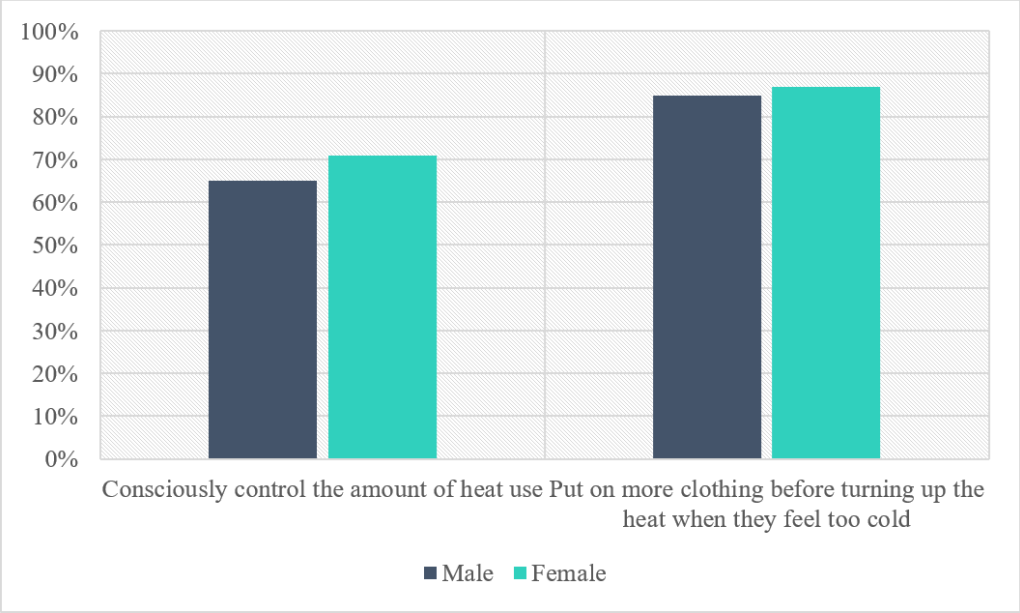

Figure 8: Survey Responses Comparing Male and Female Students

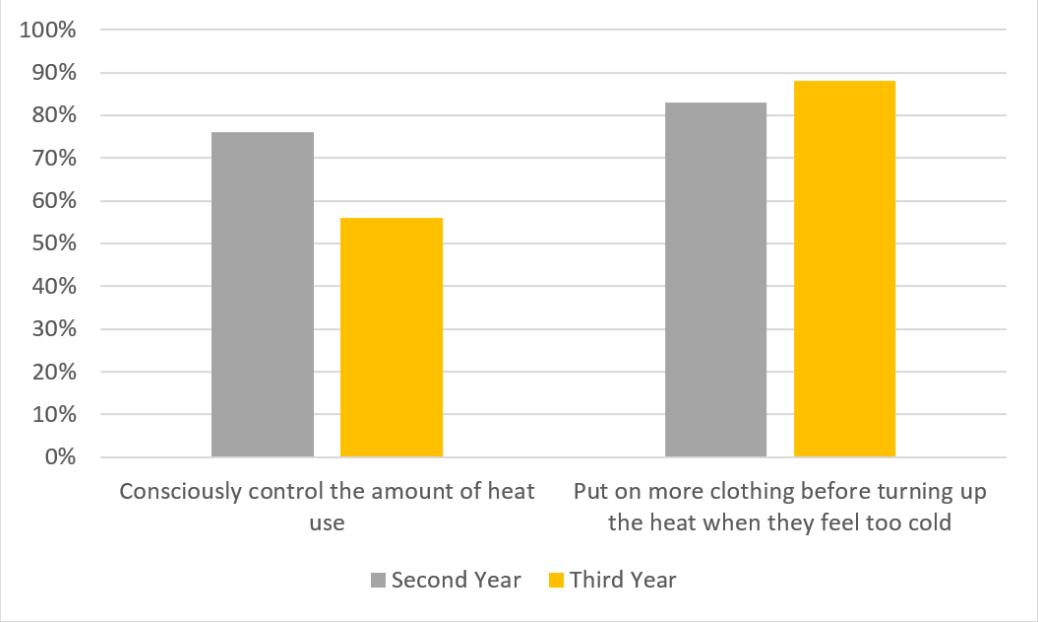

Figure 9: Survey Responses Comparing 2nd and 3rd Year Students

We found that there is little to no correlation between the demographics of a student regarding the use of thermostatic and boiler controls: whether the students turn down the thermostat when they leave their home for longer than a weekend or what their behavior is when feeling too warm or cold in the house, there is not a drastic difference from the responses between second and third year students, nor between male or female. Nonetheless, the most compelling connection was found between tenants that have all-inclusive rent and those who have non-inclusive rent.

Rent and Energy Bills

We found that 80% of students that we interviewed have inclusive rent, meaning that 8 students pay for their energy bills separately, while 32 pay for their bills included with their rent. With inclusive rent, landlords pay energy bills and students pay a flat rate for utilities and rent to the landlord. The students preferred this type of rent because they could pay upfront; our survey found that 49% of students pay their rent in either three or four installments per year, as seen in Figure 10.

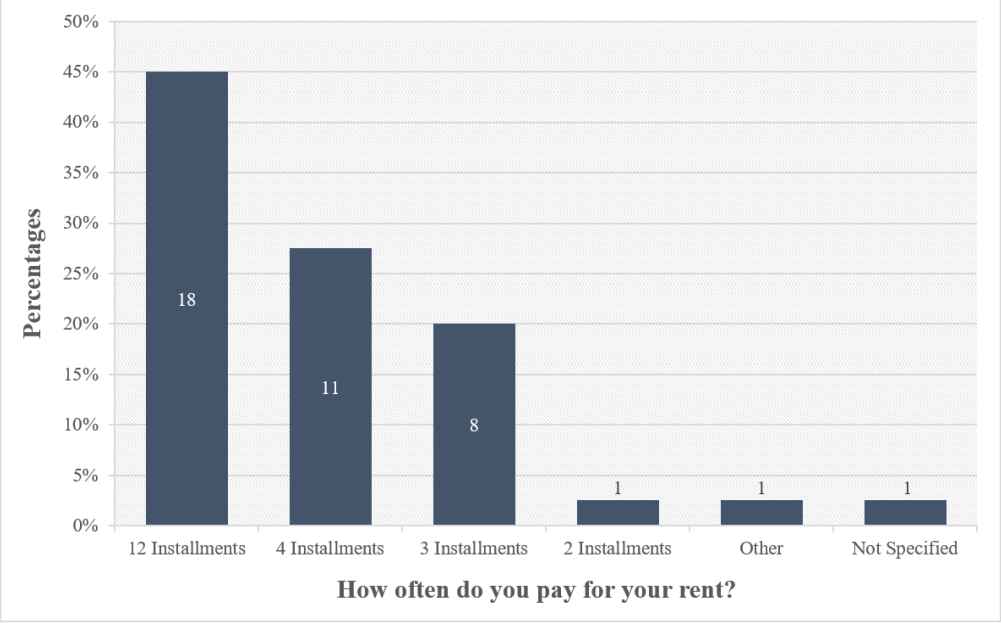

Figure 10: Survey Responses to "How Often do you Pay for Rent?"

Consequently, since the amount of money that they pay is not dependent on their heat use, we found that students who pay a fixed amount for utilities did not show as much awareness about the amount of heat they used. To try to compensate for landlords paying the energy bill, we found that 48% of the students that we interviewed had a landlord-implemented cap on their heat, which ranges from £67 to £250 monthly. We found that for most students, if they exceed this limit, they would have to pay for it out-of-pocket. Unfortunately, as seen in Figure 11, 64% of these students did not know the amount of this limit.

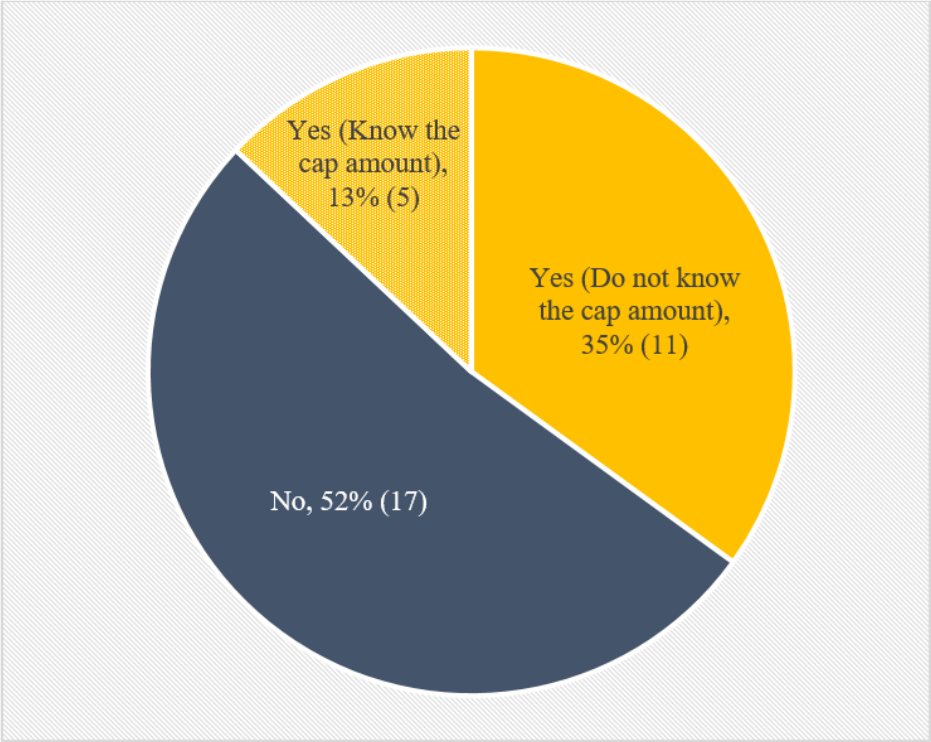

Figure 11: Student Responses to "Do you Have a Heat Cap; If so, Do you Know the Amount?"

Student Attitudes towards Energy Consumption

We used our in-home survey to determine the students' attitudes towards energy consumption within their homes. Based on our survey responses we found that there was not a majority opinion; students felt that the heat should be kept down, while others felt that the heat should be on. We found that 29 (72.5%) students believed that they consciously controlled the

heat, 66% solely to save money, 24% to protect the environment, and 10% for both environmental and monetary reasons (see Figure 12).

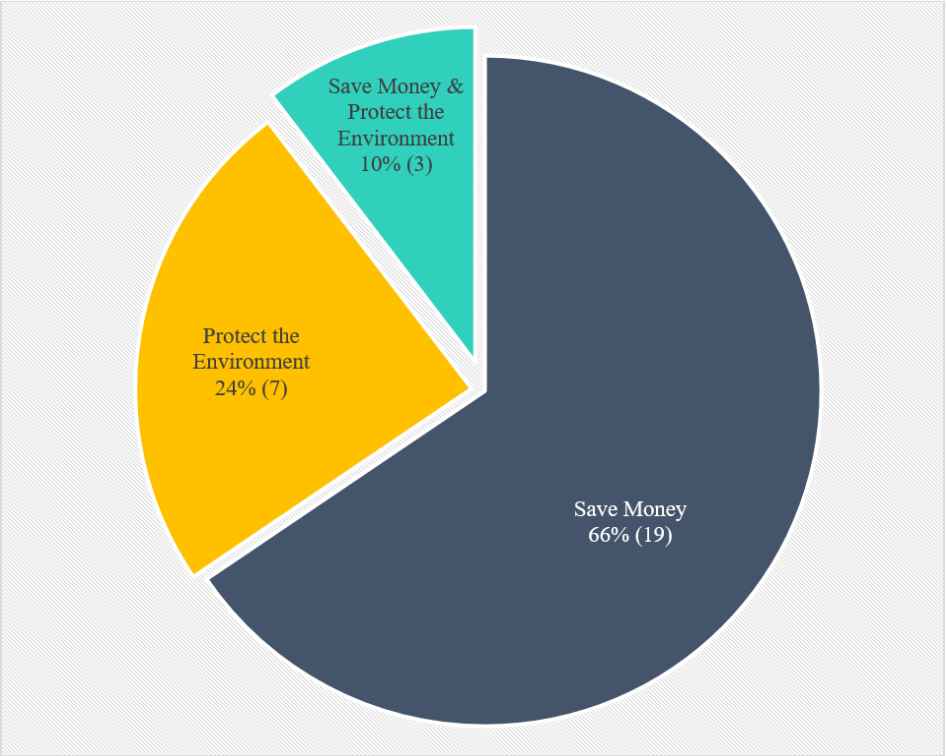

Figure 12: Student Responses of Reasons for Consciously Controlling Heat

Twenty percent of students surveyed, those who pay for utilities separately from rent, tend to keep the temperature down. As for the remaining 80%, which are students who pay all-inclusive rent, we saw a correlation between current thermostat temperature and whether the students have a heating cap or not. Data shows that 56% (9/16) of students who had a cap on heat within their inclusive rent reduce the amount of heat they use. In Figure 13, a few key survey questions regarding tenants' opinions towards heat use and saving money were plotted and used to compare students who pay heat separately with those who pay for utilities included in rent and have a heating cap, and those who have utilities included in rent but do not have a heating cap.

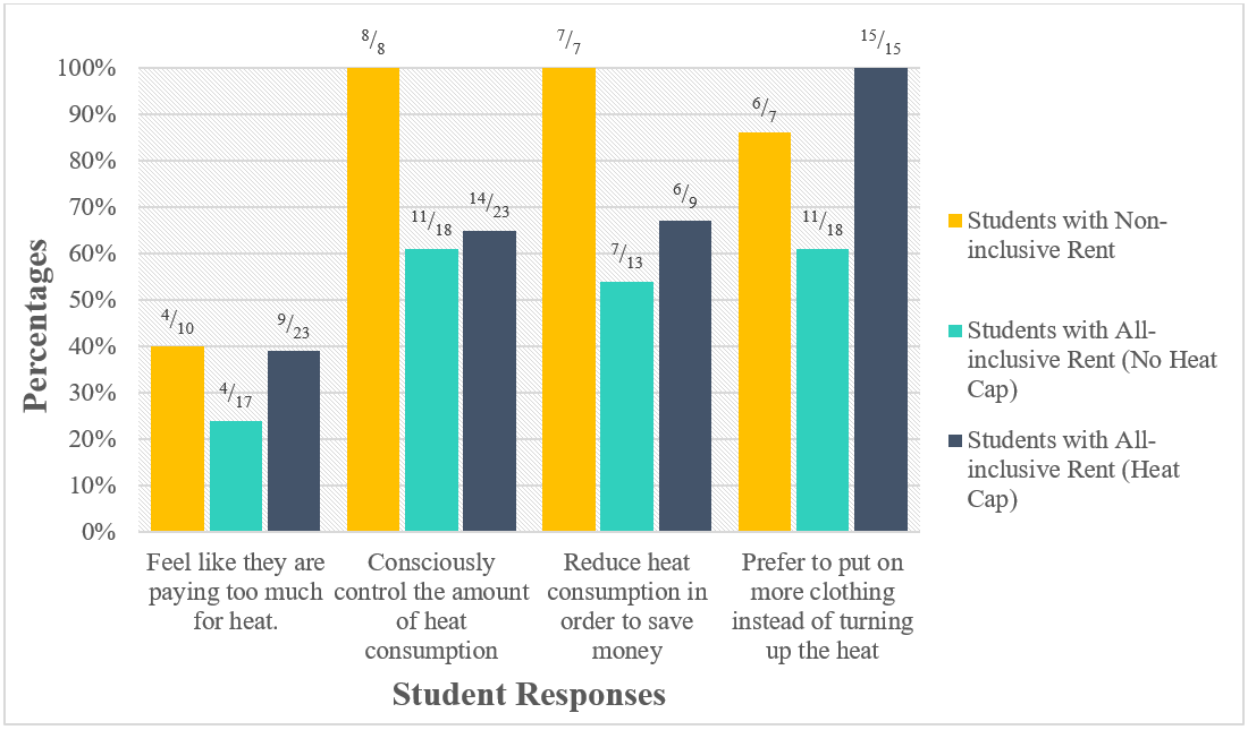

Figure 13: Comparing Heat Caps and Rent to Students' Opinions

It can be seen from the graph that students who pay for utilities separately or have utilities included with a cap claimed that they would prefer to add an extra layer of clothes before turning up the heat. However, those students who do not have a cap on heat were less inclined to do so (see Figure 13). These students pay a set amount regardless of the heat they use. They do not consciously control their heat as much because they are not monetarily affected by their energy consumption. When these students were asked why they did or did not consciously control their heat, one student responded, "We always leave everything on. We don't pay, so whatever." Understandably, none of these students responded that they feel too cold during the winter within their homes. Based on these findings, we can infer that students believe that, in order to be comfortable, they must constantly have the heat on.

Additionally, when students must pay for their heat separately or in addition to bills already being paid, the data show that these students are more inclined to save money than to feel comfortably warm. When asked about their motivation behind keeping the heat down, 66% of students responded with money being their only reason, compared to 24% of students who

responded with environmental reasons only. Originally, we assumed that these students were keeping their heat use down because they were being mindful of their energy consumption. When surveyed about feeling uncomfortably cold in their homes a notable response was, "it is very cold in the winter because we can't turn up the heat too much; we keep the heat down to avoid going over the cap." This shows that students blindly use energy and remain uncomfortable in their homes in hopes that they will not exceed this unknown limit.

The graph from Figure 13 shows that students with non-inclusive rent, as well as those with inclusive rent who have a heating cap, show more awareness about heat use in their own property than students with inclusive rent who do not have a heating cap. It is interesting to note that the students who pay their energy bills separately consciously conserve energy the most, and do so in order to save money. One student studying sustainability mentioned, "It is barely warm in the house… but saving money is what counts." Therefore, while warmth and comfort are important for the students, saving money remains a priority for them.

Student Behaviors and Energy Consumption

We used our observational checklist to determine the behaviors of students regardless of their survey responses. We noted the current temperature of the HMOs, the personal attire of the students, as well as the thermostatic and boiler controls and settings. We noticed that in the HMOs the thermostats that we were able to locate (20) were set between 15°C to above 30°C (with an average temperature of 23.8°C), with 55% of thermostats being set at or above 20°C, which is normal room temperature (see Figure 14).

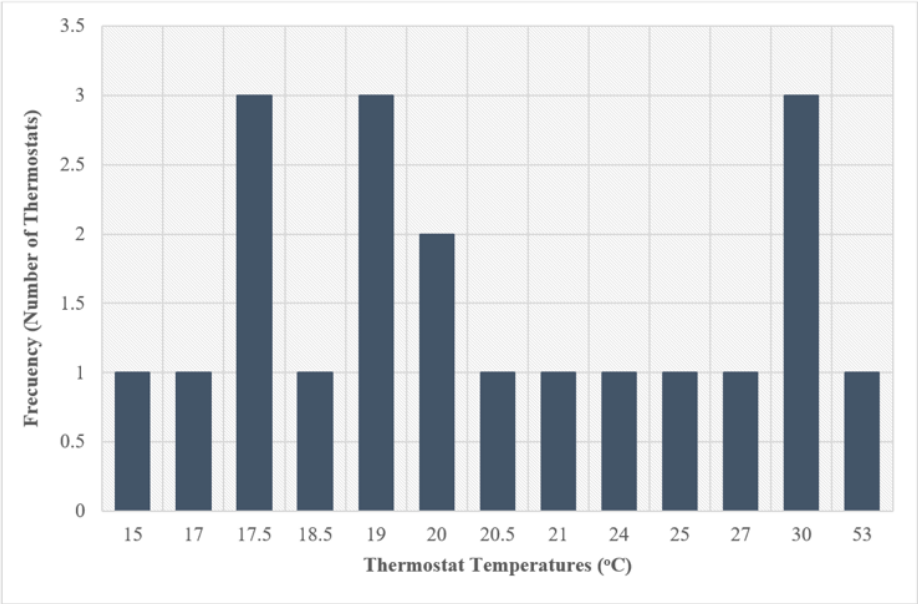

Figure 14: Observed Thermostat Temperatures in 20 Student HMOs

Inconsistencies in Students' Attitudes and Behaviors

It is interesting to compare the observational checklist to the student survey responses to be able to see that students' attitudes do not align with their behaviors. For example, 69% of all respondents claimed that they consciously control the amount of heat they use; and 65% of the respondents mentioned that they turn down the thermostat when they leave for a weekend or longer. However, as mentioned previously, the majority of these students also had their heat above room temperature, even past the 30°C setting. Although students say that they try to reduce the amount of heat use, their actions do not always reflect their claims (see Figure 15). Figure 15 shows the various temperatures at which the thermostats were set. The temperatures of those students who "consciously control their heat" are clearly higher than those of the students who say they "do not consciously control the amount of heat they use."

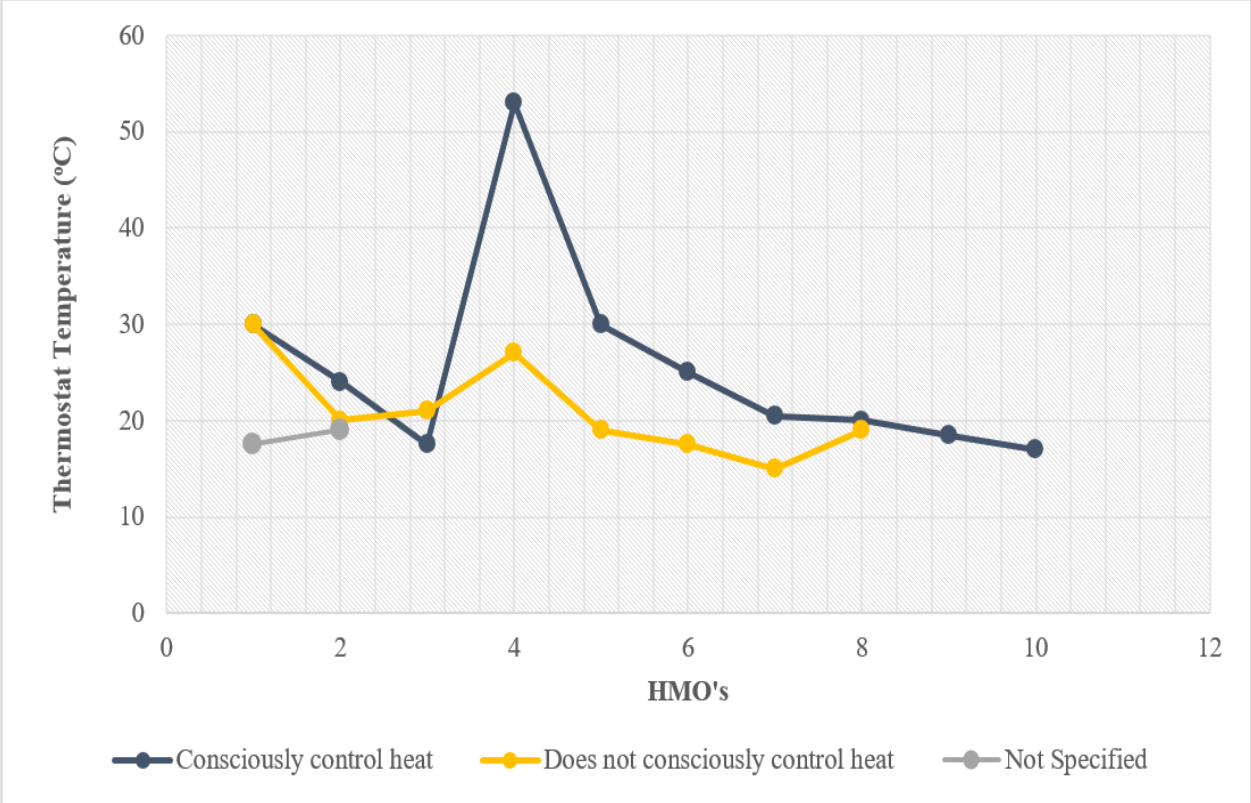

Figure 15: Survey Responses Comparing 2nd and 3rd Year Students

Also, 87.5% of the respondents (35/40) said that they do not have a controlled way of setting the thermostat temperature between their other housemates, because they "just don't talk about it ever" or because they argue about "someone leaving it on constantly and not turning it off," according to a few student respondents. Of these 35 respondents, 6 of them have non-inclusive rent, 14 have inclusive rent with a heat cap, and 15 have inclusive rent without a heat cap (see Figure 16).

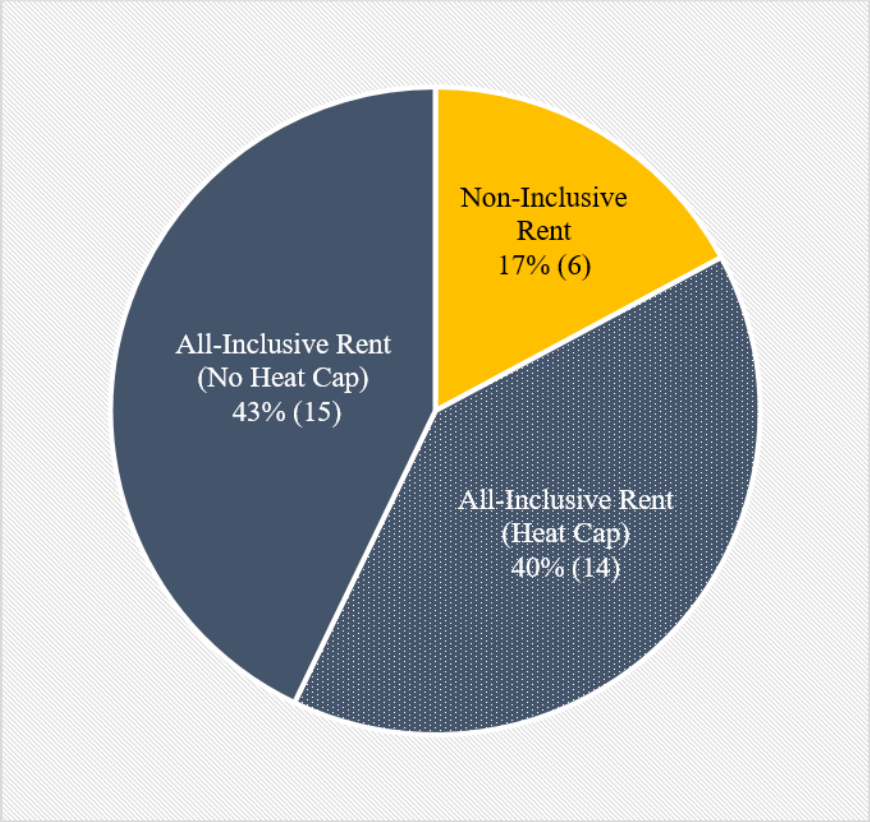

Figure 16: Rent Distribution of Respondents Who Do Not Consciously Control Heat

4.2 Landlord and Letting Agency Beliefs on Heat Use

We contacted five landlords via email inquiring if they would be available for an interview (see Appendix K). We received four responses and conducted a total of three landlord interviews. We contacted two letting agencies and interviewed the manager of student HMOs at one of these. Through these interviews we found that the landlords we talked to were informed and concerned about the efficiency of the heat use in their properties. Unfortunately, the letting agency provided no helpful information. The letting agency makes recommendations to landlords on properties, energy saving technologies, and government policies, but they cannot determine the decisions the landlords make.

Retrofitting and Energy Saving Policies and Programs

The landlords we interviewed said they did not generally take advantage of government reimbursement programs, with a few exceptions. One landlord said, "I'd rather get on and do what I want to do rather than filling out a bunch of forms and ticking boxes." The general consensus was that they are not feasible because of the time and effort that they take. However, from the government's perspective there is still an allure for offering incentives, despite this lack of participation. One landlord's thoughts on this were that it makes the government appear as if they are actively attempting to improve the housing stock, "[they] can say, 'look we're doing all these lovely green programs'" but, in reality, nobody is taking advantage of them. For example, one retrofit that is available to landlords through the government is adding insulation to older buildings. Insulation can be added internally to buildings with cavity walls, as interior or exterior insulation, or loft insulation. However, these programs are flawed and difficult to access because they are very strict: for example, to receive a tax cut for improving a student HMO, it must be occupied solely by students. Unfortunately, some student housing may not be completely renovated before a student moves out and other non-student tenants move in; at this point the government drops consideration for the HMO entirely.

Adding insulation presents its own problems, when the houses become better insulated, it does not naturally breathe. This means the homes require the windows to be opened occasionally to air out the house. Unfortunately, students do not do this, so moisture accumulates inside those homes allowing mold problems to arise which can negatively impact students' health, as well as cause damage to the building.

Bills and the Heating Cap

As previously mentioned, some students pay an inclusive bill to their landlord, and some pay for heat and utilities separately. Students would most likely be better off if they were more involved with their energy usage through bills to the landlord or direct payment to energy companies. This causes some issues; in general, when students pay their own bills, they try to reduce the energy used in an effort to save money, which leads to cold homes. This, along with

the aforementioned problem regarding insulation, causes an increased risk of mold growth, which, again, poses a health risk and damages the building.

Given the extremely competitive housing market in Worcester in recent years, most landlords have been forced to offer all-inclusive rents in order to attract student tenants. From the landlord perspective, as well as a sustainability perspective, this approach creates some problems. For example, all-inclusive rents tend to encourage excessive use of heating and a lack of regard for the property in general. As one landlord said, "as soon as [heat is] included it completely goes to abuse." This is not an energy efficient practice either; students turn the heat up as much as they desire because they are not paying for it. This not only costs the landlord more money, but also taxes the environment. One interesting side effect of this is the heating cap. If students exceed a set amount of heat in a given period, they must pay for this overage. This saves energy and money. One landlord said, "My contracts do stipulate that if too much energy is used they do have to pay it, but it's more a control thing over the students." The heating cap is a tool that prevents excessive use of heating; from a landlord's perspective, the threat of having to pay extra is incentive enough for tenants to keep their heat usage down. In either case, the root of the problem is that students do not treat the house as their own, which produces lackluster results.

Energy Saving Technologies

Some landlords are in favor of various energy saving and generating technologies. For example, one landlord stated on behalf of most landlords that, "We would love to put solar panels on all of our houses, and we'll probably do it in two years' time, but at the moment it's not tax efficient to do [so]." Solar panels would be most effective if coupled with an array of in-house batteries that could store the unused electricity so that the house could nearly run completely off the grid. Unfortunately, many battery processes and products are too expensive for the benefits of the stored energy they provide. Furthermore making batteries releases many harmful toxins into the environment through the initial stages of starting the chemical reactions between the anode and cathode of the battery. Research is being conducted to find a way to

change the process of battery creation so that the batteries are cheaper and more efficient to produce. Until then, wiring solar panels back to the grid is the most economical option.

Thoughts on Remote Thermostatic Controls

Nest, Hive, and others similar systems that allow a landlord to control a home's heating over Wi-Fi from anywhere can lead to a greater degree of control over heating, as well as produce data related to energy usage in an HMO. However, sometimes these systems have too much control. The UK government states that all homes (including rental properties) must "meet certain standards to ensure that they do not represent a risk to health and safety" (Department for Communities and Local Government, 2015). Specifically, homes must not be excessively cold; for example, they cannot be maintained in the range of 18°C-21°C (Department for Communities and Local Government, 2015). Landlords can enforce a temperature range that the tenants must operate within, but it is illegal to fully restrict a tenant's control of the heating and take full control. This also presents the possibility of an ethical issue; for example, if tenants increase the temperature, the landlord can periodically turn it back down, potentially creating an uncomfortably cold environment. Additionally, the physical disconnect presented by Wi-Fi access to thermostats makes it easier for landlords to turn the temperature down. In regards to this, one landlord commented, "For my liking that's a bit too big brother, I don't want to be that controlling." For this reason, more basic programmable thermostats seem to be ideal for landlords. With these, a landlord can set specific times of the day that the boiler is on and off, as well as the maximum temperature to which the thermostat can be set. This can help limit the amount of heating energy the students can use and keep control within the bounds of the law, money, and ethics.

Thoughts on Tenants and the Home Dynamic

When asked about the frequency and need to visit rental properties, the general consensus was that it depends on who is living in the home. A particular group may be more responsible than another, so sometimes landlords must be more observant of a particular home or group of tenants. One reason for this is gender roles. Gender seems to play a large role in the general mentality of any given HMO. We found that mixed groups of males and females are

ideal. Mixed groups seem to display the best attitudes and behaviors towards the HMO itself. These groups are generally more tidy and responsible; they also seem to lean towards a more energy efficient lifestyle. A group of all females is less ideal because they tend to be more prone to social issues, which can ultimately impact the landlord. In some cases, females will alienate one of the group members, causing her to want to move out, creating problems with the lease and payment to the landlord. At this point it would be impossible to encourage energy efficient ideas. Finally, all males are least ideal; this is because their behavior tends to lean towards creating a chaotic living space. One landlord said, "...my concern is safety. Are the exit routes clear? Are they not leaving food around so there aren't vermin?" Again, this is an environment in which students will be unlikely to develop new habits related to energy conservation.

Chapter 5. Conclusions and Recommendations

5.1 Conclusions

This report discusses students' and landlords' opinions and behaviors towards energy consumption in HMOs around the University of Worcester St. John's Campus. From our survey responses, we found that 2nd and 3rd year students are relatively uninformed about the energy consumption, as well as thermostatic and boiler controls in their accommodations. By comparing our survey responses and our observations, we found that there is a significant disconnect between students' opinions and their behaviors on energy efficiency. This could be due to a lack of education and/or a lack of incentives because the cost of utilities are often included in the rent. Inclusive rents have become the norm for student housing in Worcester due to competition among landlords for student tenants. Many students have a limited awareness of their own heat usage or of the cost that is associated with it and little understanding of how better to control energy use and expenses. The minority of students who are knowledgeable and mindful of their energy usage focus primarily on the monetary impacts, rather than the impacts to the environment.

We also found that the landlords in this area appear to be relatively energy conscious, which is evident from our small sample of interviews and in the conditions of the HMOs we inspected. It is apparent that many landlords put in effort upfront to make homes more energy efficient and overall more livable for students by retrofitting the homes with various upgrades, such as new boilers, windows, and thermostats. All of the landlords we asked about government policies thought that the policies were genuine, well-intentioned initiatives, but, ultimately, the difficulties of the application and implementation processes were not commensurate with the benefits to the landlords. Overall, landlords found it most frustrating that student tenants were not knowledgeable about living independently, using thermostatic controls, paying utility bills, and conserving energy.

5.2 Recommendations

Recommendations for Moving Forward

Based on our background research and findings, we recommend that various parties (such as the University of Worcester, the NUS, individual landlords, and landlord associations) develop a coordinated strategy to better educate students and their parents about how to manage energy use in off-campus housing. It is important that students are taught this before they begin living independently. We suggest that:

1. The University of Worcester and National Union of Students develop educational materials that are:
    a. Distributed to students and parents at the beginning of the academic year;
    b. Made available online and at key locations on campus, such as in student accommodations, the University Accommodations Office, the Pierson Center, Main Reception, and the Student Union; and
    c. Distributed to 2nd and 3rd year students when they move out of university accommodations.
2. The University of Worcester and the NUS develop assistive materials and advice for negotiating with roommates regarding energy consumption and bills.
3. Landlord associations work with landlords to develop materials for posting in rental properties regarding the use of thermostatic controls and boilers and include this information in rental agreements/contracts.
4. Landlords include details about heating caps in rental agreements/contracts and send this information to students and to parents, or whomever is paying the bills.
5. Landlords meet with student tenants at the beginning of the rental period and periodically during the year to review thermostatic controls, boilers, heating caps, and utility payments.
6. The University of Worcester and NUS continue to research conditions and behaviors regarding energy use in HMOs.

7. Landlords and the University of Worcester should continue to explore uses of new technologies (such as smart meters, and Hive and Nest thermostats) in better controlling energy in HMOs.

Through these recommendations, we aim to alter students' opinions and attitudes towards energy efficiency and improve knowledge and awareness about these issues. By attempting to better educate students, we hope to decrease the overall heat usage, lower energy costs for students and landlords, improve student comfort, and reduce environmental impacts.

Recommendations to Future Projects

Based on our experience, we have created a set of recommendations that future Energize Worcester projects may consider to improve their research. First, we recommend that the next project group use the "University Accredited Rental Properties" excel sheet as a basis for their research from the start of the project. This will save time and remove the need to identify student HMOs in the area. Additionally, if time permits, we suggest that the research area expand beyond the original eight zones on the Student House Zones map. Although these areas may not be fully defined by the excel sheet, we believe there are sufficient HMOs in the area to make canvassing advantageous.

We recommend that the next project group interview more landlords in the area, regardless of the subject matter of their project. We found the relatively few interviews we conducted to be extremely beneficial and, in hindsight, we think we should have begun interviewing much earlier in the timeline of our project. It may even be beneficial to begin interviewing landlords prior to arriving at the project site. This may aid in writing the literature review and could help the project move more smoothly at the project site. Next, it may be interesting to also conduct in-home surveys with landlords to gain more in depth information about properties and view the issues from a different perspective. Also, we believe it would be beneficial to interview the head of the local Landlords Association to gain insight about the opinions of landlords as a whole, rather than specific landlords' views.

We also recommend that the students conduct an online survey to supplement house visits (if the project entails this). This will increase the number of responses and reduce the effort required to collect these responses. This can also be done effectively using Qualtrics. Finally, we recommend that the students further test the iPad Phase One software and try to upload the results of this to the University of Worcester's GIS software.

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Appendices

Appendix A – Permission Letter from the Worcester City Council

15th May 2016

To Whom It May Concern:

Please let me introduce a group of students from Worcester Polytechnic Institute, an **engineering university in the United States**. Daniel Braconnier, Stephanie Puckett, Keaton Goddard, and Daniel Ruiz-Cadalso are conducting research for the **City Council** and **University of Worcester** on shared housing and how tenants and landlords make choices on boilers and thermostatic controls in the **St John's** area. The data will be used to help identify different energy consumption behaviours and practices in homes of multiple occupancy (HMOs).

The **Worcester City Council** works with the local community and aims to create a prosperous city and to improve the quality of life for everyone. The City Council and University of Worcester have reviewed and approved the materials that this team is using.

If you have any questions or concerns, please contact **Katy Boom**, the project manager at the University of Worcester, **k.boom@worc.ac.uk** or phone: **01905 855243**. More information can be found at the website **www.energize-worcester.com**. Alternatively contact Sally Kelsall, the Strategy and Partnership manager and the City Council at 01905 722009 or by email at sally.kelsall@worcester.gov.uk.

Yours sincerely

SCKelsall

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Appendix B – Protocol for Approaching Houses

1. Identify and map out initial zone of houses within approximately a 15 minute walk from St. John's Campus. This zone may be expanded based on progress in the coming weeks.
2. We will survey one street at a time in pairs, with each pair covering one side of the street.
3. Each pair will communicate with the other between visits to houses to check in.
4. We will wear our Energize Worcester t-shirts and hoodies for identification purposes.
5. When approaching houses, we will use discretion and be cautious about our general safety (i.e. any abnormalities, evidence of disrepair, any uncomfortable situations).
6. Knock on the door or ring the doorbell and immediately introduce ourselves with our permission letter and preamble, which include official logos from the University of Worcester and Worcester City Council, the nature of the project, and that the interview is voluntary and confidential.
7. Ask permission to enter their property, or if there is another time that would be better. Enter only if permission is given, stay only in common spaces, and be respectful.
8. Know a way out should we feel uncomfortable or in the case of an emergency.
9. Conduct survey thoroughly and politely.

Appendix C – Preamble for Student In-Home Surveys

Thank you for agreeing to participate in this survey. My name is XX and this is my colleague, YY. We are students at Worcester Polytechnic Institute. As part of our degree, we are conducting research in collaboration with the Energize Worcester team at the University of Worcester on heating in homes of multiple occupancy.

We would like to ask you a few questions about the heating in your house, and with your permission we would like to take some pictures of the thermostat and boiler. Your participation in this survey is completely voluntary. If you do not feel comfortable answering a question, you may ask to move on to a different question or stop the survey at any time. Your responses will remain entirely confidential and no identifying information will be presented in our reports.

Shall we begin?

Appendix D – Student In-Home Survey Script

Table 2: Script Student Survey

Student In-Home Survey (used for Qualtrics Survey)								
Questions	**Tenant 1**		**Tenant 2**		**Tenant 3**		**Tenant 4**	
SECTION 1. DEMOGRAPHICS								
1. Which of the following best describes how you think of yourself?	☐ Male ☐ Female ☐ Another way ☐ Prefer not to say		☐ Male ☐ Female ☐ Another way ☐ Prefer not to say		☐ Male ☐ Female ☐ Another way ☐ Prefer not to say		☐ Male ☐ Female ☐ Another way ☐ Prefer not to say	
2. What is your ethnic group?	_____		_____		_____		_____	
3. What class year are you?	☐ 2nd ☐ 3rd		☐ 2nd ☐ 3rd		☐ 2nd ☐ 3rd		☐ 2nd ☐ 3rd	
4. Have you lived in multiple occupancy housing before?	☐ Yes ☐ No		☐ Yes ☐ No		☐ Yes ☐ No		☐ Yes ☐ No	
5. What is your course of study?	_____		_____		_____		_____	
SECTION 2. HOME AND RENT INFORMATION								
1. How many students live in the house?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8

2. How many bedrooms are in the house?	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	□ 8
3. How many bathrooms are in the house?	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	□ 8
4. How many bathrooms are en suite?	□ 1	□ 2	□ 3	□ 4	□ 5	□ 6	□ 7	□ 8
5. How often does the landlord visit?	□ Once per Week	□ Once per Month	□ Once per Term	□ Whenever there is a problem	□ Never	□ Other: _____		
6. How often do you pay your rent?	□ Once per week	□ Once per month	□ Quarterly	□ All at once	□ Other: _____			
7. Do you as students pay the energy bills or does your landlord?	□ Students	□ Landlord	□ Other: _____					
8. (If answered "Students" to Q.2.7) How are the bills divided between all of you?	□ Equally	□ Size of bedroom	□ Energy used by each tenant specifically	□ Other: _____				
9. (If answered "Students" to	□ Yes	□ Yes	□ Yes	□ Yes				

Q.2.7) Do you agree with how the bills are divided?	☐ No	☐ No	☐ No	☐ No
10. (If answered "No" to Q.2.9) Why?	_____			
11. What spending cap, if any, does the landlord impose on your heating/energy?	☐ £ _____		☐ None	
12. (If answered "£" to Q.2.11) What happens if you exceed the limit?	☐ Landlord turns off energy	☐ Tenant pays for extra energy used	☐ Other: _____	
13. Do you feel that you are paying too much for heat?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
SECTION 3. HEAT CONTROL AND BEHAVIOUR				
1. Do you and your housemates control the heat in the house or does the landlord?	☐ Students	☐ Landlord	☐ Other: _____	
2. Do you know where the boiler	☐ Yes		☐ No	

is?						
3. How many thermostats are in the house?	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5+
4. Do you ever adjust the thermostat?	□ Yes		□ No		□ Don't have one	
If answered "No" on Q.3.4, disregard Q.3.5, Q.3.6 and Q.3.7						
5. How do you determine, between your housemates, the temperature at which you set the thermostat?	_____					
6. When you leave the house for several hours, do you turn down the thermostat?	□ Yes □ No □ Sometimes		□ Yes □ No □ Sometimes		□ Yes □ No □ Sometimes	
7. How about when you leave for a weekend or longer?	□ Yes □ No □ Sometimes		□ Yes □ No □ Sometimes		□ Yes □ No □ Sometimes	
8. Are there any areas where you feel uncomfortably	□ Yes □ No		□ Yes □ No		□ Yes □ No	

cold?				
9. (If answered "Yes" to Q.3.8) Where are the cold areas?	☐ Kitchen ☐ Bedroom ☐ Hallways ☐ Living Room ☐ Bathrooms ☐ Basement ☐ Other: _____			
10. During winter, do you often feel uncomfortably cold in the house?	☐ Often ☐ Sometimes ☐ Never	☐ Often ☐ Sometimes ☐ Never	☐ Often ☐ Sometimes ☐ Never	☐ Often ☐ Sometimes ☐ Never
11. When you feel cold, do you…?	☐ Put on more clothing ☐ Turn up Heat ☐ Study elsewhere ☐ Other: _____	☐ Put on more clothing ☐ Turn up Heat ☐ Study elsewhere ☐ Other: _____	☐ Put on more clothing ☐ Turn up Heat ☐ Study elsewhere ☐ Other: _____	☐ Put on more clothing ☐ Turn up Heat ☐ Study elsewhere ☐ Other: _____
12. During winter, do you often feel uncomfortably warm in the house?	☐ Often ☐ Sometimes ☐ Never	☐ Often ☐ Sometimes ☐ Never	☐ Often ☐ Sometimes ☐ Never	☐ Often ☐ Sometimes ☐ Never
13. When you feel warm, do you…?	☐ Open windows ☐ Turn down heat ☐ Stay elsewhere ☐ Other: _____	☐ Open windows ☐ Turn down heat ☐ Stay elsewhere ☐ Other: _____	☐ Open windows ☐ Turn down heat ☐ Stay elsewhere ☐ Other: _____	☐ Open windows ☐ Turn down heat ☐ Stay elsewhere ☐ Other: _____

14. How many supplemental heaters do you have?	☐ None	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
15. (If did not answer "None" for Q.3.14) Were they provided by the landlord or not?	☐ Landlord Provided			☐ Student Provided		
16. (If did not answer "None" for Q.3.14) Where are they placed?	☐ Kitchen	☐ Bedrooms	☐ Hallways	☐ Living Room	☐ Other: _____	
17. (If did not answer "None" for Q.3.14) At what time do you most often use them?	☐ At night	☐ During the day	☐ Whenever you feel the need	☐ Other: _____		
18. Do you consciously control the amount of heat you use?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No		
19. (If answered "Yes" to Q.3.18) For what reasons?	☐ Save Money ☐ Protect the Environment ☐ Other: _____	☐ Save Money ☐ Protect the Environment ☐ Other: _____	☐ Save Money ☐ Protect the Environment ☐ Other: _____	☐ Save Money ☐ Protect the Environment ☐ Other: _____		

SECTION 4. ADDITIONAL COMMENTS			
1. Is there anything else you would like to tell us about the heating and the comfort of your house?			

Appendix E – Complete Survey Responses

Question 1.1 How many students live in the house?	Number of Responses	Percentage of Responses
1	0	0.00%
2	1	2.50%
3	9	22.50%
4	11	27.50%
5	12	30.00%
6	6	15.00%
7	0	0.00%
8	1	2.50%
Total Number of Respondents:	40	100%
Question 1.2 How many bedrooms are in the house?	Number of Responses	Percentage of Responses
1	0	0.00%
2	1	2.50%
3	6	15.00%
4	14	35.00%
5	12	30.00%
6	6	15.00%
7	0	0.00%
8	1	2.50%
Total Number of Respondents:	40	100%
Question 1.3 How many bathrooms are in the house?	Number of Responses	Percentage of Responses
1	19	47.50%
2	13	32.5%

3	4	10.00%
4	3	7.5%
5	0	0.00%
6	0	0.00%
7	0	0.00%
8	1	2.5%
Total Number of Respondents:	40	100%
Question 1.4 How many are en-suite?	Number of Responses	Percentage of Responses
0	26	65%
1	10	25%
2	3	7.5%
3	0	0.00%
4	0	0.00%
5	0	0.00%
6	0	0.00%
7	1	2.5%
8	0	0.00%
Total Number of Respondents:	40	100%
1.5 How often does the landlord visit?	Number of Responses	Percentage of Responses
Monthly	6	15%
Whenever there is a problem	19	47.5%
Never	5	12.5%
Weekly	2	5%
Biweekly	2	5%
Termly	1	2.5%

Other: “Surprise”	4	10%
No Response	1	2.5
Total Number of Respondents:	40	100%
1.6 How often do you pay for your rent?	Number of Responses	Percentage of Responses
2 Installments	1	2.5%
3 Installments	8	20%
4 Installments	11	27.5%
Monthly	18	45%
No Response	2	5%
Total Number of Respondents:	40	100%
1.7 Do you as students pay the energy bills or does your landlord?	Number of Responses	Percentage of Responses
Landlord	7	17.5%
Students	33	82.5%
Total Number of Respondents:	40	100%
1.8 (If answered students in 1.7) How are the bills divided between each of you?	Number of Responses	Percentage of Responses
Equally	5	95.14%
One Pays All	1	2.43%
Amount used by each tenant	1	2.43%
Total Number of Respondents:	7	100%
1.9 (If answered students in 1.7) Do you agree with how the bills are divided?	Number of Responses	Percentage of Responses
Yes	5	95.14%
No	0	0.00%
No Response	2	4.86%
Total Number of Respondents:	7	100%

1.11 What spending cap, if any, does the landlord impose on your heating/energy?	Number of Responses	Percentage of Responses
None	22	55%
Yes, Didn't Specify	5	12.5%
Yes, Don't Know	8	20%
£200/Quarter	1	2.5%
£250/Quarter	1	2.5%
£2000/Year	1	2.5%
Pay as you go	1	2.5%
No Response	1	2.5%
Total Number of Respondents:	40	100%
1.12 (If there is a cap) What happens if you exceed the limit?	Number of Responses	Percentage of Responses
Don't Know	2	12.5%
Tenant pays excess	14	87.5%
Total Number of Respondents:	16	100%
1.13 Do you feel that you are paying too much for heat? (Asked of all students present)	Number of Responses	Percentage of Responses
Yes	35	70%
No	15	30%
Total Number of Respondents:	50	100%
2.1 Do you and your housemates control the heat in the house or does the landlord?	Number of Responses	Percentage of Responses
Students	36	90%
Landlord	3	7.5%
Electronically Controlled	1	2.5%
Total Number of Respondents:	40	100%
2.2 Do you know where the boiler is?	Number of	Percentage of

	Responses	Responses
Yes	32	80%
No	7	17.5%
No Response	1	2.5%
Total Number of Respondents:	40	100%
2.3 How many thermostats are in the house?	Number of Responses	Percentage of Responses
0	8	20%
1	24	60%
2	1	2.5%
No Response	7	17.5%
Total Number of Respondents:	40	100%
2.4 Do you ever adjust the thermostat?	Number of Responses	Percentage of Responses
Yes	31	77.5%
No	6	15%
No Response	3	7.5%
Total Number of Respondents:	40	100%
2.5 How do you determine, between your housemates, the temperature at which you set the thermostat?	Number of Responses	Percentage of Responses
Change Whenever	22	55%
Whatever's Comfortable	2	5%
On Timer	1	2.5%
Other	4	10%
No Response	11	27.5%
Total Number of Respondents:	40	100%
2.6 When you leave the house for several hours do you turn the thermostat down? (Asked of all students present, some	Number of Responses	Percentage of Responses

did not respond)		
Yes	18	45%
No	22	55%
Total Number of Respondents:	40	100%
2.7 What about when you leave for the weekend or longer? (Asked of all students present, some did not respond)	Number of Responses	Percentage of Responses
Yes	24	64.86%
No	12	30%
Sometimes	1	5.14%
Total Number of Respondents:	37	100%
2.8 Are there any areas in the house that are uncomfortably cold?	Number of Responses	Percentage of Responses
Yes	24	60%
No	15	37.5%
No Response	1	2.5%
Total Number of Respondents:	40	100%
2.9 Where are the cold areas? (If there are cold areas, also some respondents gave multiple answers)	Number of Responses	Percentage of Responses
Living Room	5	15.15%
Bathroom	6	18.18%
Kitchen	4	12.12%
Hallways	5	15.15%
Bedroom	9	27.27%
Basement	2	6.06%
Attic	1	3.03%
Everywhere	1	3.04%
Total Number of Respondents:	33	100%

2.10 During the winter, how often do you feel uncomfortably cold in the house? (Asked of all students present)	Number of Responses	Percentage of Responses
Often	18	35.29%
Sometimes	11	21.57%
Never	22	43.14%
Total Number of Respondents:	51	100%
2.11 When you feel too cold, do you: (Asked of all students present)	Number of Responses	Percentage of Responses
Put on more clothing?	16	40%
Turn up the heat?	8	40%
Both	16	20%
Total Number of Respondents:	40	100%
2.12 During the winter, how often do you feel uncomfortably warm in the house? (Asked of all students present)	Number of Responses	Percentage of Responses
Often	3	6%
Sometimes	14	28%
Never	33	43.14%
Total Number of Respondents:	50	100%
2.13 When you feel warm, do you: (Asked of all students present)	Number of Responses	Percentage of Responses
Turn down the heat?	6	19.35%
Open the windows?	10	32.25
Both	14	45.16%
Other: Turn on a fan	1	3.24%
Total Number of Respondents:	31	100%
2.14 How many supplemental heaters (electric heaters) do you have?	Number of Responses	Percentage of Responses

0	23	57.50%
1	13	32.5%
2	1	2.5%
3	2	5%
No Response	1	2.5%
Total Number of Respondents:	40	100%
2.15 Were they provided by the landlord or not?	Number of Responses	Percentage of Responses
Landlord	5	12.50%
Student	9	22.5%
No Response	26	65%
Total Number of Respondents:	40	100%
2.16 Where are they used? (If they had any)	Number of Responses	Percentage of Responses
Living Room	2	14.30%
Laundry Room	1	7.14%
Bedroom	8	57.14%
Basement	1	7.14%
Everywhere	1	7.14%
Bathroom	1	7.14%
Total Number of Respondents:	14	100%
2.17 At what times do you most often use them?	Number of Responses	Percentage of Responses
As needed	8	57.14%
Never	3	21.42%
During the day	2	14.30%
During the night	1	7.14%

Total Number of Respondents:	14	100%
2.18 Do you consciously control the amount of heat that you use? (Asked of all students present)	Number of Responses	Percentage of Responses
Yes	33	68.75%
No	15	31.25%
Total Number of Respondents:	48	100%
2.19 For what reasons? (Asked of all students present, some did not respond)	Number of Responses	Percentage of Responses
Save Money	22	64.71%
Protect the environment	10	29.41%
Don't Care	1	2.94%
Landlord's Request	1	2.94%
Total Number of Respondents:	34	100%
3.1 Which of the following best describes how you think of yourself?	Number of Responses	Percentage of Responses
Male	17	42.50%
Female	14	35.00%
No Response	9	22.50%
Total Number of Respondents:	40	100%
3.2 What is your ethnic group?	Number of Responses	Percentage of Responses
English/ Scottish/ Welsh/ Northern Irish/ British	25	62.50%
White and Black Caribbean	1	2.50%
Any other Mixed/ Multiple ethnic background	3	7.50%
No Response	11	27.50%
Total Number of Respondents:	40	100%
3.3 What class year are you?	Number of Responses	Percentage of Responses

2nd	20	50.00%
3rd	20	50.00%
No Response	0	0.00%
Total Number of Respondents:	40	100%
3.4 Have you lived in multiple occupancy housing before?	Number of Responses	Percentage of Responses
Yes	30	75.00%
No	10	25.00%
No Response	4	0.00%
Total Number of Respondents:	40	100%
3.5 What is your course of study?	Number of Responses	Percentage of Responses
Business	2	5.00%
Education Studies	10	25.00%
Fine Arts	4	10.00%
History	2	5.00%
Literature	1	2.50%
Nursing	1	2.50%
Physical Education	13	32.50%
Psychology/Sociology	2	5.00%
Science	5	12.50%
No Response	0	0.00%
Total Number of Respondents:	40	100%

Appendix F – Qualtrics Student In-Home Survey (Page 1)

Section 1: Home and Rent Information

Thank you for agreeing to participate in this survey. My name is XX and this is my colleague, YY. We are students at Worcester Polytechnic Institute. As part of our degree, we are conducting research in collaboration with the Energize Worcester team at the University of Worcester on heating in homes of multiple occupancy.

We would like to ask you a few questions about the heating in your house, and with your permission we would like to take some pictures of the thermostat and boiler. Your participation in this survey is completely voluntary. If you do not feel comfortable answering a question, you may ask to move on to a different question or stop the survey at any time. Your responses will remain entirely confidential and no identifying information will be presented in our reports.

Shall we begin?

What is the address?

Pair's Initials

- ○ KG/DR
- ○ SP/DB

1.1 How many students live in the house?

1 2 3 4 5 6 7 8

Appendix G – Setting up Qualtrics for Offline use on Tablets

Register with Qualtrics, a free account can be made at:

https://www.qualtrics.com/free-account/

Or, if you are a Worcester Polytechnic Institute student, you already have an account, simply log in using your WPI credentials.

Surveys must be made on a computer and are straightforward to create. After finishing the survey click the "Launch Survey" button and then the "Activate Survey" button. The survey is now ready to use.

Log into the account on the tablet. If the tablet does not have the Qualtrics app, search "Qualtrics" or "Qualtrics Surveys" in the app store/ play store to download.

After logging in, all of your surveys will appear on the tablet, but you must click on them and download them to actually use them. After downloading the survey it may be completed offline, in which case the results will be saved on the device. Once you have an internet connection, the responses can be uploaded and viewed online in Qualtrics.

Appendix H – Observational Checklist

Table 3: Observational Checklist

Observational Checklist			
Date		Address	
Pair's Initials	☐ KG, DR ☐ DB, SP	Weather	☐ Sunny ☐ Overcast ☐ Rainy ☐ Other: _____
Age of house	☐ Pre 1900 ☐ 1900-1930 ☐ 1930-1950 ☐ 1950-1990 ☐ 1990-present		
Condition of Exterior of House	☐ Good ☐ Fair ☐ Poor		
Condition of Interior of House	☐ Good ☐ Fair ☐ Poor ☐ Damp/Mold ☐ Peeling paint		
Personal	☐ "Warmer weather" clothes: t-shirt, shorts etc.		

	☐ "Colder weather" clothes: sweater, hoodie, joggers etc. ☐ Presence of blankets, dressing gowns, etc. ☐ Other: _____
Windows	Number of windows open _____ Number of windows closed _____
Thermostat and Control	☐ Analog ☐ Digital ☐ Current temperature_____ ☐ Picture ☐ Other _____
Heating System	☐ Boiler ☐ Picture ☐ Separate water tank ☐ Supplemental heater(s) ☐ Other _____
Student Quotes	_____

Appendix I – Qualtrics Observational Checklist (Page 1)

Information

Date

Address

Pair's Initials

- ○ KG, DR
- ○ DB, SP

Weather

- ○ Sunny
- ○ Overcast
- ○ Rainy
- ○ Other

Observations and Quotes

Age of House

- ○ Pre 1900

Appendix J – Complete Observational Checklist Responses

Weather	Number of Responses	Percentage of Responses
Overcast	11	27.50%
Rainy	8	20.00%
Sunny	11	27.50%
Other	7	17.50%
No Response	3	7.50%
Total Number of Respondents:	40	100%
Age of House	Number of Responses	Percentage of Responses
Pre 1900	3	7.50%
1900-1930	4	10.00%
1930-1950	9	22.50%
1950-1990	12	30.00%
1990-Present	6	15.00%
No Response	6	15.00%
Total Number of Respondents:	40	100%
Condition of Exterior of House	Number of Responses	Percentage of Responses
Good	21	52.50%
Fair	11	27.50%
Poor	2	5.00%
No Response	6	15.00%
Total Number of Respondents:	40	100%

Condition of Interior of House	Number of Responses	Percentage of Responses
Good	28	70.00%
Fair	9	22.50%
Poor	0	0.00%
Damp/Moldy	0	0.00%
Peeling Paint	2	5.00%
No Response	1	2.50%
Total Number of Respondents:	40	100%
Personal	Number of Responses	Percentage of Responses
“Warm Weather” Clothes: T-shirts, shorts, etc.	14	35.00%
“Colder weather” clothes: sweater, hoodie, joggers etc.	22	55.00%
Presence of blankets, dressing gowns, etc.	2	5.00%
Other	1	2.50%
No Response	1	2.50%
Total Number of Respondents:	40	100%
Windows	Number of Responses	Percentage of Responses
Number of Windows Open		
0	2	5.00%
1	38	95.00%
Number of Windows Closed		
All	38	95.00%
All but one	2	5.00%
No Response	0	0.00%
Total Number of Respondents:	40	

Thermostat and Control (Multiple Answers per Survey)	Number of Responses	Percentage of Responses
Analog	9	22.50%
Digital	16	40.00%
Current Temperature Available to Read	20	50.00%
No Response	15	37.50%
Total Number of Respondents:	40	
Heating System (Multiple Answers per Survey)	Number of Responses	Percentage of Responses
Boiler	22	55.00%
Separate Water Tank	2	5.00%
Supplemental Heater(s)	7	17.50%
Other	8	20.00%
No Response	10	25.00%
Total Number of Respondents:	40	

Appendix K – Landlord Contact Email

Good Morning [Name of Landlord],

We are exchange students from Worcester Polytechnic Institute, a university in America, conducting research for the Worcester City Council and the University of Worcester on heating in homes of multiple occupancy. We are working alongside Katy Boom, Director of Sustainability of the University of Worcester, and Energize Worcester. We were informed that you are a landlord managing several properties in areas near the St. John's Campus. We were wondering if you would be available for 20-30 minutes for an interview within the next two weeks.

We have attached the permission letter given to us by Energize Worcester, which is signed by Sally Kelsall, the Strategy & Partnership manager of Worcester City Council.

Kind Regards,
The Energize Worcester Team
Daniel Ruiz-Cadalso (Danny)
Keaton Goddard
Stephanie Puckett (Steph)
Daniel Braconnier (Dan)

Appendix L – Landlord Interview Script

Table 4: Landlord Interview Script

Topic	Questions
Preamble	*Thank you for agreeing to participate in this interview. My name is XX and this is my colleague, YY. We are students at Worcester Polytechnic Institute, a university in America. As part of our degree, we are conducting research in collaboration with Energize Worcester at the University of Worcester on energy conservation in homes of multiple occupancy.* *We would like to ask you a few questions about your rental properties regarding energy use, billing, and policies. Your participation in this interview is completely voluntary. If you do not feel comfortable answering a question, you may ask to move on to a different question or stop the interview at any time. If you do not mind, we will be taking notes throughout the interview. We may wish to quote you in our final report, but we will give you the right to review any quotations that we use prior to publication. If you prefer, we can make any quotations and references to this conversation anonymous.* *Shall we begin?*
1. Properties	Q.1.1. How many rental properties do you manage? Q.1.1.a. How many of them are student HMOs? Q.1.1.b. On average, how many bedrooms do they contain? Q.1.2. How often do you feel the need to pay a visit to your student properties?

2. Payment/Bills	*We believe the rental market has changed in the past couple of years. Rent nowadays typically includes utilities such as gas, electricity, water, and internet.* Q.2.1. What utilities, if any, are included in the tenants' rent payments? Q.2.1.a. (If utilities are included) Have these utilities always been included? (Has there been any change in your rent in the past?) If No: Q.2.1.a.i. When was this change made and why? Q.2.1.b. (If utilities are not included) Have the utilities always been paid separately? If No: Q.2.1.b.i. When was this change made and why? (If utilities are included) *Energy use varies every day, and therefore, the amount you have to pay for utilities every certain period of time fluctuates.* Q.2.2. (If utilities are included) How do you determine a permanent price of utilities to charge tenants? Q.2.4. (If utilities are included) Do you impose a cap on utility use related to heat use in your properties?
3. Heat Use and Eco-Technologies	*Recently, some landlords have begun to take control over some utilities in their properties. For example, some landlords have installed thermostats that are remotely controlled via means such as an application in their phone.*

	Q.3.1. Do you control the heat in your properties, and if so, how? If Yes: Q.3.1.a. Why? (i.e. Do you feel like tenants are going to waste too much heat if this is not implemented?) Q.3.1.b. How do you control it? (i.e. app) Q.3.1.c. What feedback, if any, have you received from the tenants about this? If No: *We can imagine that giving the tenants the liberty of controlling utilities in your properties may bring disagreements.* Q.3.1.d. Is there anything that you find frustrating with what tenants do with the heat they control? If Yes: Q.3.1.b.i. Have you had to make any substantial changes to your property/heating because of this? Q.3.2. Are you aware of energy efficient technologies? (i.e. smart meters) If Yes: *Some landlords have started to install energy efficient technologies because it limits the amount of energy that the tenants are able to use.* Q.3.2.a. Have you installed such technologies?

	Q.3.2.a.i. Why or why not? Q.3.3. Have you gotten any complaints about how cold the houses are during the winter? *We are aware that houses around this area vary in terms of age. Some houses are older than 100 years while others are not even 20 years old yet. Newer houses are often built with cavity walls, which allows the walls to be insulated. However, older houses are usually not insulated, and thus, require some types of reconstruction in order to do so.* Q.3.4. Have any of the properties been renovated/retrofitted recently? Q.3.4.a. Why or why not? <u>If Yes:</u> Q.3.4.b. Are there any scheduled upgrades?
4. Energy Policies and Programs	Q.4.1. In recent years, have you taken advantage of any government programs to help retrofit or save energy in your rental properties? Q.4.2. What are your opinions on these policies/ programs? Q.4.3. How did you learn about these policies/ programs Q.4.4. Do you participate in or support any of these policies/ programs? Q.4.5. Have you heard about the Green Deal? Q.4.5.a. What are your thought and opinions on it? Q.4.6. Have you taken the Green Deal plan? Q.4.6.a. Why or why not?