ANALYSIS OF CONSUMER ENERGY BEHAVIOR IN THE ARBORETUM

Charles Frick
Nicholas Lemere
Alexander Shoop
Stefan Smith

WPI

ANALYSIS OF CONSUMER ENERGY BEHAVIOR IN THE ARBORETUM

An Interactive Qualifying Project Report

Submitted to the Faculty of

Worcester Polytechnic Institute

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

In cooperation with

The University of Worcester, England

Submitted on June 26, 2014

Submitted By:

Charles Frick

Nicholas Lemere

Alexander Shoop

Stefan Smith

Submitted To:

Katy Boom, Sponsor Liaison

Peng Li, Project Manager

Project Advisors:

Professor Carolina Ruiz

Professor Ingrid Shockey

Abstract

Our project, sponsored by the University of Worcester, established a baseline energy consumption profile of residents within the Arboretum in Worcester, England. We performed door-to-door canvassing, spoke with 240 residents, and received a total of 102 survey responses. We found that residents struggle with energy bills, costs of retrofits, and heating. We recommended that future researchers continue to engage the community, create an educational campaign to teach energy conservation behaviors, and facilitate smart meter implementation within the Arboretum.

Executive Summary

The rising demand for fossil fuels has driven a surge in the cost of oil, and has forced both consumers and nations to look for ways to reduce their energy consumption. This increase in the cost of oil has a vast impact on the production of goods, transportation, and most importantly the cost of living for many individuals in the world. UK homes are among the least thermally and energy efficient in Western Europe and are responsible for 28% of UK's total carbon dioxide (CO_2) emissions annually. In order to combat this, the government has instituted regulatory programs for citizens to reduce CO_2 emissions through energy conservation activities.

The University of Worcester (UW), located in Worcestershire County, UK is working with students, landlords, the Worcester City Council, and other stakeholders in an effort to reduce energy use in residential buildings. Building on a program known as "Student Switch Off," the University has developed a new initiative called Energize Worcester. This initiative received funding from the National Union of Students (NUS) Student Green Fund to continue the initial student led program.

Figure 1: A view of Worcester from the Cathedral (Photo: Chas Frick, 2014).

With the success of the Energize Worcester program, our project sought to expand the Energize Worcester program to non-student residents within the Arboretum of Worcester, a small neighborhood of around 800 residences. Our objectives to achieve this goal were assessing local housing conditions and understanding the community demographic, studying the community perception and attitudes towards sustainability and energy conservation, and assessing the feasibility of educational materials to teach sustainability behaviors to those in this community. In order to implement this project, the University of Worcester has partnered with Worcester Polytechnic Institute (WPI) to develop a baseline energy consumption profile of the Arboretum. To achieve this goal, we worked closely with the Director of Environmental Sustainability for the UW, Katy Boom; the Project Manager of Energize Worcester, Peng Li; the Worcester City Council; and the secretary of the Arboretum Residents Association, member of Transition Worcester and Arboretum resident, Paul Brohan. As an overall goal we aimed to influence consumer behavior to be more sustainable.

Literature Review

Carbon footprint

Every action has an effect on the environment; the extent of the actions is measured by the carbon footprint. Carbon footprints are essentially a measure of the CO_2 emissions. The carbon footprint is directly proportional to the amount of CO_2 emitted into the atmosphere due to combustion of fossil fuels. According to the website Energy Saving Trust, the UK aims to reduce CO_2 emissions by 80%, below the recorded levels in 1990, by the year 2050 (Energy Saving Trust, 2014). One way to accomplish this is to

shift towards more carbon efficient forms of technology and reduce the extensive packing and processes behind products (Climate Group, 2008).

To help solve the energy efficiency issue, the government has instituted a program known as the "Green Deal." This "Green Deal" is a financial compensation program where the government "provides energy efficiency improvements to properties at no up-front cost to landlords" (NLA, n.d.).

Consumer Behavior and Direct Feedback

Energy utility companies need to realize that not all consumers will implement energy retrofits inside their homes. For low-income consumers, acquiring expensive but technologically advanced and energy-efficient products may not be their first option. Nonetheless consumers desire low cost options for reducing energy consumption. While cost is important, a "rewards-based incentive program" is a good strategy to use to convince customers to change their energy consumption behaviors (Shaw, 2012).

Direct feedback, with regard to electricity usage, is a strategy where electricity consumption data is provided back to consumers in almost real time (Faruqui et al., 2010b). Hunt Allcott and Sendhil Mullainathan in their article on Behavioral Science and Energy Policy describe how many behavior programs fail because of a lack of feedback of some form (Allcott, 2010). Sarah Darby, in her 2006 literature review on the Effectiveness of Feedback on Energy Consumption, states that "without feedback it is impossible to learn effectively" (Darby, 2006b, p.17). This feedback can be accomplished in a number of ways including using an in-home display in combination with a smart meter or even by simply using the smart meter alone.

Methodology

To start the project we conducted a site assessment, which included mapping who lived in the Arboretum using our house-by-house checklist and a short questionnaire (Appendix H), conducting a main survey (Appendix K), and documenting the external conditions of houses for evidence of solid walls. To better understand the region, we also compiled a listing of all of the Energy Performance Certificates (EPC) on the various properties around the Arboretum. We did this for all of the streets in the Arboretum, and from these EPCs we were able to understand the baseline levels of sustainability for the region in terms of energy efficiency and possible energy retrofits for the properties. As part of our site assessment, we performed a door-to-door canvassing of the Arboretum and initiated our work by distributing 724 leaflets to homes in the area to inform residents of our surveying.

We approached every residence in the Arboretum to find out who lived at each property. In the beginning, the project focused on tenants living in houses of multiple occupancy (HMOs), as defined by the Worcestershire City Council. Due to the low response rate from HMO tenants, we expanded the project to any residents willing to speak with us. We asked interested residents to fill out our main survey and one of our team members can be seen helping a resident work through the survey in Figure 2.

Figure 2: Chas Frick surveying an Arboretum resident (Photo: Alex Shoop, 2014).

Results and Discussion

Site Assessment

Our site assessment revealed a quiet and friendly neighborhood with many solid wall terrace houses dating to the 1890s. We learned that solid wall has several drawbacks when it comes to wall insulation: the insulation becomes costly, physically intrusive into a room and difficult to install. Additionally, solid walls are less thermally efficient than cavity walls. Our site assessment also revealed that despite residents' best efforts, some homes still experience damp and mold. These are problems that can easily be fixed by proper insulation, by keeping homes at correct temperatures in the winter and by using dehumidifiers.

Housing and Demographics

Part of the project involved EPCs which are required for every property that is rented (excluding HMOs), built or sold. These EPCs are publically available online through a web search using the postal code and address of a property. The important information from an EPC is the current and potential rating of a property. The current and potential ratings of a property score the overall energy efficiency features and retrofit capabilities of a property. Other highlights of an EPC are the cost of living (energy bill cost) in the property, as well as an estimate of the costs to retrofit the property and improve the property's energy efficiency.

We received 102 survey responses from residents of the 195 surveys that we gave out, resulting in a 52% response rate. Within the group of responses for our survey a majority (62%) of these people owned their homes. Only 38% of respondents rented their homes and only 16% of all respondents rented and shared the property with others.

In terms of demographics of those who responded, a majority were males. Above half of the respondents were 46 years of age and over (almost 58%), and the majority of the responders (84%) were White from the British Isles (i.e. English, Welsh, Scottish or Northern Irish). A solid 50% answered that their income was less than £20,000 a year. This correlates well with the fact that the largest age group of respondents was over the age of 60 and living on pensions.

Perceptions and knowledge of energy conservation

The most common retrofits in the Arboretum are double glazed windows and energy saving light bulbs (mainly compact fluorescents or light emitting diode bulbs). Other less common types of retrofits include energy efficient boilers and loft insulation. We found low levels of wall insulation primarily because of the old Victorian style of solid wall housing.

Our survey also showed that residents generally share an average level of awareness of retrofit technologies and energy saving behaviors, as respondents ranked themselves around 5, "average knowledge," on a scale of 1, "no knowledge," to 10, "expert knowledge." Additionally Figure 3 shows that many residents are aware of and perform many simple energy saving behaviors.

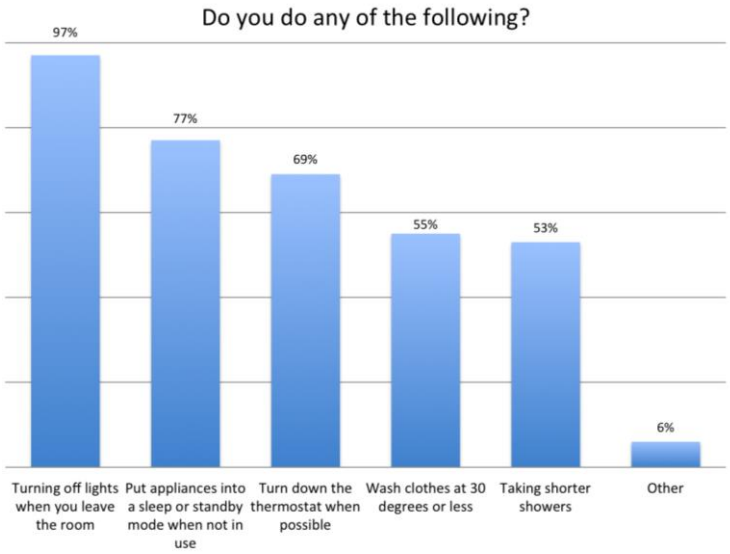


Figure 3: Percentages of respondents performing energy saving actions

From our data, the community profile of the Arboretum is a neighborhood with a diverse but aging populous with varying levels of energy consumption knowledge, and properties that contain various stages of retrofits.

Discussion

Overall the data shows that the community is diverse and perceptive of many retrofits and energy saving behaviors. However, not everyone has installed these technologies due to large expenditures required to purchase energy efficient technology and because many people live on a low income. Some older residents oppose investing in retrofits for their homes because they feel that they will not experience the benefits in their lifetime. Naturally, the available technology must also be taken into account when considering retrofits. As one resident said "just remember the majority of houses in the Arboretum were built before WW1, therefore luxuries like cavity walls and insulated building blocks are out!" (Survey 63). This is important to note when discussing housing conditions as most homes contain solid walls, thus many homes require exterior insulation and cause significant expenses to residents.

A majority of residents does try to monitor their energy consumption however. To aid in this endeavor, about half of the participants want smart meters installed. Some

respondents indicated they already owned a smart meter. Other residents indicated they may not have enough information about how a smart meter can benefit them by leaving the "Do you want a smart meter?" survey question blank. We believe others may fear an additional charge on their monthly energy bill caused by the smart meter and do not want a smart meter.

However, there are those who do not monitor their consumption as they were too busy with other activities or did not care about their consumption. In some cases the landlord paid the bills and the tenants had no motivation to monitor consumption. Some respondents indicated they did not know enough about the monitoring process. To this end a majority felt there were insufficient educational campaigns to teach energy saving behaviors. From speaking with several residents, we also perceived the potential need for multilingual information dissemination for this campaign to best engage all the demographics of the community.

Recommendations

Our first recommendation results from the fact that our largest response group was the elderly (65 years of age and over). This is most notable in the Arboretum Residents Association as this group is primarily comprised of retired residents. Ideally, as the University's Energize Worcester program moves forward, it should involve all age groups and demographics to achieve maximum implementation. Future teams may want to consider hosting informal barbeques or design competitions with prize vouchers redeemable at local businesses as incentives for the younger community to participate.

In terms of educational campaigns, the majority of participants said that there is an insignificant amount of educational campaigns to teach energy saving behaviors and roughly half said they would be interested in learning more on how to save energy through a leaflet. Thus, we recommend using a modification of our prototype booklet (Appendix N), which gives information on a number of knowledge gaps in the area. These include the lack of information regarding solid wall insulation, the Green Deal, smart meters, EPCs and other energy saving tips. The easiest way to distribute this booklet of information would be another canvassing of the Arboretum (ideally between the hours of 4:30 PM and 7:00 PM) and slipping the document through the mail slot of each residence.

Conclusion

To reiterate, our project focused on establishing a baseline profile of the Arboretum. We determined the types of properties within the Arboretum and who lived at each residence, and showed the breakdown of owned and rented homes. Our surveying showed that there are those who are more energy efficient and knowledgeable of sustainability, but many still could lower their energy bills. Almost half of respondents felt that they spent too much on their bills, and while some properties could not be made more energy efficient, many still wished to learn more about energy saving behaviors through an informational leaflet. With this knowledge, future teams could better tailor programs to engage all the various demographics through more informal events within the community. With our initial work, we are confident that we have established a solid foundation for future programs to increase the overall sustainability of the region.

Acknowledgements

First a special thanks to Katy Boom, Director of Environmental Sustainability and Peng Li, the project manager, for their invaluable support and guidance during the project, and to the University of Worcester for providing the accommodations and office space for the length of the project time. We also thank all the other staff members around the University who helped with testing of the prototype survey.

We also thank the Worcester City Council for meeting with us, listening to our presentation, providing feedback on surveys and giving us the permission to complete our door-to-door canvassing of the region. Thanks to the deputy Mayor of the City of Worcester, Roger Knight, for giving us a tour of Guild Hall (the City Council meeting chambers). Additional thanks to the Director of Finance and Corporate resources at HEFCE (Higher Education Funding Council for England), Steve Egan, Pro Vice Chancellor of Students, John Ryan, and Lord Richard Faulkner of Worcester for listening to our project and bringing enthusiasm to the meetings we had with them.

In addition we want to give an extra special thanks to Mr. Paul Brohan, an Arboretum resident and the Secretary of the Arboretum Residents Association, for his contributions to technology for future projects, expertise on retrofits and for allowing us to use his mail slot as a centralized collection for surveys within the Arboretum.

Lastly we thank Professor Carolina Ruiz and Professor Dominic Golding for helping get us settled into the University and we give a hearty thank you to Professor Ingrid Shockey and Professor Carolina Ruiz for contributing countless revisions and feedback on our many drafts and submissions.

Without the assistance of these people our project would not have been possible.

Authorship

Each team member contributed equally to the overall completion of this report. This includes, but is not limited to, the literature review, data gathering, and paper writing. We would like to give special thanks to team member Chas Frick who took charge and led the team for the majority of this project.

Table of Contents

Abstract i
Executive Summary ii
Acknowledgements vii
Authorship viii
List of Figures xi
List of Tables xi
Chapter 1. Introduction 1
Chapter 2. Literature Review 3
2.1 Site description 3
2.2 Stakeholders 4
2.3 Understanding sustainability and carbon footprint 5
Sustainability 5
Carbon footprint 6
2.4 Pre-existing programs for technology upgrade 7
2.5 Background to smart meters 8
2.6 Background to consumer behavior 10
2.7 Case studies of in-home displays and direct feedback 11
2.8 Energy-efficient lighting case study 12
2.9 Case study of overall household sustainability 14
2.10 Thermochrons 17
2.11 Summary 18
Chapter 3. Methodology 20
3.1 Assessing local housing conditions and understanding the community demographic 20
3.2 Understanding community perception and attitudes towards sustainability and energy conservation 22
3.3 Assessing the feasibility of educational materials to teach sustainability habits to those in this community 23
3.4 Final compilation of data 24
3.5 Timeline 24
Chapter 4 Results & Discussion 26
4.1 Site assessment 26

4.2 Local housing conditions and community demographics 27
4.3 Perception and knowledge of energy conservation 34
4.4 Feasibility of educational campaigns 40
4.5 Discussion 41
Demographics 41
Income 42
Nationality 43
Housing conditions 43
Community awareness 44
Additional observations 47
Chapter 5. Recommendations & Conclusion 49
Community engagement 49
Educational campaigns 50
Toolkit and best practices for follow-on work 51
5.2 Conclusion 52
References 53
Appendices 62
Appendix A – Additional smart meters background 62
Appendix B – Additional consumer behavior background 67
Appendix C – Additional information regarding in-home displays and direct feedback 69
Appendix D – Additional information regarding energy-efficient lighting 71
Appendix E – Landlord letter created by the University of Worcester 73
Appendix F – Leaflet notification slip for Arboretum residents 75
Appendix G – Cards for when no resident was available 76
Appendix H – Door-to-door canvassing initial questionnaire and notes 77
Appendix I – Permission letter we carried when surveying 78
Appendix J – Cover letter for main survey 79
Appendix K – Main survey 80
Appendix L – Landlord survey 86
Appendix M – Worcester News article on project 91
Appendix N – Our prototype booklet 93
Appendix O – Summarized survey responses 95

List of Figures

Figure 1: A view of the Arboretum community (Photo: Alex Shoop). 3
Figure 2: Cross sectional views of several types of envelopes (Mehta, 2013). 15
Figure 3: Gantt chart breakdown of project tasks. 24
Figure 4: Venn diagram of data collection methods for our objectives. 25
Figure 5: Several solid wall properties (Photo: Alex Shoop, 2014). 26
Figure 6: Mold buildup in the attic (Photo: Stefan Smith, 2014). 27
Figure 7: A sample Energy Performance Certificate (Landmark, n.d.). 30
Figure 8: The canvassed region of the Arboretum. 31
Figure 9: Reported occupancy of Arboretum residences. 32
Figure 10: Breakdown of annual incomes among respondents. 34
Figure 11: Percentages of appliances with eco-friendly labels or stickers. 35
Figure 12: Percentages of reported consumers' energy saving actions. 36
Figure 13: Percentages of primary purpose reported for energy saving actions. 37
Figure 14: Percentage response of common barriers to energy saving actions. 37
Figure 15: Percentage responses on monitoring gas and electricity consumption. 38
Figure 16: Percentage of responses regarding monthly energy bill costs. 39
Figure 17: Percentage response of best delivery methods of energy saving information. 41
Figure 18: Heavy traffic in the Arboretum on Northfield Street (Photo: Alex Shoop, 2014). 48

List of Tables

Table 1: Average Energy Performance Certificate (EPC) grades for the Arboretum. 29
Table 2: Responses regarding fuel type usage. 32
Table 3: Reported temperature settings for residences in summer and winter. 33
Table 4: Percentages of reported energy retrofits in homes. 35
Table 5: Percentages of respondents who had heard of different organizations 40
Table 6: Distribution of preferred energy savings information source 40

Chapter 1. Introduction

The rising demand for fossil fuels has driven a surge in the cost of oil, and has forced both consumers and nations to look for ways to reduce their energy consumption. This increase in the cost of oil has a vast impact on the production of goods, transportation, and most importantly the cost of living for many individuals in the world. Fortunately, scientific and technological advances in recent years have increased the efficiency and availability and decreased the cost of alternative energy technologies, thus making these advances more attractive.

UK homes are among the least thermally and energy efficient in Western Europe and are responsible for 28% of UK's total carbon dioxide (CO_2) emissions annually. In order to combat this, the government has instituted regulatory programs for citizens to reduce CO_2 emissions through energy conservation activities. To this end, each citizen and household becomes accountable to reduce energy consumption.

College campuses and residential halls are among institutional settings that are pressed to lower energy usage. The University of Worcester (UW), located in Worcestershire County, UK is working with students, landlords, the Worcester City Council, and other stakeholders in an effort to reduce energy use in multiple occupancy rental housing. Building on a program known as "Student Switch Off," the University has developed a new initiative called Energize Worcester. This initiative received funding from the National Union of Students (NUS) Student Green Fund to continue the initial student led program. The program aims to encourage students to retrofit energy improvements and to adopt energy saving habits. The goal is that students spread these energy conservation behaviors with those in their communities as they move to non-university living accommodations.

With the success of the Energize Worcester program, our project sought to expand the Energize Worcester program to non-student residents living in Houses of Multiple Occupancy (HMOs) within the Arboretum of Worcester. The Arboretum is a small neighborhood of around 700 residences bounded by Landsdowne Road in the North, the railway in the South, Sansome Walk in the West and the Worcester Birmingham Canal in the East. In order to implement this project, the University of Worcester has partnered with Worcester Polytechnic Institute (WPI) to develop and conduct a baseline energy consumption profile of the Arboretum. To achieve this goal, we worked closely with the Director of Environmental Sustainability for the UW, Katy

Boom; the Project Manager of Energize Worcester, Peng Li; the Worcester City Council; and the secretary of the Arboretum Residents Association, member of Transition Worcester and Arboretum resident, Paul Brohan.

The initiatives promoted by the university are not new. In fact the Department of Energy and Climate Change (DECC) of the UK Government has already started a program of residential energy audits, which tallies many of the costs and energy saving measurements for a given household. The Energy Performance Certificate (EPC), as a part of this audit, also provides a listing of proposed retrofitting options for saving energy. These options can be either partially funded or completely funded through a program known as the "Green Deal" as published by the DECC. Similar certifications exist in other countries as well such as the Leadership in Energy and Environmental Design (LEED) Certification of the US Green Building Council, which ranks the energy efficiency and sustainability of buildings in the US. The main purpose of these programs is the physical realization of energy conservation measures that not only reduce costs to tenants, but also allow for an energy-sustainable future.

As an overall goal we aimed to influence consumer behavior to be more sustainable. Our objectives to achieve this goal were assessing local housing conditions and understanding the community demographic, studying the community perception and attitudes towards sustainability and energy conservation and assessing the feasibility of educational materials to teach sustainability behaviors to those in this community.

In order to best frame the complexity of the problem, we present a review of the literature and background for this project, describe our methods to achieve our objectives, present selected data from surveying and outline recommendations for continuing our work.

Chapter 2. Literature Review

This literature review discusses background research that was conducted for the project report. First we cover a description of the project site, followed by an analysis of the key stakeholders, and definitions of terminology specific to this topic. We include essential information on smart meters, consumer behaviors/perceptions on energy conservation and direct feedback to improve consumer knowledge, action and household sustainability.

2.1 Site description

The standard home in the Arboretum tends to be a terraced-style building as can be seen in Figure 1, which shows Wolverton Street and Chestnut Street. More specifically, the Worcestershire County Council identifies the typical houses in the Arboretum as terraced, flat/maisonette, semi-detached or detached houses (Worcestershire County Council, 2013). The same article also states that 54.8% of the population of the Arboretum is categorized as "comfortable communities" which are essentially middle class communities (Worcestershire County Council, 2013).

Figure 1: A view of the Arboretum community (Photo: Alex Shoop).

The sponsor for this project is the University of Worcester, a mixed liberal arts and life sciences higher education institution located in Worcester, England. The university is located near the center of the city, which hosts a population of about 100,000 people. Worcester is roughly two and a half hours by train from London, a distance of approximately 200 kilometers.

The Director of Environmental Sustainability for the university, Katy Boom, in addition to the project manager for Energize Worcester, Peng Li, supported and oversaw the project through completion. The overall goal of the Energize Worcester program is to reduce the energy consumption of students in student housing on the University of Worcester campus. To achieve this, the program emphasizes energy-saving behavioral policies for students. This organization has its roots as a student initiative through the University of Worcester Student Union and grew into its own program after winning a sustainability-oriented competition as part of the Higher Education Funding Council of England's Student Green Fund (HEFCE, 2013).

While student programs are well underway at the university, within the city of Worcester another organization dedicated to energy conservation and increasing energy conservation, called Transition Worcester, seeks "a positive vision of a resilient and sustainable future beyond the age of abundant fossil fuel energy" (Transition, 2014). Transition Worcester tries to reduce the influence and dependence on foreign oil and "transition" the city of Worcester and regional communities towards more sustainable practices through programs aimed at educating the townspeople on sustainable practices, increasing connections with other sustainability initiatives and further growing the number of green spaces available in Worcester for local gardens (Transition, 2014).

2.2 Stakeholders

Our project targeted many different but interconnected parties and interests. The primary stakeholders were residents in the Arboretum, and the landlords who own rental properties in the area. Among this mostly English-speaking middle-class community are families and individuals representing a variety of age ranges: from mid-20s to elderly residents. Those living in the area were not adversely affected by this census-based collection.

In terms of rental properties, landlords can benefit from lower overall bills and happier tenants. To reduce energy bill costs landlords may have to implement any retrofits and shoulder the full financial burden of these technologies if programs for financial compensation are not available. The landlords also benefit in that they may have lower maintenance costs and fewer repairs (NLA, n.d.). The landlords may also be able to potentially charge higher rental rates with

a more prime property where the tenant is saving money (NLA, n.d.). Another benefit is that the tenant may want to increase their rental time due to the new energy saving measures (NLA, n.d.).

Other stakeholders included the neighboring residences to the Arboretum and the city of Worcester as a whole. One important note is that this project specifically focused on the Arboretum and the recommendations are for this population alone.

2.3 Understanding sustainability and carbon footprint

In order to increase the sustainability of the Arboretum, the residents must understand the vocabulary that accompanies energy conservation programs. This section introduces and defines several of the terms used in this literature review and the project.

Sustainability

Sustainability is a term that is often over-used without consensus of what it means or how to actually measure sustainable behavior. The Merriam-Webster dictionary defines sustainable as: "able to be used without being completely used up or destroyed" (Merriam-Webster, 2014). Sustainability in ecology means that the production and use of energy will be able to be continued at the same level or higher for an extended period of time (decades/centuries) without causing negative effects on the environment and without fear of a diminishing energy source (e.g. fossil fuels). Within the scope of this project, the definition of sustainability will be any process or resource whose extraction and availability is guaranteed for at least the imaginable future. This also applies to types of energy production wherein the conversion is from a renewable (readily available into the near future) resource (e.g. solar energy, wind energy, thermal energy) to a readily usable power source such as electricity or heat. Naturally, in order for the consumption of electricity to be sustainable, the consumption of electricity must be matched by electricity production. In order to ensure this process is sustainable, all aspects of production must be sustainable and use renewable resources.

We define "energy efficient" as a term that accompanies processes or products which reduce or minimize their energy usage and environmental impact. Those who have "environmental consciousness" consider the environmental consequences of their actions and strive to be energy efficient whenever possible. Tied into this definition is the concept of being

"green." For the purpose of this report we define the word "green" to describe processes, activities and resources that are environmentally sustainable, have low effect on the environment or have a low carbon footprint as defined below.

Carbon footprint

According to the Intergovernmental Panel on Climate Change (IPCC) in their Summary for Policymakers summarizing the 2013 IPCC report on climate change:

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (IPCC, 2013, p. 4).

Every action has an effect on the environment; the extent of the actions is measured by the carbon footprint. Carbon footprints are essentially a measure of the carbon dioxide (CO_2) emissions. The carbon footprint is directly proportional to the amount of carbon dioxide emitted into the atmosphere due to combustion of fossil fuels. According to the website Energy Saving Trust, the UK aims to reduce carbon dioxide emissions by 80%, below the recorded levels in 1990, by the year 2050 (Energy Saving Trust, 2014). One method of doing this may be to use a comprehensive program of production comprised of a multitude of renewable energy sources. In his 2009 book "Sustainable Energy - Without the Hot Air," David MacKay details five plans that break down the required percentages of each renewable resource to generate the entirety of UK electrical consumption and reduce the UK's carbon footprint (MacKay, 2009).

Moreover there are many ways to reduce one's carbon footprint. The Climate Group describes one process known as "dematerialisation," which they define as "the substitution of high carbon products and activities with low carbon alternatives for example, replacing face to face meeting with videoconferencing, or paper with e-billing" (Climate Group, 2008, p. 29). This "dematerialisation" is a shift towards more carbon efficient forms of technology and a reduction in the extensive packing and other preparation processes behind products (Climate Group, 2008). The Climate Group also recommends a number of other ways to reduce the carbon footprint such as using SMART motors, SMART grids, SMART logistics and SMART buildings (Climate Group, 2008). The real benefit of using this technology is an overall reduction in the CO_2

emissions, and in conjunction with technology upgrade policies, these new methods of carbon footprint reductions can become multiplicatively effective. With an understanding of the terminology of sustainability, consumers can further explore technological options to bring the abstract vocabulary to concrete actions.

2.4 Pre-existing programs for technology upgrade

With the British government deciding to reduce the overall carbon footprint, the citizens have to reduce energy consumption (Energy Saving Trust, 2014). One method of reducing the overall energy consumption is to use the most energy efficient technology possible. This technology (e.g. heating systems, lighting systems, metering systems) tends to be expensive and a financial burden for a landlord or tenant to take on. To help solve this dilemma the government has instituted a program known as the "Green Deal." This "Green Deal" is a financial compensation program where the government "provides energy efficiency improvements to properties at no up-front cost to landlords" (NLA, n.d.). The program recommends an energy audit and Green Deal assessment of all property (NLA, 2014). This process is split into two parts: the "technical assessment" and the "occupancy assessment" (NLA, 2014), which look at the actual energy efficiency of the home and the consumer behavior. The British government already has a method for auditing energy efficiency of a house called an Energy Performance Certificate (EPC), which lists the various energy features of the house and how energy-efficient each feature is as compared to the latest technology (DECC, 2012a). This report, in conjunction with the Green Deal, rates each feature of the home (such as insulation, heating, lighting, walls, windows and hot water) and then specifies a series of recommended steps for the user to take for retrofitting their residence (DECC, 2012a). The Green Deal is incorporated into these EPCs to show how the various energy efficiency measures can actually be implemented and financed by the person who pays the bills (DECC, 2012a; NLA, 2014). With the list of improvements from the assessments, both the landlord and tenant can come to a consensus on which improvements to implement (NLA, 2014). After both parties agree, the Green Deal provider supplies a loan to support the retrofits, which is to be paid back by a certain portion of each utility bill (NLA, 2014).

However, this requires good mutual communication and understanding of the program and its potential benefit for both landlords and tenants. Another important aspect of the program

is that not all improvements can be financed under this program. The full listing can be found on the National Landlords Association website under the name of "Measure qualifying for the Green Deal and ECO" (NLA, 2013). If a certain provision is not supported then either the tenant or landlord will have to front this cost potentially raising financial stress or perhaps altogether removing any chance of the improvement occurring. For the many technological improvements supported by the Green Deal, it is important to remember who is paying the bills. If the landlord pays the bills then the tenant will see and use the improvements while the landlord pays and this can create an issue the National Landlord Association calls the "Split Incentive" (NLA, 2014). The purpose of the Green Deal financing option is to assess the current bills and create a payback plan that can enact the improvements while lowering or keeping tenant bills the same in a principle called the "Golden Rule" (NLA, 2014). This operates because the technology will reduce the costs and bills into the future, even if prices for electricity increase, thus the tenant will still see savings (NLA, 2014). This program is one governmental plan to help reduce the consumption through alteration of the rental property. A drawback to this program is that it focuses on the living space rather than alteration of the consumer behavior. In order to change the consumer behavior and reduce consumption other methods are needed. One such method is to implement a smart meter.

2.5 Background to smart meters

In recent years a new style of electricity meter called a smart meter has been introduced to help increase transparency and facilitate meter readings. In their 2008 report called "SMART 2020: Enabling the low carbon economy in the information age," the Climate Group defines smart meters as "advanced meters that identify consumption in more detail than conventional meters and communicate via a network [such as 3G or wireless] back to the utility for monitoring and billing purposes" (The Climate Group, 2008, p. 85; MacDonald, 2007).

Several potential benefits to the consumer deriving from smart meters include the potential for a real-time indication of current and past electricity usage, "fraud reduction," the elimination of a human meter reader and the associated lost time waiting for the person to show, a "detailed consumption feedback to the utility," "easier supplier switching" for changing energy companies and the ability to incorporate renewable energy generation sources into the home

electrical supply (Darby, 2010b, Table 1). Another advantage that smart meters have is that they allow two-way communications between the consumer and the supplier. This allows the power company to send feedback to the consumer in the form of alerts, notifications, and other energy saving tips (Darby, 2010b). As Sarah Darby points out, effective forms of feedback in the smart meter should include at least two of the following: "an interactive element," "detailed appliance-specific breakdown of [energy] usage," data in the form of "continuous [consumption information], daily load curves, or immediate [plotting of energy usage] after the action [of switching on or off and appliance]," and data "comparisons with previous periods" (Darby, 2010b). This information could be displayed on the meter itself or through a new display, such as an in-home display (IHD). For more information on IHDs, please consult section 2.7.

It would seem that given the benefits from smart metering, consumers would flock to smart meters, but the major deterrent is cost. In order to bolster the use of smart meters, the UK has announced the installment of a smart meter in all UK homes by 2020 (Kearney, 2010). For the European Union (EU), as a whole, to implement smart meters the cost would be around €51 billion (Faruqui et al., 2010a). In the same paper Ahmed Faruqui et al. estimate the savings after implementing smart meters to be between "€26 and 41 billion, leaving a gap of €10-25 billion between benefits and costs" (Faruqui et al., 2010a). Obviously the consumers cannot be expected to make up the difference, but herein lies another benefit of smart metering: dynamic pricing (Faruqui et al., 2010a). A dynamic pricing system would essentially allow suppliers to change the cost of electricity on an hourly basis to change more during peak hours (Faruqui et al., 2010a).

No form of technology or innovation is perfect. One of the first issues that has been raised concerning smart meters is the potential for adverse health effects. In order to relay information back to the smart grid and ultimately to utilities and consumers, the smart meter uses Radio Frequency (RF) waves (like those used for cell phone communications) (Monterey County Health Department, 2011). The main concern raised with these RF waves is the likelihood of contracting cancer, as the waves are electromagnetic radiation (Monterey County Health Department, 2011). The Monterey County Health Department does describe the lack of long term studies into the effects of these low levels of RF radiation from smart meters on humans, but has done long term studies on radiation from cell phones and microwaves and concludes the

danger is minimal (Monterey County Health Department, 2011). For more information on smart meters, please consult Appendix A to find more discussion of this technology.

2.6 Background to consumer behavior

Within society itself, no matter how many different organizations offer energy efficient products or how many authors report on the benefits of energy conservation techniques, there will always be people who are skeptical, uncooperative, in denial, or opposed. However, by judging the situation from an expert point of view, changes to the technical energy consumption in a household will lead to a profitable outcome in relatively short payback time periods (Zundel, 2011). For low-income occupants though, going after expensive but technologically advanced and energy-efficient products may not be their first option.

Nonetheless occupants desire low cost options for reducing energy consumption. Comfort, needs, status, and convenience may be factors in changing one's energy use behavior, but there is no argument that the economic aspects are the sole deciding points. As stated by Stefan Zundel in his 2011 journal article on consumer behavior, research finds that residents underestimate the vast potential of energy savings they can achieve within their homes by simply changing their consumption behaviors (Zundel, 2011). In particular, when residents change the way they use the hot shower, the furnace, or the kettle, the heating bill will be noticeably reduced.

Energy utilities need to realize that not all consumers will engage in energy retrofits changes inside their homes. It was found that in a study done on approximately 30,000 households, only 13.4% of them would try out energy efficient programs if they were allowed "to earn points for reducing [their] energy use - where points are redeemable for cash, merchandise" (Shaw, 2012). A "rewards-based incentive program" is a good strategy to use to convince customers to change their energy consumption behaviors, but companies should also consider education and engagement strategies aimed at encouraging consumers to change their habits by their own free will (Shaw, 2012).

Yet another important concept to consider for consumer perception of sustainable products is what "kind" of product the consumer would purchase. "Gentleness-related" attributes in products versus the "strength-related" attributes are found to be essential factors for the

consumer base (Luchs, 2010). Examples of "gentle" products are baby shampoo, house-cleaning products, and hair care items, where examples of "strong" products are tires, drills, and construction related products. In particular when considering a green-version of a gentle product such as hand sanitizer over the normal hand sanitizer, Michael Luchs did extensive testing within cafeteria environment in a business university. Participants were told to choose either versions of hand sanitizer. It was found that a "significant portion of participants chose the green (versus regular) hand sanitizer" (Luchs, 2010). As a counterpoint though, a customer will probably reject a green, energy efficient, and potentially lower performance, power drill for a much stronger normal brand product, simply due to the labeling of "green." To this end, emphasizing the sustainable aspect for strong products can actually harm the image of these products and consumers may prefer the non-efficient counterparts; this is called "sustainability liability" (Luchs, 2010). For more in depth information on consumer behavior, please consult Appendix B.

2.7 Case studies of in-home displays and direct feedback

The Office of Gas and Electricity Markets (OFGEM) is a sub department within the Department of Energy and Climate Change (DECC) in the British Government. This group has performed and analyzed numerous studies on the implementation of smart meters and in-home displays (IHDs). In this context, an IHD is essentially a separate monitor with information regarding the current electricity usage, current pricing, and comparisons to past energy usage data (OFGEM, 2010). According to the OFGEM report "longer-term behaviour change [toward more energy conscientious practices] can be triggered by short-term use of an IHD" (OFGEM, p.17, 2010). In fact the OFGEM recommends requiring energy suppliers provide an IHD to consumers within a year of installation of a smart meter if the customer opts into the program (OFGEM, 2010). The main rationale behind this sort of program is the concept of "direct feedback." Direct feedback is a method where electricity consumption data is provided back to consumers in almost real time (Faruqui et al., 2010b). In their article on informational feedback on energy consumption, Faruqui et al. summarize 12 case studies on the use of direct feedback through IHDs and find an average energy savings ranging from 3 to 13%, with the average savings being 7% (Faruqui et al., 2010b). Another study has shown the potential for direct feedback to reduce household electricity usage by 2 to 28% (Neenan, 2008). This further shows

the need for some form of direct and quantitative feedback to the consumer (Faruqui et al., 2010b).

On a broader topic of publicity campaigns and forms of behavior feedback, Hunt Allcott and Sendhil Mullainathan in their article on Behavioral Science and Energy Policy describe how many behavior programs fail because of a lack of feedback of some form (Allcott, 2010). Darby, in her 2006 literature review on the Effectiveness of Feedback on Energy Consumption, states that "without feedback it is impossible to learn effectively" (Darby, 2006b, p.17).

The main lesson to be learned from this study of consumer behavior with feedback is that the most effective form of changing consumer behavior is direct feedback. As Darby points out in her Literature Review for the Energy Demand Research Project, she mentions that multiple interventions (i.e. advice, community involvement and/or local energy conservation competitions) coupled with feedback prove to be the most effective in altering behavior (Darby, 2010a). This is corroborated by Trilations in their white paper on increasing energy efficiency where the most effective forms of feedback and behavior change included "continuous personal interaction with the consumer" and communication between consumers and utility companies to compare progress (Trilations, n.d., p. 4). For more in depth information on case studies on IHDs and direct feedback, please consult Appendix C.

2.8 Energy-efficient lighting case study

According to the Energy Saving Trust website in the "Lighting" subsection, household light usage accounts for approximately 7% of a household's typical energy bill (Energy Saving Trust, 2014). On the topic of lighting, two actions are taken to save energy: replacing bulbs and turning lights off. For replacement of lighting, there are two types of bulbs available in the UK; compact fluorescent lamps (CFLs) and light emitting diode (LEDs) bulbs. While both bulbs are proven to be energy efficient countless times (Feng et al., 2012; Yuen et al., 2010), in the past many households especially in the USA used incandescent bulbs. For a case study that took place in the Meridian Charter Township in Michigan, USA, researchers evaluated the connection between a person's socio-demographic background and his or her perception of energy-efficient lighting (Park et al., 2013). These researchers' questionnaire contained three main topics: "energy efficient lighting perceptions in general, perceptions of CFLs, and environmental

lighting behaviors" (Park et al., 2013, p. 1). The paper established categories for lighting perception; visual comfort, aesthetics, impression, cost, and technological attributes (Park et al., 2013). A wide category of respondents were surveyed: males and females, ages 25 to 65, low income households (under $50,000 annually) to high income households (over $100,000 annually) and lastly small house sizes (2,000 square feet or less) to large house sizes (over 3000 square feet) (Park et al., 2013).

In terms of perceptions of energy efficient lighting, the results showed that males responded positively to visual comfort, aesthetics, impression, costs and technological attributes (Park et al., 2013). By comparison, females had a more negative response toward each of these attributes of CFLs. This seems to go against another study, in which the researchers expect females to find CFLs appealing "considering environmental concerns and impacts" (Hunter et al., 2004).

When identifying the consumers' perception of CFLs, it was found that inaccurate or insufficient information was available for those contemplating energy efficient lighting (Park et al., 2013). An example was provided by Linda Banwell et al. where a model household was outfitted with CFLs and demonstrated to consumers (2004). This control group was then informed about the basics and benefits of energy efficient lighting (2004). Overall, roughly 90% of the participants answered that they would prefer easier to understand and simpler information available for energy efficient lighting on the market (Banwell et al., 2004).

Another factor about CFLs is that they emit a white "cool" toned light while the previously available incandescent bulbs had a "warm" toned light (Park et al., 2013). Many people are accustomed and are even conditioned to enjoy the warm glow of incandescent bulbs. Therefore these consumers feel skeptical and uncomfortable switching to the cold color of CFLs. For those with sensitivity to the blue-tone of many CFL/LED bulbs, there are other options that replicate incandescent lighting.

Looking at the habitual energy consumption behaviors of households, those that had a low income seemed to express more interest in pursuing, or continuing, energy efficient behaviors in comparison to high income households (Park et al., 2013). Therefore while low-income consumers are not able or willing to invest in an expensive green alternative, their behaviors tend to be greener than higher income consumers.

The case studies seemed to suggest that marketing strategies should offer simple, updated, and interesting facts about energy efficient lighting for all ages and genders. Researchers and publicists should work together to combat the misconceptions and inform the consumers concerning the benefits of new lighting technology (Park et al., 2013). For more in depth information on the case study on energy-efficient lighting, please consult Appendix D.

2.9 Case study of overall household sustainability

Architectural engineers usually call the exterior of a house the envelope according to Building Construction by Medan Mehta (Mehta et al., 2009). It is essential that the envelope be sealed against air infiltration and air exfiltration. This will result in lower heating and cooling expenditures. This does not however mean that the house is to be sealed airtight; the house should still be able to "breathe," reducing the risk of toxic mold and similar blights from occurring. According to Brenda Boardman in her 2004 article in Energy Policy, "there is a direct link between our energy-related behavior and climate change" and that "it is increasingly clear that major carbon reductions cannot be achieved without active support and positive actions by the residents of the developed countries" (Boardman, 2004). The most practical method to improve household energy efficiency is to target two main areas: the envelope and the systems of the household. The envelope is divided into subsections: the exterior, the interior, the windows and the doors. Meanwhile the systems of the household are divided into subsystems such as the water system and the heating and cooling systems; these subsystems are broken down into subsections such as appliances (e.g. refrigerator, freezer, washing machine).

The following diagram (Figure 2) from Mehta shows the typical cross sections of sample envelopes and gives a good representative picture of insulation and structural components.

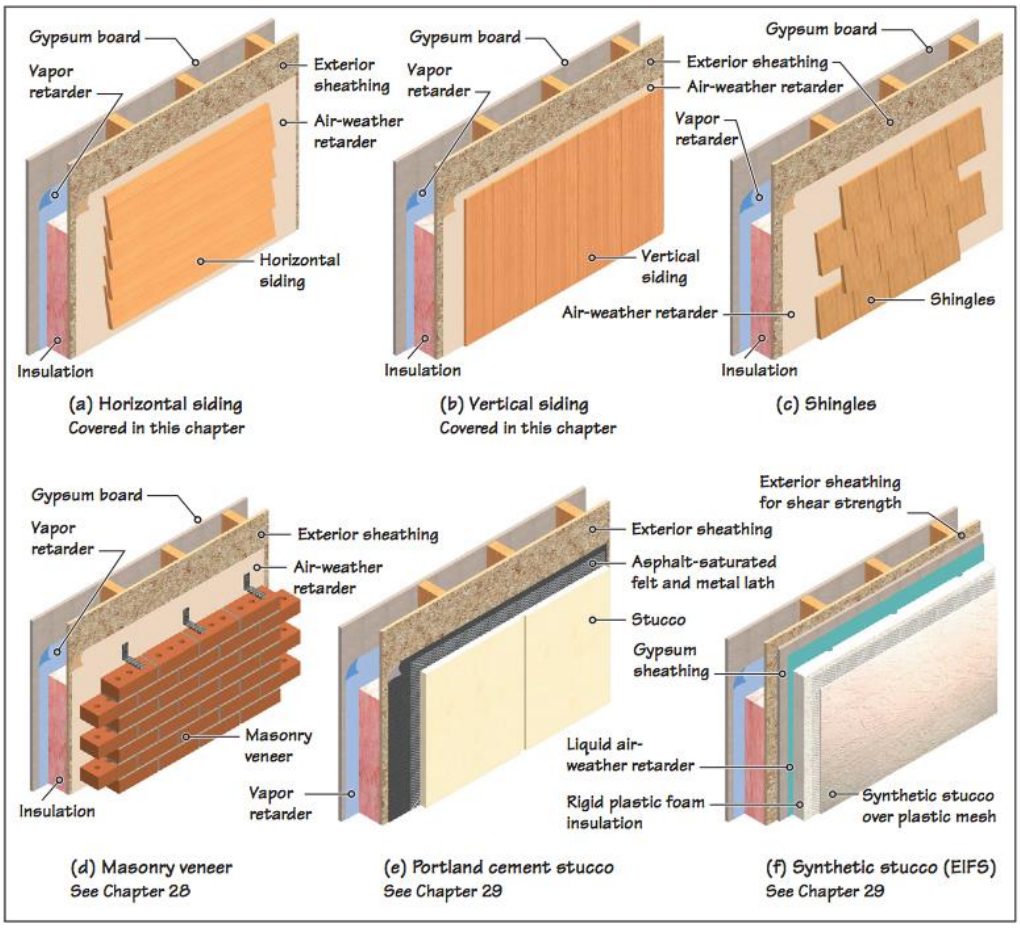


Figure 2: Cross sectional views of several types of envelopes (Mehta, 2013).

We investigated a variety of ways to improve insulation and to seal leaks contained in the envelope of the household, creating a more comfortable and energy efficient atmosphere. In conjunction the analysis of the exterior and interior is essential (Mehta et al., 2009). Effective insulation decreases the chance of heat flowing out of the house during winter and into the house during the summer; resulting in less energy being used in heating or cooling respectively. The exterior and interior of homes are mutually inclusive and it is essential to implement similar insulation methods for both to maximize the effectiveness of insulation.

Beyond adding insulation, a homeowner can caulk holes and gaps in the exterior envelope to better seal the home. Sealing minute holes can increase the thermal efficiency of the household (John, n.d.). Wind drives air into gaps and when it rains, there will be both water and air infiltration (John, n.d.). Caulking helps with energy conservation, but also with building

preservation as well (John, n.d.). Additionally, gaps in baseboards and hard floors should be filled to prevent air entering from the ground level (John, n.d.).

Another important consideration of the envelope of a home is the windows. Old windows can be adapted with energy saving models to boost their energy efficiency. According to the EnergyStar.gov website, replacing single-pane windows will save 7% to 15% of the heating and air-conditioning bills per year, which results in about $146 to $500 payback per year (U.S. Department of Energy, 2009). Along with this, some example energy saving retrofits that do not involve a lot of time and money are weather-stripping and adding storm windows (Research Triangle Institute, 1990).

Weather-stripping sealant is clear caulk designed to stick in place but can be peeled off without damaging the infrastructure finishing when the weather stripping is no longer required. Reports suggest that weather-stripping reduces air infiltration and also stops dust particles and insects from entering the house (Bartos, 2006). However one disadvantage of temporarily caulking windows is that once the caulk is in place, the window cannot be opened without destroying the seal (Bartos, 2006). This is problematic when there is a day when the occupant wants to open the window for a warm breeze or to simply let air in.

Another option is to implement disposable, interior storm windows; they are effective in keeping out cold drafts and increasing the R-value of a window assembly (Cohen, 2006). However one disadvantage of this option is the windows must remain shut (Cohen, 2006). This is an ideal option when the windows will be closed for a couple of months. While these are effective in preventing heat loss, they are noticeable and might look alarming in the more formal areas of the home (Cohen, 2006). On the other hand installing them can add an extra layer of glazing and cut down on neighborhood and traffic noise (Cohen, 2006). These storm windows keep out dust and dirt that might filter through leaky “prime” windows (Cohen, 2006).

However, to effectively achieve complete energy efficiency, the systems within the household have to be examined and improved. Appliances and systems need to be checked and maintained to reduce the energy wasted (Cohen, 2006). Dust that collects on appliances and irregular maintenance of heating and cooling equipment results in energy being wasted (Cohen, 2006). The coils underneath and behind a refrigerator attract dust particles. This is unpleasant to the eye and the dust on the coils prevents the exhaust fan from effectively removing heat (Cohen,

2006). To properly correct this, vacuuming and cleaning the coils helps the fridge to operate at its maximum performance level (Cohen, 2006).

Another major system that should be checked is the furnace filter. This filter should be replaced at least every two months (Striven Industries LLC, 2007). The filter improves the performance of the systems by preventing dust from building up and forming layers of insulation to prevent heat exchange within the system (Striven Industries LLC, 2007). These excess dust layers cause the system to put more energy into these processes thus resulting in valuable loss of energy (Striven Industries LLC, 2007).

Improving the water conservation in the households saves on water bills and water heating expenditures. There are various methods to boost water conservation such as checking the insulation of pipes, which can reduce expenditures spent on heating or cooling within the household (Cohen, 2006). It is also suggested to remove the sediment build up within the water heater's tank to maximize the efficiency of the device (Cohen, 2006).

There are many more ways to retrofit one's home and make it more energy efficient. The above tips are just several small changes that can be made. Taking the effort to carefully seal the envelope and checking the maintenance of various systems and appliances can save on the monthly electrical and water expenditures. These techniques save money but also make the home environment more comfortable, improve air quality and protect water reserves. Of course once maximum energy efficiency is achieved the next major step is to install renewable energy sources and go fully "green."

2.10 Thermochrons

When it comes to describing the quality of housing, the temperature is important to consider. The temperature must be logged on a regular time basis for comparison and cataloging. A regular thermometer could perform this task, but a new piece of technology can help. This device is known as a thermochron and is basically a digital thermometer that gives temperate data a timestamp at a programmable interval (Maxim Integrated, n.d.). The programmable interval is 1 second to 273 hours (Maxim Integrated, n.d.). This sensor can operate in a temperature range from -55 degrees Centigrade to 100 degrees Centigrade, features a humidity sensor and is rugged and waterproof (Maxim Integrated, n.d.). The real benefit of using this

autonomous data logging device is the ability to quickly visualize the data using the included graphing software and the specialized reader hardware. The reader communicates with the device through a simple serial protocol to ensure the data is transmitted using the lowest number of data lines as possible (Moi-Tin et al., 2008). With this simple interface and easy communication the thermochron has direct application in measuring the temperature of food in packaging, load lines and animal habitats (Loudin, 2005; Moi-Tin et al., 2008; Kearney et al. 2011). If animal habitats are being measured it is important to consider the presence of the animal as affecting the data (Kearney et al., 2011). Scientists have even used these devices to record the improvement in thermal efficiency of homes in New Zealand after improving air circulation (Fitzgerald et al. 2011). The most beneficial aspect is that these thermochrons are easy to work with; one elementary school even started using them in a science course (Avard, 2010). In terms of this project, future research could use these thermochrons to monitor the temperature at various points throughout the home. These readings could be compared among houses with good efficiency and poor efficiency to determine points where improvements could be made in efficiency. Additionally these devices could record the temperature of a home before and after solid wall insulation to show the benefits gained by participating in energy retrofits.

2.11 Summary

Energy efficiency in the UK is an issue that policymakers and engineers are struggling to solve. With the price of oil rising and reserves dwindling, saving every bit of energy possible is important in making sure that consumers are able to reliably receive power and heat. An important part of conserving energy is using newer energy efficient technology and using devices such as smart meters or IHDs to track and improve personal energy consumption.

Energize Worcester is working to improve the energy efficiency of student housing on the University of Worcester campus. They have campaigned to raise energy conservation awareness among the student body.

Following in this vein, the research in this literature review points to the need for increased consumer feedback. This form of direct feedback is most easily applied by using either increased consumer knowledge on energy usage, or using smart meters and IHDs. Many energy suppliers will already be providing these meters and displays to customers as part of the UK

mandated roll-out, however consumers may not be immediately aware of their potential cost savings. In order to further decrease energy consumption, it becomes necessary to increase awareness and change behavioral patterns toward conservation. In order to determine what information needs to be conveyed to the target audience, surveys can be conducted to find out the general opinions of the tenants and landlords, as well as the level of knowledge held by the average homeowner. This knowledge should also include information on energy retrofits and overall household sustainability. Overall, the reviewed literature points to the simple premise that increased consumer knowledge and feedback lead to decreased energy consumption.

Chapter 3. Methodology

Our goal for this project was to establish a baseline profile of the properties and general community of the Arboretum in Worcester, England, and to enable future extensions of this project and the Energize Worcester program. In order to accomplish this goal we had three objectives:

1. Assessing local housing conditions and understanding the community demographic.
2. Understanding community perception and attitudes towards sustainability and energy conservation.
3. Assessing the feasibility of using educational materials to teach sustainability behaviors to those in this community.

In this chapter we outline the methodological strategies we used to accomplish these objectives.

3.1 Assessing local housing conditions and understanding the community demographic

For this objective we conducted a site assessment including generating a map of the Arboretum using a short questionnaire, conducted a main survey (as in Appendix K), and documented the external conditions of houses.

We wanted to understand who lives in the Arboretum. After consulting our sponsors, we elected to perform a door-to-door canvassing of the Arboretum. Before we began canvassing the area, we distributed 724 leaflets to homes in the area to inform residents that we had Worcester City Council and University permission to survey. This leaflet can be found in Appendix F. In order to keep a record of the houses we visited, we crafted a checklist which allowed us to keep notes on each house. When we were canvassing the Arboretum, we also documented the exterior of the house by taking a photograph with the resident's permission and we also inquired about the build date. This was to determine if they would be eligible for exterior insulation as part of a larger City Council project. As part of our project, we did not have to determine the feasibility of this insulation.

Residents who chose to speak with us were given a short initial questionnaire (under 5 questions) to inquire if they rent or own their home. If the individual rented we asked the number of other tenants in the property to determine if the person lives in a house of multiple occupancy (HMO) or lives as a group or family. In the beginning, we only considered tenants in HMOs.

Due to the low response rate from HMO tenants and with permission from our sponsor we elected to include any residents willing to allot time to speak with us. We conducted our site assessment in casual attire by wearing Energize Worcester branded t-shirts and carried ID badges from the University of Worcester to provide evidence of our project affiliation. If no one answered the door at a particular household, we left a note indicating that we had stopped by and wanted to speak to them at a later date.

While performing our site assessment, we provided our survey to all those interested in filling out the questions. We offered several ways to complete our survey; the first option was to simply complete the survey with us through a semi-structured interview. The second option of collection was to have residents drop the completed survey through the mail slot at 8 Arboretum Road (Mr. Brohan's house). The third option of collection was that the resident could email our team at energizeworcester@gmail.com and ask us to stop by the house to pick up the survey. Finally the fourth option was to give residents the free post address for the University and an envelope, which they could use to mail in the survey.

As part of our site assessment we also compiled a listing of all of the Energy Performance Certificates (EPC) on the various properties around the Arboretum. We did this by finding the zip code of the property through Google Maps and then used the online website called EPCRegister to search the postal code and bring up the EPCs for the street (Landmark, n.d.). We did this for all of the streets in the Arboretum. From these EPCs we were able to understand the baseline levels of sustainability for the region in terms of energy efficiency and possible energy retrofits for the properties. One limitation when using these EPCs is that the EPCs are only for houses that are being rented (not for HMOs), built or sold. Additionally these EPCs do not specify if the house is privately rented, rented as an HMO or is privately owned.

Our project was primarily geared towards collecting census data about the tenants and we did not have to implement any sort of educational campaigns or energy retrofits. The information gained through our census-style collection of data was augmented through interviews with landlords, tenants and homeowners when possible. The initial questionnaire and main survey were used to get a broad idea of the properties in the Arboretum. The questions from the surveys were related to strategies practiced to promote sustainability in the environment. The questionnaire and main survey can be seen in Appendix H and K respectively.

3.2 Understanding community perception and attitudes towards sustainability and energy conservation

We designed our initial questionnaire survey to categorize the population into homeowners, single renters and those in HMOs. Through our main survey, we also strived to gain an understanding of the levels of energy awareness and conservation in the HMOs and the community as a whole. The main survey also sought a basic demographic profile of the Arboretum population.

We assessed the willingness of those in the Arboretum to participate in sustainability initiatives, and collected a purposeful sample of the population rather than conducting a fully randomized sample or interviewing every HMO resident one-on-one. As Maxwell described in his book on research methods, "there are four possible goals for purposeful sampling" (Maxwell, 1996, p. 71). The first step was to carefully select individuals that seemed to be closer to the average as this would better represent the population of this area than a random sample of the same size would (Maxwell, 1996). The information from our main survey helped in this case, as we used responses from the residents to establish an average profile of the community's response to energy efficient technology.

How does one decide who is average? We compared the occupant age to the average for the census data for the region. A strategy known as "stratified sampling" was an ideal method to consider all opinions of our sample size. As said by Hunt and Tyrrell, "the bigger the differences between the strata, the greater the gain in precision" (Hunt & Tyrrell, 2004). Additionally we chose this method of stratified sampling as "it ensures better coverage of the population than simple random sampling" (Hunt & Tyrrell, 2004). For our stratified sampling we used age to split the sample. From the information in our main survey we chose 7 groups (as in delineated by the age categories in Appendix K), and broke the raw data down into these categories for submission to our sponsor.

Another note about the selection of participants is that we used a smaller sample size with several interviews (talking with a participant to fill out our main survey) and data sets and, based on Maxwell's work, chose to include perspectives that oppose the original perceptions of the region (Maxwell, 1996). From discussions with our sponsor and background research this original perception was that sustainability and energy awareness levels were low in the Arboretum. To counter this we spoke to people who have adopted more green technology and

follow better sustainability practices than the average consumer resident. We did not limit our study to these residents alone and worked to include those with varying levels of technology retrofits and knowledge by canvassing respondents. To this end, we also spoke to members of the Arboretum Residents Association about their knowledge of the community and HMOs. This assisted us in obtaining a stratified sample of the population to provide heightened awareness and insight into the community.

3.3 Assessing the feasibility of educational materials to teach sustainability habits to those in this community

Similar to the previous two objectives we used the data from our main survey to satisfy our third objective. As part of this main survey we asked several questions on about educational programs to teach energy saving behaviors and technology options to reinforce these concepts. We also asked about the best delivery scheme for this information whether it be a leaflet, consultation session, poster, online video, class, or radio ad. We also asked residents about their sustainability behaviors. The exact questions can be seen in the main survey in Appendix K. The information in this survey set enabled us to understand the perception of an educational campaign such as Energize Worcester for the community. Naturally our main survey had several limitations including participant bias (as we could not force everyone to fill out the survey), response limits (not all surveys were returned) and the fact the data is only valid for those in the Arboretum. The IQP Handbook on surveys describes several limitations we also experienced such as time constraints and issues with people self-reporting data (Doyle, n.d.).

We conducted one-on-one interviews in a semi-structured yet informal style. After a brief round of introductions we worked through our main survey (relating to objectives one to three) and recorded their responses. Due to scheduling constraints, we selected the Energize Worcester program to promote as our model educational campaign. Where possible we informed participants of the benefits and strengths of the Energize Worcester program. We then asked the resident their opinion on this program. This also included questions on how best to deliver this information and how to best tailor the program for the needs of the participant.

3.4 Final compilation of data

From our research in the community we compiled a final report providing insight into the energy and sustainability habits of tenants and landlords in the Arboretum. These data will assist in future project work on implementing sustainability programs in the area. The data were tabulated for the survey results and coded for content pertaining to each objective. We also formulated a set of recommendations based on our data. The final report was provided to the University of Worcester, Energize Worcester and any other interested parties including Transition Worcester and the Arboretum Residents Association. For the duration of the project the raw data was stored in a password-protected drive and then stored by our sponsor.

3.5 Timeline

In order to maximize productivity a timeline was constructed to place deadlines on different aspects of our work (as seen in Figure 3). Due to delays experienced in the first two weeks waiting for permissions, the project activities were shifted back. We asked for the completion of all surveys by June 13th to have the data analyzed and compiled for the project. A more detailed breakdown of time can be seen in the Gantt chart (Figure 3). We have also included a Venn diagram (see Figure 4) showing the breakdown of data collection techniques for each objective.

Project task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Final report preparation							
Data analysis							
Video and photo documentation							
Door-to-door canvassing/initial questionnaire							
Main survey/Interviews							
Recommendations							
Final presentation preparation							

Figure 3: Gantt chart breakdown of project tasks.

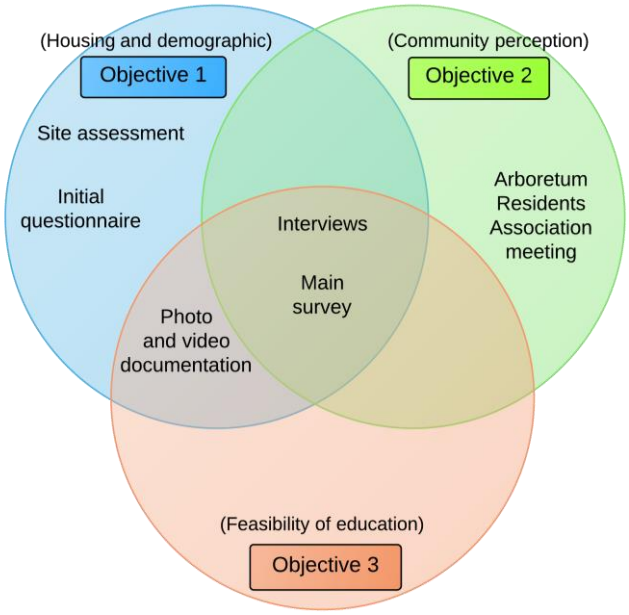


Figure 4: Venn diagram of data collection methods for our objectives.

Chapter 4 Results & Discussion

In this chapter, we present the results and analysis of our data from the Arboretum, including our survey and interviews with the community as a whole (homeowners, individual renters, group renters and family renters). The full summary of survey results can be seen in Appendix O.

4.1 Site assessment

From our literature review, we learned that the Arboretum is a small and compact neighborhood. It used to be called the Worcester Pleasure Gardens until many acres were converted to create public residences (Worcester Arboretum, n.d.). Our site assessment revealed a quiet and friendly neighborhood with many terrace houses dating to the 1890s. Many of the homes had a small garden or set of flower pots out front. From speaking with residents, we determined there used to be a multitude of corner shops and commercial enterprises which have now been converted to homes. Also several older buildings have been renovated into newer apartment complexes. With many of the houses being built prior to 1900, we observed the Victorian style of brickwork on the exterior of the properties. In many cases this brickwork showed the home to have solid walls rather than cavity walls (see Figure 5).

Figure 5: Several solid wall properties (Photo: Alex Shoop, 2014).

Our background research also supported the conclusion that a majority of the homes are solid walls. Unlike cavity wall insulation, solid wall has several drawbacks with insulation: the insulation is costly, physically intrusive into a room and difficult to install as well as being less thermally efficient than cavity wall insulation. As a result some buildings do experience mold and damp due to less insulation. Figure 6 shows an example of some of the mold that exists in these homes.

Figure 6: Mold buildup in the attic (Photo: Stefan Smith, 2014).

Residents have tried to combat this using dehumidifiers and plastic wrap around the insulation. From our site assessment we saw the need for further documentation of housing conditions using our survey.

4.2 Local housing conditions and community demographics

We conducted many meetings over the course of our project with the secretary of the Arboretum Residents Association, Mr. Brohan, who has lived in the area for the past 7 years. During these meetings we discussed energy retrofits and the Arboretum community and even toured his home (built in 1897) as he showed off the retrofits he has made to improve his energy

efficiency. From these meetings we better understood what retrofits homeowners can do to improve their own residences. Mr. Brohan also gave his impression of the Arboretum and mentioned that there is a growing number of houses of multiple occupancy (HMOs) in the area. He also showed us the boundaries of the Arboretum on a map. In conjunction with our meetings with Mr. Brohan, we also attended the Arboretum Residents Association meeting. This meeting was comprised of 10 participants with 5 being residents of the Arboretum. The persons in attendance echoed the specific concern over the growing number of HMOs in the community and the resulting overcrowding of car parking in the region.

We also compiled the Energy Performance Certificates (EPCs) for all streets within the Arboretum. From this information we constructed Table 1, which includes an average of the current EPC rating and the potential EPC rating for each street, where A is the highest and G is the lowest. We compiled a total of 434 EPCs to build the average energy rating of residences within the Arboretum.

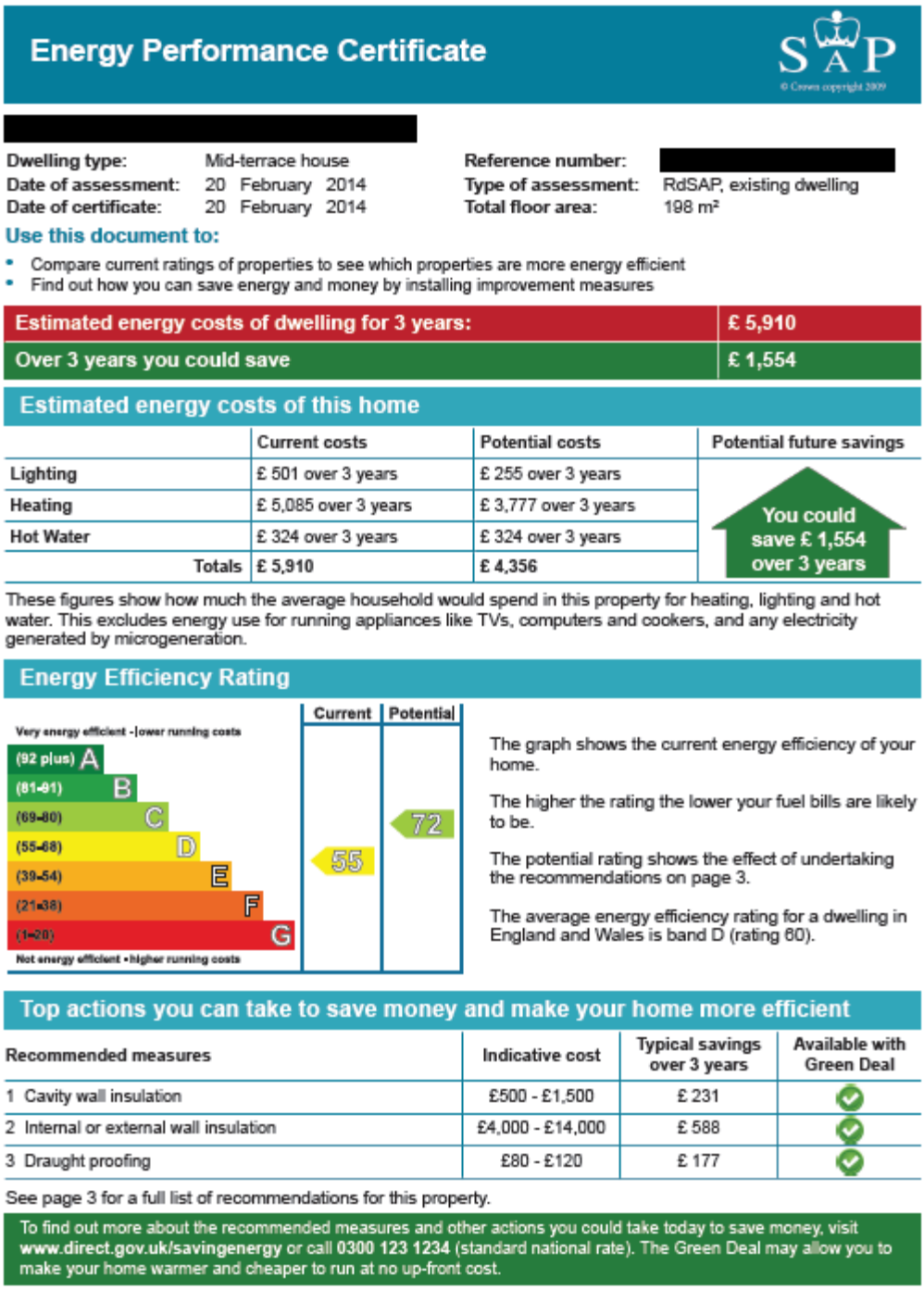
Street name	Current Average EPC	Current Letter Grade	Potential Average EPC	Potential Letter Grade	Average Area m^2	Average Area ft^2
Arboretum Road	58	D	71	C	101	330
Barry Street	59	D	73	C	86	281
Chestnut Street	54	E	70	C	97	317
Chestnut Walk	45	E	62	D	108	355
East Street	60	D	76	C	55	181
Lansdowne Road	54	E	72	D	85	278
Little Chestnut Street	49	E	56	D	71	233
Little Southfield Street	51	E	62	D	76	248

Lowell Street	53	E	67	D	72	235
Lower Chestnut Street	57	D	67	D	74	243
Middle Street	60	D	70	C	86	282
Northfield Street	52	E	65	D	87	285
Sansome Walk	60	D	69	C	58	192
Southfield Street	58	D	66	D	65	212
Washington Street	57	D	67	D	72	237
Wolverton Road	65	D	74	C	86	282
Wood Terrace	47	E	60	D	85	280

Table 1: Average Energy Performance Certificate (EPC) grades for the Arboretum.

Table 1 shows information about the average Energy Performance Certificate ratings for each street. The difference between the current EPC grade (current efficiency) and the potential EPC grade (potential efficiency) is what is most important. This difference indicates room for improvement in energy efficiency. Additionally the average area, in meters squared and feet squared, of the home gives a reference for home sizes within the street.

To further support the table, Figure 7 shows a representative EPC from a house within the Arboretum (with the address and reference number blocked out). The important information from this figure is the current and potential rating of the property below the "Energy Efficiency Rating" section. This document also specifies the date of the assessment, and it is important to note that the levels of efficiency may change throughout the year. A home assessed during the summer might seem more efficient than a house surveyed in the winter, because in the winter the drafts will be more noticeable. This document also specifies costs of living (energy bill costs) for owners and renters, as well as estimates for costs to make retrofits to improve property energy efficiency, such as measures sponsored by the Green Deal under the "Top Actions" heading.



Energy Performance Certificate

SAP

[redacted]

Dwelling type: Mid-terrace house
Date of assessment: 20 February 2014
Date of certificate: 20 February 2014
Reference number: [redacted]
Type of assessment: RdSAP, existing dwelling
Total floor area: 198 m²

Use this document to:

- Compare current ratings of properties to see which properties are more energy efficient
- Find out how you can save energy and money by installing improvement measures

Estimated energy costs of dwelling for 3 years:	**£ 5,910**
Over 3 years you could save	**£ 1,554**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 501 over 3 years	£ 255 over 3 years	You could save £ 1,554 over 3 years
Heating	£ 5,085 over 3 years	£ 3,777 over 3 years	
Hot Water	£ 324 over 3 years	£ 324 over 3 years	
Totals	£ 5,910	£ 4,356	

These figures show how much the average household would spend in this property for heating, lighting and hot water. This excludes energy use for running appliances like TVs, computers and cookers, and any electricity generated by microgeneration.

Energy Efficiency Rating

The graph shows the current energy efficiency of your home.

The higher the rating the lower your fuel bills are likely to be.

The potential rating shows the effect of undertaking the recommendations on page 3.

The average energy efficiency rating for a dwelling in England and Wales is band D (rating 60).

Top actions you can take to save money and make your home more efficient

Recommended measures	Indicative cost	Typical savings over 3 years	Available with Green Deal
1 Cavity wall insulation	£500 - £1,500	£ 231	✓
2 Internal or external wall insulation	£4,000 - £14,000	£ 588	✓
3 Draught proofing	£80 - £120	£ 177	✓

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit **www.direct.gov.uk/savingenergy** or call **0300 123 1234** (standard national rate). The Green Deal may allow you to make your home warmer and cheaper to run at no up-front cost.

Figure 7: A sample Energy Performance Certificate (Landmark, n.d.).

With the EPC data prepared, we commenced our door-to-door canvassing of the region. Figure 8 shows the region that we covered highlighted on a Google Maps image. This image shows a total of 17 streets that were covered (these streets are also listed in Table 1).

Figure 8: The canvassed region of the Arboretum.

Our first objective was to determine site-specific and demographic information. From the responses that pertained to homeownership, a majority of participants owned their homes (62%). Only 38% of respondents rented their homes, and a clear majority of those who rented did so in a shared home (43%). When asked about the number of tenants or family members living in the home, the majority of respondents indicated that only one or two people shared the residence. This data includes all houses: houses of multiple occupancy (HMOs), non-shared rented homes and owned homes. Figure 9 shows the full breakdown of these percentages.

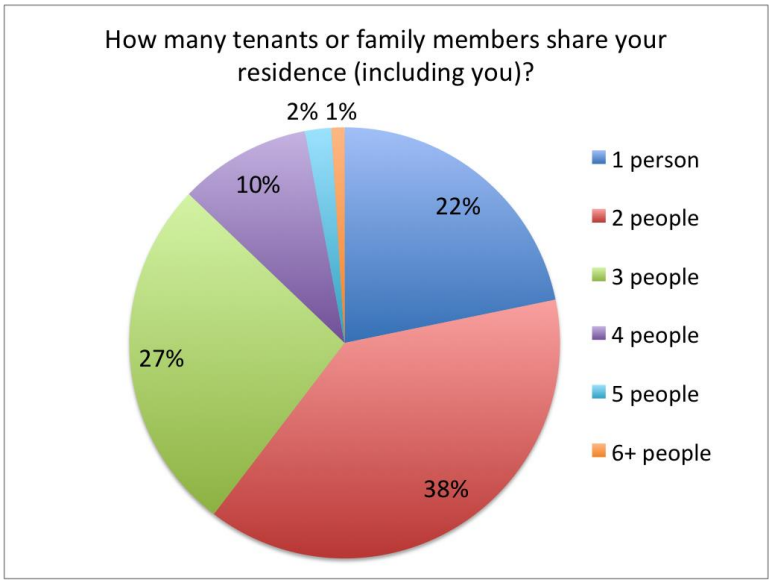


Figure 9: Reported occupancy of Arboretum residences.

With regards to baseline energy assessment, a majority of respondents said that damp was not occurring in their home (53%). Of the 36% who did experience dampness, over half (58%) of the responses indicated a building issue was to blame for the damp. Responses marked as *other* totaled nearly 21% of all responses. These included rising damp, low levels of heating, or leaks. Additionally poor windows and poor insulation ranked highly as the cause for dampness. The primary source of heating for most residents was gas, with 87% usage. Also it was found that 18% used electricity as their primary source of heating. These data are shown below in Table 2. Some respondents answered for a combination of heating sources, thus the percentages do not add to 100%.

Type of heating	Number of responses for each option	Percentage of total responses
Gas	87	87 %
Electric	18	18 %
Wood	1	1 %
Other	1	1 %

Table 2: Responses regarding fuel type usage.

For the summer, as shown below in Table 3, most residents kept their thermostat set to less than 16 degrees Centigrade. This group also includes those that did not have their thermostat on during the summer. During the summer nearly 30% set their thermostat in the 16 to 21 range for reasons ranging from feeling cold in the mornings to needing to keep elderly residents warm. Interestingly enough, a landlord stated that his tenants turned on the radiators during the summer to dry their clothes even when it was not raining or when it was sunny. For the winter, most residents preferred to leave the thermostat in the 16 to 21 degree Centigrade range.

Temperature Range	Summer – number of responses	Summer - percentages	Winter – number of responses	Winter - percentages
< 16 C	42	45%	12	12%
16 to 21 C	27	29%	50	51%
22 to 25 C	4	4%	18	18%
> 25 C	0	0%	1	1%
I do not control my heating	4	4%	3	3%
I do not have a thermostat	18	19%	17	17%

Table 3: Reported temperature settings for residences in summer and winter.

Finally, in terms of demographics among those who responded, a slight majority were male. Around 58% of the respondents were 46 and over. The majority of the responders (84%) were White from the British Isles (i.e. English, Welsh, Scottish or Northern Irish). A large number answered that their income was less than or equal to £10,000 (28%). This complies with the fact that many participants are over the age of 60 and live on pension. The second highest income group was £10,001 to £20,000 (at 22%). Again this is because of the number of people on pension as well as the number of young families and students in the area. Figure 10 shows the full breakdown of the responses for the income levels.

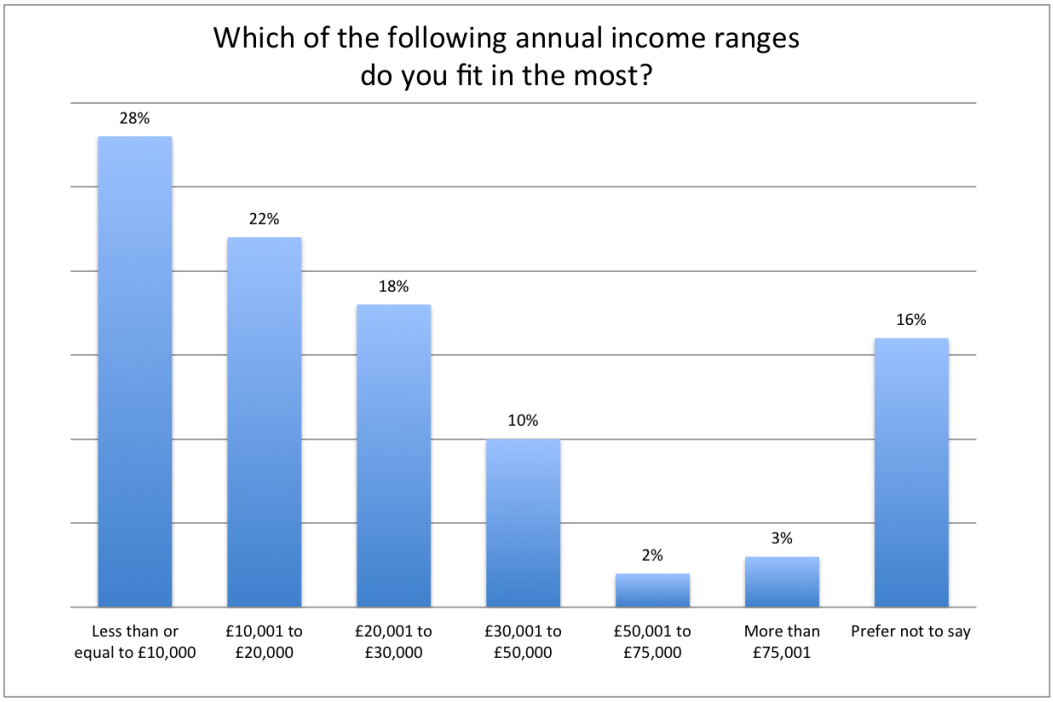


Figure 10: Breakdown of annual incomes among respondents.

4.3 Perception and knowledge of energy conservation

Our survey asked a number of question related to objective two, which was to understand community perception and attitudes towards sustainability and energy conservation. Many residents have tried to retrofit their homes in a number of different ways. The most common methods are by double glazing windows or by installing energy saving light bulbs (mainly CFLs or LED bulbs). Other less common types of retrofits include energy efficient boilers and loft insulation. Levels of wall insulation and the usage of electric space heaters were found to be quite low however. The full breakdown of types of installed retrofits can be seen in Table 4.

Features in properties	**Percentages of *yes* responses**
Double glazed windows	86%
Energy saving light bulbs	83%
Loft insulation	64%
Energy efficient boiler	52%
Wall insulation	27%

Electric space heaters	18%
Renewable energy generator	1%

Table 4: Percentages of reported energy retrofits in homes.

When it comes to having energy efficient appliances, most respondents do not have eco-friendly labels on their appliances or do not know if the appliance has such a sticker. The most common appliances that had such a sticker were the washing machine, refrigerator and boiler. Figure 11 shows the breakdown of these responses.

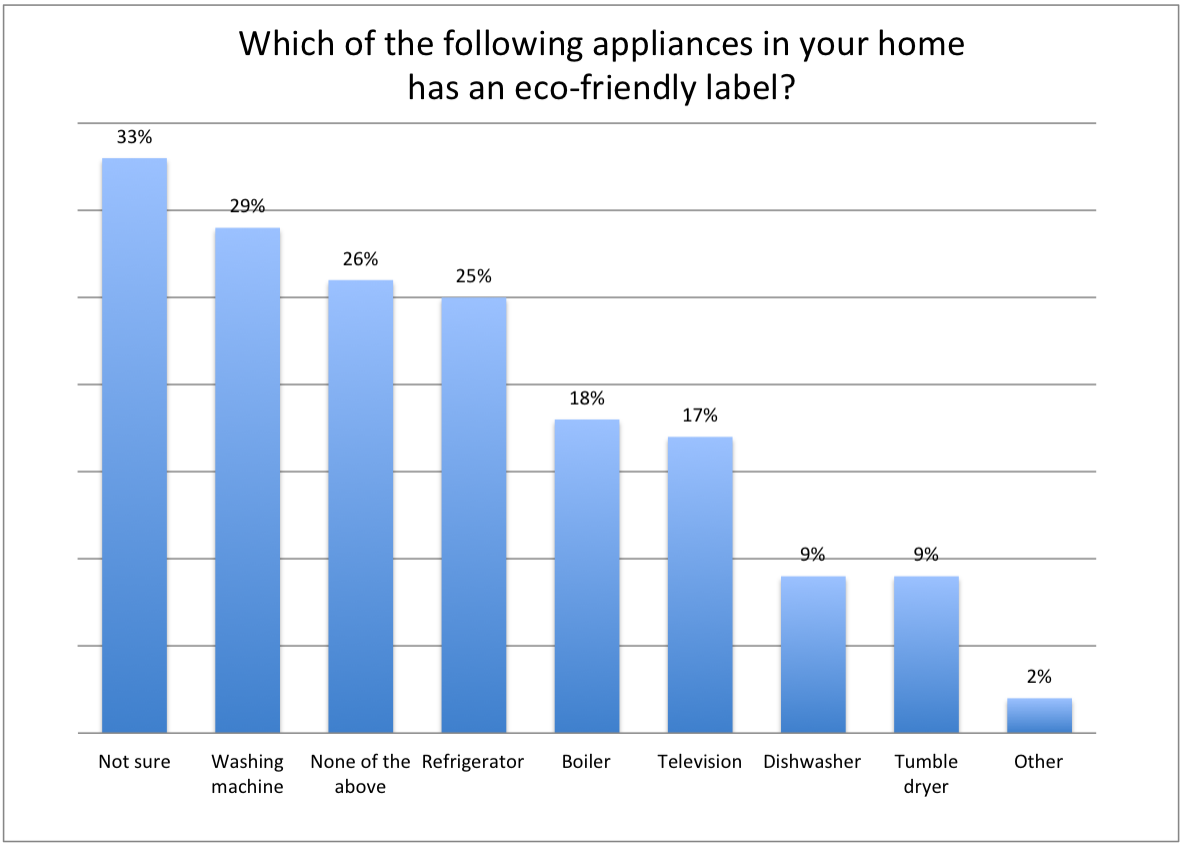


Figure 11: Percentages of appliances with eco-friendly labels or stickers.

To better understand the behaviors of Arboretum residents we asked about their energy behaviors. In addition to asking what temperature the thermostat was set to during winter and summer, (as shown previously in Table 3), most people indicated that they turn off lights when they leave the room and put appliances into a sleep or standby mode. The third and fourth most

common responses with regard to energy behaviors were to turn down the thermostat when possible and to wash clothes at 30 degrees. Taking shorter showers only occurred in about half of the responses. Figure 12 shows the detailed percentages for each category of response.

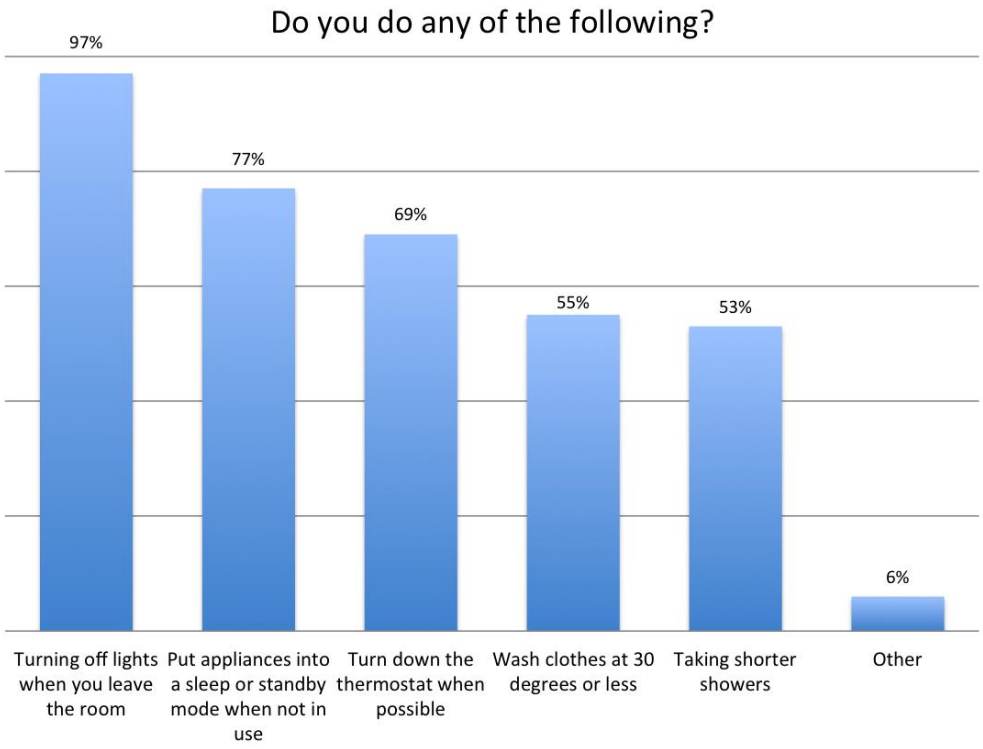


Figure 12: Percentages of reported consumers' energy saving actions.

When asked why consumers performed such actions, the most popular response was saving money on bills. Second was protecting the environment. Of those who answered *other*, the responses were not conclusive. More details are shown in Figure 13.

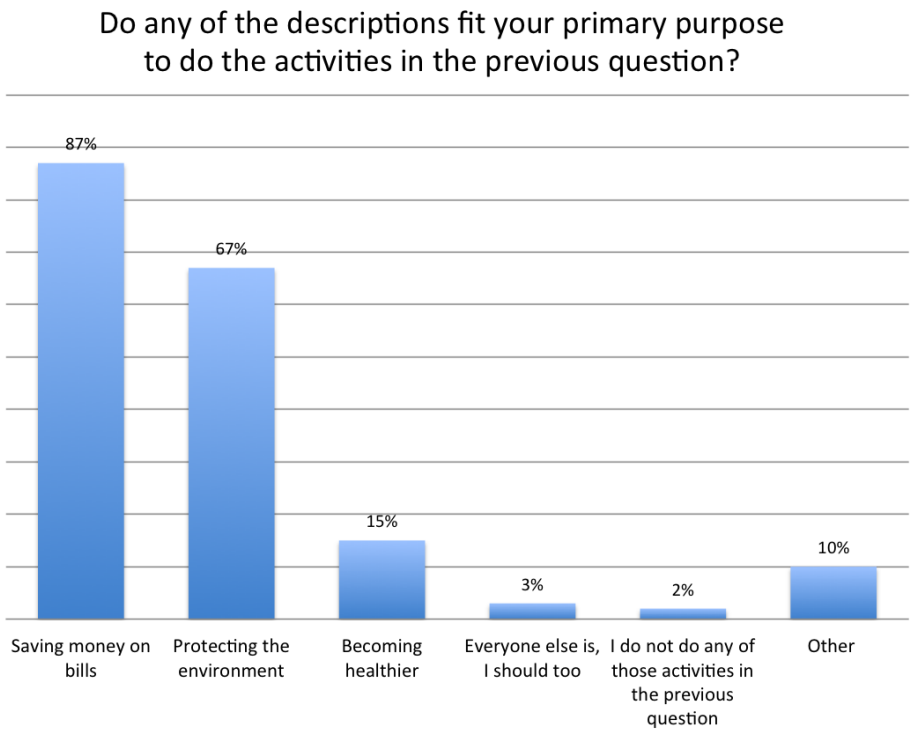


Figure 13: Percentages of primary purpose reported for energy saving actions.

On the whole, many indicated that the most common barrier to them performing sustainability and energy conservation practices was expensive new retrofits and appliances. As Figure 14 shows, 24% chose *other*, which included laziness, forgetfulness, and concern of fire or darkness.

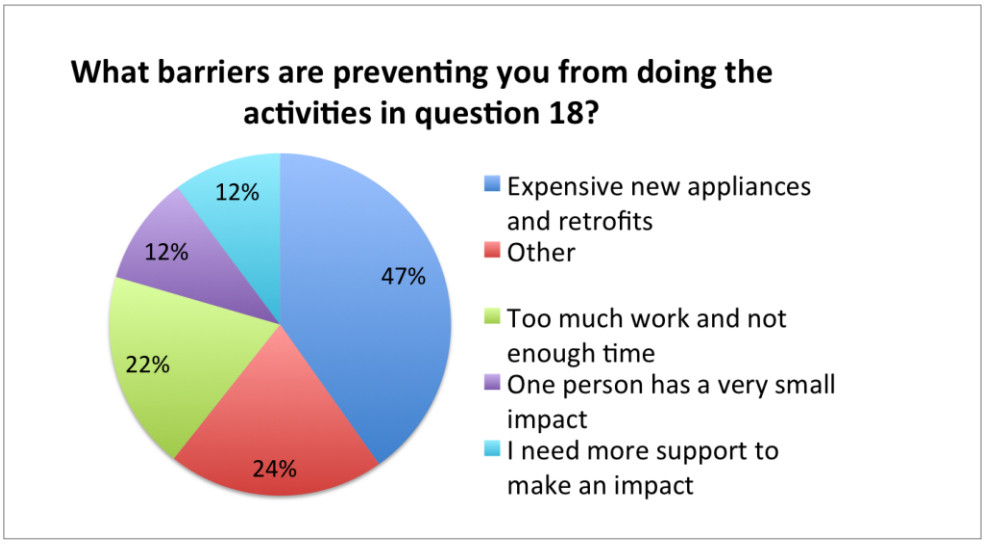


Figure 14: Percentage response of common barriers to energy saving actions.

Nonetheless, well over half of the participants did express that they regularly or occasionally monitor their gas and electricity consumption (See Figure 15 for the detailed breakdown). Those who did not monitor their consumption expressed that their consumption did not matter to them or they were busy with other activities.

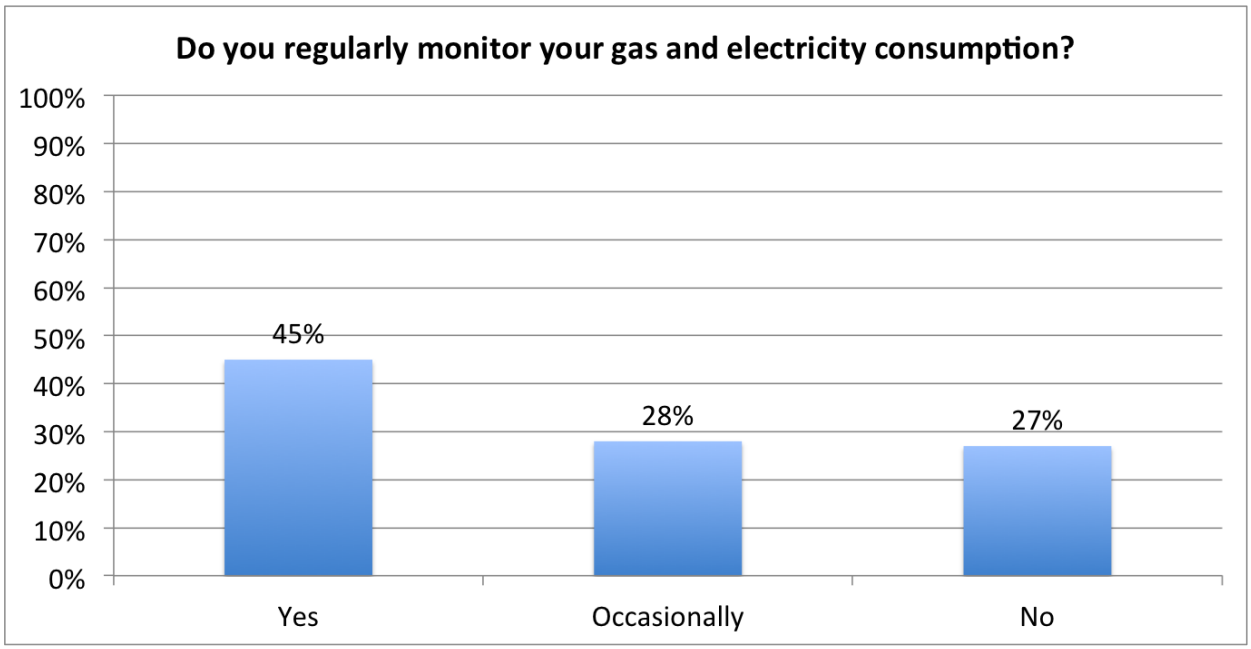


Figure 15: Percentage responses on monitoring gas and electricity consumption.

The most common energy bill per person for houses was over £41 per month. This combines the responses from the top three categories as shown in Figure 16.

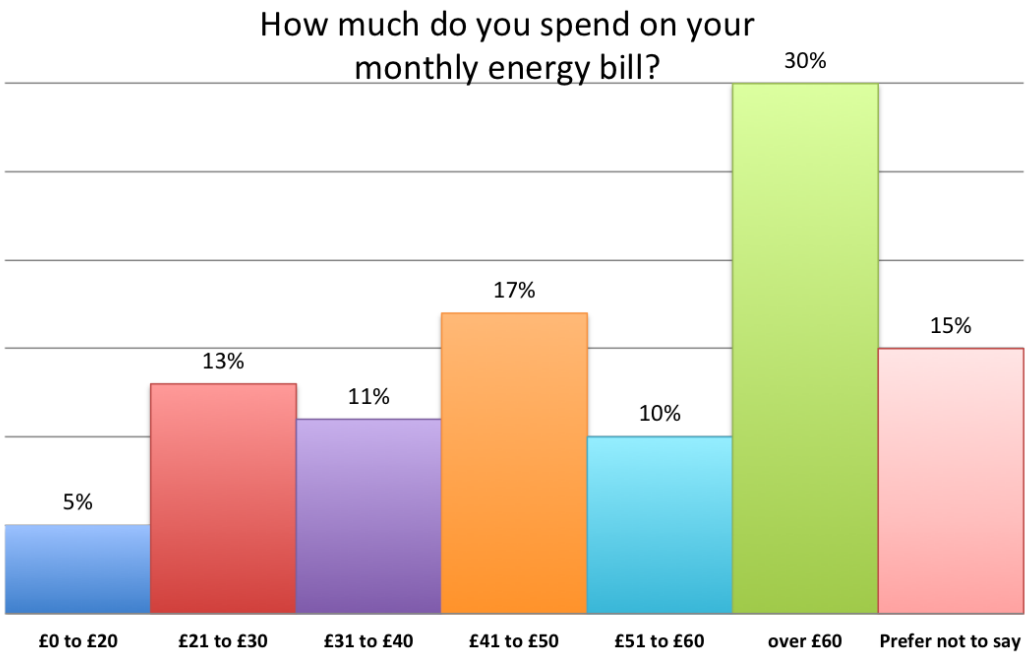


Figure 16: Percentage of responses regarding monthly energy bill costs.

When it comes to spending money on an energy bill, almost half of respondents felt they pay just enough for their bill. However, nearly 44% felt they pay too much for their monthly bill. Consequently most respondents indicated that they would be interested in learning more about how to save energy. Almost unanimously responses indicated that residents know where the electricity meter is located and that they have access to it. A majority of people indicated that they had not heard of a smart meter before, and surprisingly, only a slight majority indicated that they wanted to have smart meters installed in their homes (55%). One respondent even preferred to borrow the meter.

Finally, from all respondents, the list of energy suppliers are British Gas, E.On, Scottish Power, Good Energy, SSE, Cooperative Energy, Ensure, Empower, Utility Warehouse, N Power, and Ecotricity. The most prevalent companies are British Gas, E.On, and N Power respectively.

Other topics that the main survey asked about are the Energy Performance Certificate (EPC) and the Green Deal. Our survey revealed that close to 55% of respondents have heard of an EPC before. In terms of the property having an EPC, however, a clear majority either did not know if they had or did not have an EPC for their property.

4.4 Feasibility of educational campaigns

From the results of our survey we found that clear majorities of people had heard of the University of Worcester, the City Council and the Arboretum Residents Association. The most recognized institution was the City Council (Table 5 and Table 6).

Worcester City Council	99 %
University of Worcester (UW)	98 %
Arboretum Residents Association (ARA)	75 %
National Landlords Association (NLA)	33 %
Transition Worcester	20 %
Energize Worcester	17 %
Worcester Polytechnic Institute (WPI) (US university)	17 %

Table 5: Percentages of respondents who had heard of different organizations

When asked about whom residents would most prefer to receive information regarding how to save energy from, most preferred either the University of Worcester or the City Council (Table 6). The city council is the most preferred at 43% with the University being the second most popular at 28%. Almost a quarter of the respondents did not want to receive information from any of the organizations. An important note is that despite our directions to only indicate one response, several people marked multiple answers, which explains why the percentages do not add up to 100%.

Worcester City Council	43 %
University of Worcester (UW)	28 %
None of the above	24 %
Arboretum Residents Association (ARA)	17 %
Transition Worcester	11 %
Energize Worcester	10 %
National Landlords Association (NLA)	2 %
Other	1 %
Worcester Polytechnic Institute (WPI) (US university)	0 %

Table 6: Distribution of preferred energy savings information source

In terms of knowledge of energy efficient techniques and technology, most respondents ranked themselves about a 5, “average knowledge,” on a 1, “no knowledge,” to 10, “expert knowledge, scale.

Pertaining to educational programs, a very slight majority (51%) said that they would not be interested in learning more about saving energy, yet 68% believe that there are an insufficient number of educational programs currently in place. Generally speaking, the best method to receive the educational materials that most participants preferred is a leaflet. Figure 17 shows the preferred options.

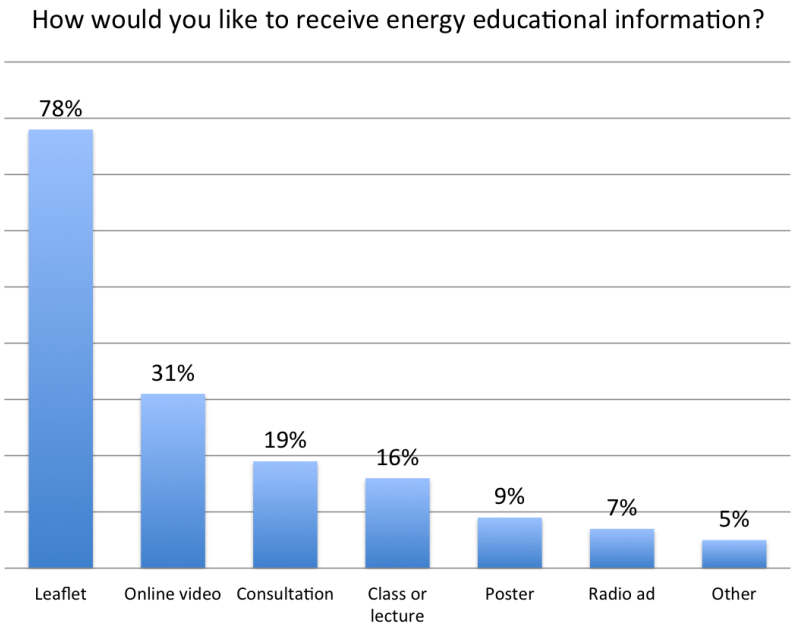


Figure 17: Percentage response of best delivery methods of energy saving information.

When asked if participants would be interested in being contacted for future research, about half responded positively, and those who provided contact information tended to give their name and address.

Overall, we received 102 surveys out of the 195 or so we gave out. This is a 52% response rate for the surveys which is quite good considering the length of the survey (45 questions) and the timeline for the project.

4.5 Discussion

Demographics

Within our data one of the most prevalent trends was the demographics of the community. The following discussion includes income and nationality.

Income

As concluded from our survey results, a high percentage of residents earn an annual income of £30,000 or less. One of the biggest issues that we encountered while analyzing the survey results was that many people did not want to spend the money to make the retrofits needed in their homes, especially the more expensive appliances such as a boiler or solid wall insulation. In some cases residents could not afford the efficient technology. It is clear that participants are careful with their spending as we observed a majority indicated cost as the primary concern when purchasing a cleaning product such as bleaches and washing gels.

Another factor in consumer spending is age, where the largest demographic that responded to our survey was over 65 years of age. Due to age and because many live on pensions, many residents said that they were less inclined to make retrofits as they would not be as likely to see the payback from retrofits. The mentality of "if I'm going to die before I see results from a retrofit, why bother paying for it?" applies in this case. This is why it is important to convince the younger generation to engage with the community on energy conservation. The most ideal situation would be one where all ages are actively pursuing efficient technology and sustainability behaviors.

However, many of the younger families and occupants in the Arboretum, even those with decently paying occupations, are also hesitant about making retrofits since they may not have as much extra money to spend or they may be new to the region. Renters may also feel that it is not their place to make retrofits, and that it is the landlord's obligation to make improvements within the property. This is best expressed by one participant's statement: "I do not own the house so I'm not going to renovate it" (Survey 83). Newer people to the Arboretum may not have had many energy bills yet, which was an issue with several respondents. This further backs up the point that one should enhance the younger residents' participation within the community. Regarding spending money on efficient technology, one simple retrofit would be energy saving light bulbs such as compact fluorescent lamps (CFLs) or light emitting diode (LEDs) bulbs. Not only are they relatively cheap, but they are also simple to install. Even this simple retrofit can show substantial financial savings. Despite higher levels of these lighting options, a substantial number of respondents still expressed displeasure at how much they spend on their energy bills. One resident felt that "without greedy corporations bills would be cheaper" (Survey 18). Others

felt that they were simply spending too much, but this could be improved by reducing their consumption.

Nationality

According to the 2011 UK census data, the Arboretum was made up of mostly White English residents. After speaking to many residents and canvassing the area, it quickly became clear that there exists an immigrant population. We occasionally ran into problems with language barriers, in particular residents that did not speak or understand English. In an interview with one resident, he mentioned a number of the households opposite his were Bangladeshi (Survey 66). He even told us that, in his opinion, any future leaflet or informational campaign should be in a number of languages including Bangladeshi, Portuguese and English (Survey 66). This is spurred by the changing demographic of the Arboretum caused by immigration from other countries. The resident also told us to speak with the local convenience store owners to get the best idea of the changing demographic (Survey 66). While we did not have the opportunity to speak with the store owners, we did observe the changing demographic profile with the Eastern Europeans, Bangladeshi, and other Asian nationalities' presence in the area. This becomes important when considering the educational campaign as materials can be tailored to meet language and cultural preferences.

Housing conditions

From the site assessment of the Arboretum, and through correspondence with the residents, we realized that most of the houses were built within the late Victorian era (1837 to 1901). During the Victorian era, "New industrial towns built rows of terraced back-to-back houses for people to work in the mills and factories" (Barrow, n.d.). Worcester, England has cold winters and homes within the Arboretum require heating systems in order to maintain a comfortable living environment during the winters. However, due to the manner in which the Victorian houses were built, the envelope of the houses in the Arboretum is generally poor with regard to thermal efficiency, as the walls tend to be solid brick without any air gap. As a result of this poor thermal efficiency, the envelope is unable to retain the heat produced within the household, and a lot of heat energy is lost to the outside environment. This results in homes being colder and more uncomfortable.

In addition results of the main survey indicated that some of the respondents had damp occurring within their household. Damp is the result of moist air condensing on cold surfaces such as walls and windows (the envelope). This is primarily because heat is lost from the solid wall structure. One elderly woman said the damp "creeps up the walls." Another resident said there was no damp at the moment, but that he and his flat mates were "fighting it all the time" (Survey 10).

However, to reduce the steep gradient of heat flowing outward to the environment and to reduce damp, some of the residents have made various retrofits to make the envelope of their house more thermally efficient. Since most homes are solid wall, it becomes impossible to insulate the inside of the wall without intruding in the room space (as there is no easily fillable air gap). As one resident said "just remember the majority of houses in the Arboretum were built before WW1 therefore luxuries like cavity walls and insulated building blocks are out!" (Survey 63). Thus, people must pay for costly exterior foam insulation or must install insulation inside the wall that decreases the usable space of the room. This is why a very small number of the respondents have wall insulation installed. On the other hand, many houses were built with sliding sash windows which shows why a high number of the respondents have inserted double glazed windows to improve thermal efficiency. With regard to loft insulation, a majority of the respondents have it installed in their property as this is one of the easier types of insulation to install in Victorian homes. Many of the homes previously contained old inefficient boilers, and only a little less than two-thirds of the respondents have made the necessary retrofit to change their boilers to a more energy efficient one (e.g. a condenser boiler). The main trend of the houses is that people make the best effort to install retrofits that fit with their budget and their property.

Community awareness

Overall, the levels of community awareness vary. In terms of energy retrofits, the community is reasonably aware of what retrofits are possible for their home. Despite the knowledge of these retrofits, not everyone has the technology, as many do not have wall insulation. Almost half of participants ranked their knowledge between a 4 and a 6 on a scale of 1 being "no knowledge" and 10 being "expert knowledge" in terms of energy efficient technologies. There are those who have more knowledge and awareness of the technologies, but

the general trend is the opportunity for more community awareness. While the community seemed to rank themselves with "average knowledge" of retrofits, we only found one person living in the Arboretum with a renewable energy generator (e.g. solar panels). The overall lack of solar panels can be explained partly by the climate. Nevertheless many residents still have tried to make their residences as energy efficient as possible, which shows the motivation necessary to change their behavior exists. This is especially true as a clear majority is aware of their consumption through regular or occasional checks of their energy usage. This might be because people want to save as much money as possible and determine their peak spending periods. There are those who do not monitor their consumption as they were too busy with other activities or that they did not care about their consumption. Of course not everyone is willing to cooperate as one respondent stated "I'm lazy and couldn't be bothered" (Survey 19). This lack of care about consumption can also stem from the fact that, in some cases, the landlord is responsible for paying the energy bills. With a little engagement and more funding or knowledge, the community members could be persuaded into additional retrofits or actions that can improve their efficiency, save them money and can help reduce the energy consumption of the region.

In terms of awareness about the Green Deal slightly under half of the community knows of this program. This shows the community is not informed of cost-saving options for retrofits such as wall insulation or a boiler. A clear majority assumes the Green Deal would not benefit them, but this stems from the lack of awareness of the Green Deal. Some respondents expressed misgivings about the Green Deal because they thought they did not qualify for the program due to income or other reasons. Due to the reported average levels of knowledge and the low levels of retrofits, there exists the option to educate residents regarding these technologies and funding options (such as the Green Deal).

Only a little over half of the respondents had heard of an Energy Performance Certificate (EPC) however, and this shows a clear need for improvement. An EPC for a home or rental property can give vital information regarding the cost of living and consumers should have the most information possible when considering renting or buying a home. Most residents may not know of EPCs because they live in rental properties (such as an HMO where an EPC is not required), they have lived in their home since before the EPC protocol was created or they have not tried to sell, rent or build their home recently. This is especially true as we spoke to a number

of residents who had lived in the Arboretum for over 20 years (which predates the creation of the EPC scheme in the late 2000s). One resident has even lived in the region for 60 years!

When it comes to awareness of smart meters, a large majority had heard of a smart meter. While this seems high, some people may mistake a smart meter with an in-home display tethered to a clip on meter (as several residents had an in-home display and thought it was a smart meter). A very slim majority actually wanted a smart meter. This may result from some respondents already having a smart meter installed in their property. Others may not have enough information about how a smart meter can benefit them or may fear an additional charge on their monthly energy bill. One participant even stated "I wouldn't even look at [the smart meter] anyway" (Survey 21).

In terms of energy saving behaviors, most already turn off the lights in a room when not using it and put appliances into sleep or standby modes. These are rather simple behaviors, which require minimal effort. While only about half of respondents wash clothes at 30 degrees Centigrade or less, this is not always lack of awareness, but rather other reasons. Participants mentioned that their washer did not have a lower setting than 40 degrees Centigrade and that difficult stains require a higher temperature to remove. Surprisingly, taking shorter showers was only performed by about half the population. One resident succinctly expressed why not: "I need a long shower so I don't smell" (Survey 69). A sizeable majority does turn down the thermostat where possible, and this shows a general trend toward saving money on heating. Some residents living in the area do feel that heating is a problem in their home (as found through speaking with residents). These residents indicated their main method of staying warm with lower heating levels was to use additional layers. One person indicated on a survey that "in winter, when reading or watching TV, I get into a sleeping bag [to stay warm]" (Survey 12). If people did not turn their thermostat down it was generally to keep a comfortable temperature for the elderly as one participant said "keeping [my] elderly mother warm is considered priority" (Survey 31). While saving money was important to all, the community members also showed awareness of their environmental impact and a desire to protect the environment.

Lastly, a large majority is aware that the community lacks sufficient educational campaigns to teach sustainability and energy conserving behaviors. This program, as many respondents noted, would be best delivered in the form of a leaflet. While we did not speak to many residents regarding the Energize Worcester campaign, those with whom we did responded

positively to that style of initiative. Several landlords expressed annoyance at their tenants who did not care about energy usage and wished these tenants would be further educated on curbing usage.

Additional observations

While the project focused on housing specifically, we did notice the overcrowding of streets and the lack of parking. This was corroborated by many residents around the area and by those in the Arboretum Residents Association (ARA). As the population grows, the parking will run out. Other Worcester residents park their cars in the Arboretum even if they do not live in the area and need to work in the city. To compound the issue the streets are narrow as their size has not been increased from Victorian times. We noticed the parking issue most clearly as one side of the street would be blocked off with parallel parked cars (see the left part of Figure 18) and the street would essentially become one lane of traffic. While the number of car parking spaces available is definitely an issue, the real issue is the pollution caused by the increased traffic in the region. This includes the health hazards from the emissions as well as the CO_2 footprint. Future teams may want to continue looking into reducing the over parking by working with the ARA to bring back their parking sticker scheme or developing a program to lessen the traffic within the city streets.

However, the project was primarily focused on assessing the community in terms of energy usage behaviors and trying to determine the demographics associated with this neighborhood. As a result the project tended to be more census focused. From our discussions with Mr. Brohan, we learned about several different technologies that could be used to find the thermal efficiency of a home. These technologies included thermochrons and draft sniffers (essentially fans with colored dye). While we were not able to directly use these technologies within the scope of our project, future teams may find them valuable for in-depth analysis of each home.

Figure 18: Heavy traffic in the Arboretum on Northfield Street (Photo: Alex Shoop, 2014).

With all of our discussion the main theme is that everyone needs to be involved in the project. This includes all ages and demographics. To spur community engagement, the University of Worcester has a grant which could help to reach out to more residents and bolster the community's support for any changes or educational initiatives. The community is generally aware of the project and they want to learn more about how to save energy. Even the UK government recognizes the need to reduce energy bills and energy consumption, as evidenced by the Green Deal program. If everyone is involved then residents begin to become accountable for their actions and their effect on others. This helps to keep the community engaged, focused on learning and making the whole neighborhood more sustainable.

Chapter 5. Recommendations & Conclusion

From the results of our survey, we found a number of areas for improvement and future expansion. This chapter gives recommendations that future teams could use to improve the effectiveness of this project. These specific recommendations are limited to this project and this community alone, but could be generalized to future projects concerning other communities.

Community engagement

Our first recommendation results from the fact that our largest response group was the elderly. This is most notable in the Arboretum Residents Association as this group is primarily retired residents. Ideally, as the University's Energize Worcester program moves forward, it should involve all age groups and demographics to achieve maximum implementation. In order to achieve this we recommend several different strategies.

First, we recommend having competitions as part of the program, whether this be a t-shirt design competition or a poster design competition. These competitions could generate new ideas for the project, and give younger residents a way to contribute their creative concepts. As a prize we suggest vouchers to a local pub or restaurant that are raffled off at the end of the competition. This allows for community engagement with local businesses and can offer an incentive for participation.

In order to include more families and get the next generation involved, we recommend hosting more events that are geared toward the family, such as free lunch events. Our inspiration came from "Big Lunch" that the local Worcester Baptist Church hosted, where families enjoyed free food and socialization. This sort of activity could be tailored around sustainability and teaching good energy behaviors with kid-friendly exhibits. This event could also be similar to the "Your Green Future" event hosted by the University, a fair which showcased many companies and ideas involving sustainability. The most important aspect of the "Your Green Future" event is the interactivity of the exhibits to engage the youth.

To target a slightly older college-age demographic, we recommend having more informal food events such as a barbeque. At this event the Energize Worcester representatives could talk to other students one-on-one and give information on how to best save energy. This model could

also be tailored to casually speaking with Arboretum residents. This sort of event could also help increase the presence of the project team in the area and help to gain the residents' trust.

An important note is to not exclude older residents (above 65 years of age) from participating, but rather to involve more of the other demographics as our responses were overwhelmingly from the older community. We also found roughly 50% of respondents within each age group from the survey were willing to be contacted in the future, and we recommend getting in touch with these residents to continue future work. With more community engagement of all ages, the project should see further success.

Educational campaigns

In terms of educational campaigns, the majority of participants said there is an insignificant amount of educational campaigns to teach energy saving behaviors. Additionally, roughly half said they would be interested in learning more on how to save energy via a leaflet. To help support this campaign we recommend using our prototype booklet or another leaflet, which gives information on a number of knowledge gaps we discovered in the area. These include the lack of information regarding solid wall insulation, the Green Deal, smart meters, EPCs and other energy saving tips. Our prototype booklet can be seen in Appendix N. The easiest way to distribute this booklet of information would be another canvassing of the Arboretum and slipping the document through the mail slots. From speaking with a few residents in interviews and from our door-to-door canvassing, we established the potential need for a leaflet in several different languages. One resident advised that we should have a booklet in Bangladeshi, Portuguese, and English (Survey 66). Additionally the Energize Worcester program could be modified to accompany this information for application in the Arboretum.

From speaking with home owners and tenants, we found a number of homes suitable for energy retrofits, but these residents did not, could not or would not purchase retrofits such as energy efficient lights, boilers or better wall insulation. Especially poignant was the lack of solid wall insulation in many homes. To spur implementation of retrofits in some homes, we recommend any future campaigns to further increase knowledge of the Green Deal to help finance these technologies. We also recommend increasing community awareness of the City Council grant to install exterior solid wall insulation on a street-by-street basis.

From our work we observed that only a small number of people knew about Energy Performance Certificates (EPCs). This information should be more widely known around the area as people have the right to know how their property may be doing in terms of energy efficiency. This information can benefit residents and help assist them in making energy retrofits and saving money. We recommend any future work increase community awareness of EPCs and how to acquire one for a property. Similarly, only about two-thirds knew what a smart meter was. In order to increase awareness, we recommend that future teams supply a detailed and simplified account of what a smart meter is and how a meter can benefit each person. With this information, resident uptake of smart meters may be greater than the present half of surveyed respondents who want one. This could also be covered by a consultation with a utility company representative or a group panel of several different utility companies.

Toolkit and best practices for follow-on work

From our surveying and door-to-door canvasing, we found that most people were available during tea time (4:30 PM to 7:00 PM) and during the weekend (especially on Sunday). Future teams should also try to appear as much like students as possible to avoid being seen as door-to-door marketers (as we had several residents tell us that they talked to us because we resembled students). We also recommend that any action be preceded by a leaflet explaining the project as we disturbed 724 notification leaflets (describing the project and the upcoming surveying) around the Arboretum.

In our meetings with Mr. Brohan, we learned of several tools that can be used to assess the various levels of efficiency around the home. These include draft-sniffers (to find drafts in a home), thermochrons (see Section 2.10 for a more detailed discussion), thermal cameras and clip-on in-home displays. In order to take quantitative readings of levels of heating in homes and increase the thermal efficiency, we recommend future teams use these tools.

5.2 Conclusion

Our report covered the preparation and research that assisted us in assessing and surveying the Arboretum community. From our site assessment we perceived low levels of energy conservation and disregard for energy consumption behaviors. The Energy Performance Certificate (EPC) data supported our perception of the region and showed that the area can improve from its current rating of a D to a low C rating (see Chapter 4 for the EPC scale). Our work covered a baseline survey of the population of the Arboretum and showed a range of levels of energy usage and conservation. While there are those who are more energy efficient and knowledgeable of sustainability, many still could lower their energy bills. Almost half of respondents felt that they spent too much on their bills and some, who felt that they spent just enough money on their bills, still indicated dissatisfaction with their bills. While some properties could not be made any more energy efficient, many still wished to learn more about energy saving behaviors through an informational leaflet. To further learn about their electricity consumption, about half wished to have a smart meter installed in their property to provide real-time feedback of the resident's electricity usage.

To reiterate, our project focused on establishing a baseline profile of the Arboretum. We determined the types of properties within the Arboretum, who lived at each residence and the breakdown of owned and rented homes. We also determined those willing to participate in future research and to receive information on saving energy. With this knowledge, future teams could better tailor programs to fit the community by engaging the various demographics. Any continuation of this project could focus on crafting of a program to help educate residents concerning energy saving behaviors, the Green Deal and its options, and facilitate smart meters implementation.

Given the challenge of entering and canvassing an entirely new area, the project went smoothly. At this stage the project put the Energize Worcester, University of Worcester and City Council names out in the community as having started a two year initiative to help community members. Our project documented energy usage, energy efficiency knowledge, and demographics of residents within the Arboretum. With our initial work, we are confident that we have established proper groundwork for future programs to increase the overall sustainability of the region.

References

Allcott, H., & Mullainathan, S. (2010). Behavioral Science and Energy Policy. http://citeseerx.ist.psu.edu/viewdoc/download?rep=rep1&type=pdf&doi=10.1.1.208.5738

A. T. Kearney. (2010). The Smart Meter Mandate *The 2009 European Union regulations to increase energy security, reduce carbon output and improve competitiveness in the energy sector are leading national authorities to deploy smart meters*. http://www.atkearney.co.uk/utilities/ideas-and-insights/article/-/asset_publisher/yhmo7G8N4h4X/content/the-smart-meter-mandate/10192

Avard, M. M. (2010). Use of Thermochrons in the classroom. *Journal of College Science Teaching, 40*, 58.

Banwell, L., Ray, K., Coulson, G., Urquhart, C., Lonsdale, R., Armstrong, C., Rowley, J. (2004). Providing access to electronic information resources in further education. *British Journal of Educational Technology, 35*(5), 607-616. doi: 10.1111/j.0007-1013.2004.00417.x

Barrow, W. (n.d.) Victorian Houses and Homes. Retrieved from website: http://resources.woodlands-junior.kent.sch.uk/homework/houses.html

Bartos, L. (2006). The Advantages of Weather Stripping. Retrieved 16 April, 2014, from http://lancaster.unl.edu/home/articles/2006/weatherstrip.shtml

Berg, B. L., & Lune, H. (2012). *Qualitative Research Methods for the Social Sciences* (8th ed.). Pearson Education, Inc.: Ed. Karen Hanson.

Boardman, B. (2004). New Directions for household energy efficiency: evidence from the UK. *Energy Policy, 32*(17), 1921-1933. doi: 10.1016/j.enpol.2004.03.021

British Gas. Smart Meter Upgrade. Retrieved from 6 April, 2014, from britishgas.co.uk website: http://www.britishgas.co.uk/smarter-living/control-energy/smart-meters.html

The Climate Group. (2008). SMART 2020: Enabling the Low Carbon Economy in the Information Age. Retrieved from smart2020.org website http://www.smart2020.org/_assets/files/02_Smart2020Report.pdf

Cohen, Z. (2006). How to Make Your Home Energy Efficient. 1-10. Retrieved from home.howstuffworks.com website: http://home.howstuffworks.com/green-living/how-to-make-your-home-energy-efficient.htm

Cristaldi, M., & Timpanaro, S. (2009). Boosting Energy Awareness with Adaptive Real-time Environments. Retrieved from http://www.energyawareness.eu/beaware/uploads/deliverables/BeAware-D6.1-TKK-V1.0-090615.pdf

Darby, S. (2006a). *A Review For DEFRA Of The Literature On Metering, Billing and Direct Displays.* Environmental Change Institute: University of Oxford.

Darby, S. (2006b). *The Effectiveness of Feedback on Energy Consumption.* Environmental Change Institute: University of Oxford.

Darby, S. (2010a). Literature review for the Energy Demand Research Project: OFGEM, Environmental Climate Change. Retrieved from https://www.ofgem.gov.uk/ofgem-publications/59113/sd-ofgem-literature-review-final-081210.pdf

Darby, S. (2010b). Smart metering: what potential for householder engagement? *Building Research & Information, 38*(5), 442-457. doi: 10.1080/09613218.2010.492660

Darby, S. (n.d.). Literature Review for the Energy Demand Research Project. Environmental Change Institute: University of Oxford.

DECC. (2012a). Energy Performance Certificate. Retrieved 7 April, 2014, from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/49997/1790388.pdf

DECC. (2012b). First Annual Progress Report on the Roll-out of Smart Meters (Department of Energy and Climate Change ed.). Retrieved 7 April, 2014, from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/68973/7348-first-ann-prog-rpt-rollout-smart-meters.pdf

Dits, J. (17 October 2012). Energy assessment in public housing, *McClatchy - Tribune Business News*. Retrieved 4 April, 2014, from http://search.proquest.com/docview/1112422607?accountid=29120

Doyle, J. K. (n.d.). Introduction to Survey Methodology and Design. *Handbook for IQP Advisors and Students* (Chapter 10). Worcester, MA: Worcester Polytechnic Institute.

E.On. Smart Meters - Energy & Electricity Monitors. Retrieved 4 April, 2014, from https://www.eonenergy.com/for-your-home/saving-energy/smart-meters

Efthymiou, C., & Kalogridis, G. (2010). Smart Grid Privacy via Anonymization of Smart Metering Data *IEEE*.

Energy-efficient consumers. (June 2009) *Appliance Design, 57,* 6+.

Energy Saving Trust. (2014). How to Reduce Your Carbon Footprint. Retrieved 6 April, 2014, from http://www.energysavingtrust.org.uk/Take-action/Reduce-your-carbon-footprint

Faruqui, A., Harris, D., & Hledik, R. (2010a). Unlocking the €53 billion savings from smart meters in the EU: How increasing the adoption of dynamic tariffs could make or break the

EU's smart grid investment. *Energy Policy*, *38*(10), 6222-6231. doi: http://dx.doi.org/10.1016/j.enpol.2010.06.010

Faruqui, A., Sergici, S., & Sharif, A. (2010b). The impact of informational feedback on energy consumption—A survey of the experimental evidence. *Energy*, *35*(4), 1598-1608.

Feng, X., & Hu, Y. (April 2012). Design principle study of high efficiency compact fluorescent lamps. *Leukos, 8*, 301+. doi: 10.1582/LEUKOS.2012.08.04.004

Fischer, C. (2007). Feedback on household electricity consumption: a tool for saving energy? Retrieved from Springer Link website: http://link.springer.com/article/10.1007/s12053-008-9009-7/fulltext.html
doi: 10.1007/s12053-008-9009-7

Fitzgerald, W. B., Fahmy, M., Smith, I. J., Carruthers, M. A., Carson, B. R., Sun, Z., & Bassett, M. R. (2011). An assessment of roof space solar gains in a temperate maritime climate. *Energy and Buildings*, *43*(7), 1580-1588. doi: http://dx.doi.org/10.1016/j.enbuild.2011.03.001

Gosden, E. (2014). Energy giants call for review of smart meter roll-out to save consumers £1.8bn. *Telegraph*, n.p. Retrieved from The Telegraph website: http://www.telegraph.co.uk/finance/newsbysector/energy/10613535/Energy-giants-call-for-review-of-smart-meter-roll-out-to-save-consumers-1.8bn.html

HEFCE. (November 2013). Sustainable Development in Higher Education. Higher Education Funding Council for England. Retrieved from: http://www.hefce.ac.uk/media/hefce/content/pubs/2013/201331/2013_31.pdf

Hunt, N., & Tyrrell, S. (2004). Stratified Sampling. Retrieved 26 April, 2014, from http://nestor.coventry.ac.uk/~nhunt/meths/strati.html

Hunter, L. M., Hatch, A., & Johnson, A. (2004). Cross-National Gender Variation in Environmental Behaviors*. *Social Science Quarterly, 85*(3), 677-694. doi: 10.1111/j.0038-4941.2004.00239.x

IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

John, C. (n.d.). What Are the Benefits of Caulking? Retrieved 16 April, 2014, from http://www.ehow.com/info_8619892_benefits-caulking.html

Kearney, M., Ferguson, E., Fumei, S., Gallacher, A., Mitchell, P., Woodford, R., & Handasyde, K. (2011). A cost-effective method of assessing thermal habitat quality for endotherms. *Austral Ecology, 36*(3), 297-302. doi: 10.1111/j.1442- 9993.2010.02150.x

Landmark. (n.d.). Retrieve an Energy Performance Certificate Using the Postcode. Retrieved 30 May, 2014, from https://www.epcregister.com/reportSearchAddressByPostcode.html

Loudin, A. (2005). Checking The Mercury. Retrieved 26 May, 2014, from http://www.foodlogistics.com/article/10316350/checking-the-mercury

Luchs, M. G., Naylor, R. W., Irwin, J. R., & Raghunathan, R. (2010). The Sustainability Liability: Potential Negative Effects of Ethicality on Product Preference. *Journal of Marketing, 74*(5), 18-31. doi: 10.1509/jmkg.74.5.18

MacDonald, M. (2007). Appraisal of Costs and Benefits of Smart Meter Roll Out Options. National Archives: BERR. Retrieved from: http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file45997.pdf

MacKay, D. J. (2009). *Sustainable Energy - Without the Hot Air* (p. 366). Retrieved from http://www.inference.phy.cam.ac.uk/sustainable/book/tex/sewtha.pdf

Maxim Integrated. (n.d.). Overview of iButton Sensors. Retrieved 26 May, 2014, from http://www.maximintegrated.com/en/products/ibutton/ibuttons/thermochron.cfm

Maxwell, J. A. (1996). *Qualitative Research Design: An Interactive Approach*. Thousand Oaks, CA: SAGE Publications, Inc.

Mehta, M., Scarborough, W., & Armpreist, D. (2009). *Building Construction; Principles, Common, Materials & Systems*: Prentice Hall.

Mehta, M., Scarborough, W., & Armpriest, D. (2013). Building Construction: Principles, Materials, and Systems. Retrieved from ebooks website: http://tinyurl.com/kffy3pj

Merriam-Webster. (2014). Sustainable. Retrieved 21 April, 2014, from http://www.merriam-webster.com/dictionary/sustainable

Moi-Tin, C., Tatt-Huong, T., & Ye-Chow, K. (2008, 23-25 Jan. 2008). *Electrical Power Monitoring System Using Thermochron Sensor and 1-Wire Communication Protocol.* Paper presented at the Electronic Design, Test and Applications, 2008. DELTA 2008. 4th IEEE International Symposium on.

Monterey County Health Department. (2011). Review of Health Issues Related to Smart Meters (p. 11). National Electrical Manufacturers Association (NEMA): Public Health Bureau, Epidemiology and Evaluation. Retrieved 7 April, 2014, from http://www.nema.org/Technical/Documents/Smart%20Meter%20Safety%20-%20Marin%20Co%20CA%20whitepaper.pdf

Neenan, B., & Hemphill, R. C. (2008). Societal Benefits of Smart Metering Investments. *The Electricity Journal*, *21*(8), 32-45. doi: http://dx.doi.org/10.1016/j.tej.2008.09.003

NLA (National Landlords Association). (n.d.). Green Deal benefits for landlords and tenants. Retrieved 21 April, 2014, from http://www.landlords.org.uk/news-campaigns/campaigns/green-deal-benefits-landlords-and-tenants

NLA (National Landlords Association) (2013). Measure Qualifying for the Green Deal and ECO. Retrieved 21 April, 2014, from http://www.landlords.org.uk/sites/default/files/Measure%20qualifying%20for%20the%20Green%20Deal%20and%20ECO.pdf

NLA (National Landlords Association). (2014). Understanding the Green Deal. Retrieved 21 April, 2014, from http://www.landlords.org.uk/news-campaigns/campaigns/understanding-green-deal

Office of Gas and Electricity Market, OFGEM. (2010). *Smart Metering Implementation Programme: In-Home Display*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42731/233-smart-metering-imp-in-home.pdf

Park, N.-K., & Lee, E. (2013). Energy-Efficient Lighting: Consumers' Perceptions and Behaviors. *International Journal of Marketing Studies, 5*(3), 26-35.

Research Triangle Institute. (1990). An Investigation of Infiltration and Indoor Air Quality (p. 438). SciTech Connect: NYSERDA. Retrieved from: http://www.osti.gov/scitech/servlets/purl/6496739

ScottishPower. Smart Meters. Retrieved 6 April, 2014, from http://www.scottishpower.co.uk/energy-efficiency/smart-meters/

Shaw, P., & Pingitore, G. (2012). Strategic segmentation: understanding consumers' likelihood of engaging in smart energy behaviors. *Public Utilities Fortnightly (1994), 150*, 26+.

Striven Industries LLC. Benefits of a Furnace Filter. (2007). Retrieved from rememberthefilter.com website: http://www.rememberthefilter.com/what-does-a-furnace-filter-do

Transition Worcester. (2014). Retrieved 6 April, 2014, from http://www.transitionworcester.org.uk/?page_id=2

Trilations. (n.d.). How to Increase Energy Efficiency with Smart Meters (p. 4): Trilations. Retrieved 7 April, 2014, from http://www.trilations.com/sites/default/files/White%20paper%20-%20Energy%20efficiency%20with%20smart%20meters_0.pdf

U.S. Department of Energy. Energy Star® Qualified Windows. (2009). http://www.energystar.gov/ia/partners/manuf_res/downloads/PartnerResourceGuide-LowRes.pdf

Valberg, P. A., van Deventer, T. E., & Repacholi, M. H. (2006). Workgroup Report: Base Stations and Wireless Networks - Radiofrequency (RF) Exposures and Health Consequences. *Environmental Health Perspectives, 115*, pp. 416-424. Retrieved from National Center for Biotechnology Information website: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1849947/?report=classic doi: 10.1289/ehp.9633

Van den Bergh, B., Griskevicius, V., & Tybur, J. M. (2010). Going Green to Be Seen: Status, Reputation, and Conspicuous Conservation (Vol. 98, pp. 392-404). Journal of Personality and Social Psychology: American Psychological Association. doi: 10.1037/a0017346

Worcester Arboretum. (n.d.). Retrieved 20 April, 2014, from http://www.thearboretum.org.uk/history/gallery.html

Worcestershire City Council. (2013). Ward Profiles Selection: Arboretum Geo-type: Ward (p. 14). Worcestershire County Council Records. http://atlas.worcestershire.gov.uk/IAS/profiles/profile/pdf?navbar=false&controls=false&profileId=31&geoTypeId=19&geoIds=47UEFN&ajax=false&ieext=.pdf

Yuen, G. S. C., Sproul, A. B., & Dain, S. J. (2010). Performance of 'energy efficient' compact fluorescent lamps. *Clinical and Experimental Optometry*, *93*(2), 66-76. doi: 10.1111/j.1444-0938.2010.00462.x

Zundel, S., & Stieb, I. (2011). Beyond Profitability of Energy-Saving Measures-Attitudes Towards Energy Saving. Journal of Consumer Policy: Springer Science&Business Media. Retrieved 23 April, 2014, from http://link.springer.com/article/10.1007%2Fs10603-011-9156-7

Appendices

Appendix A – Additional smart meters background

A traditional electricity meter has two types of displays. Typically the meter may have a wheel or disc that spins at a speed proportional to the current energy usage (i.e., higher instantaneous energy usage means a higher angular speed of the disc). The other form of display on older meters is typically some record of the aggregate energy use since the meter was installed. In order to know how much energy has been consumed in a month, one reading is done at the beginning of the month and another is performed at the conclusion of the month. The two figures are subtracted yielding the net energy usage in the month timeframe. If the bill is sent on a quarterly system then the meter is only read once every few months. This system is a very analog and relatively labor-intensive process, which requires checking of the meter and calculations to be performed to find energy use by month or by day.

In recent years a new style of meter called a smart meter has been introduced to help increase transparency and facilitate meter readings. In their 2008 report called "SMART 2020: Enabling the low carbon economy in the information age," the Climate Group defines smart meters as "advanced meters that identify consumption in more detail than conventional meters and communicate via a network [such as 3G or wireless] back to the utility for monitoring and billing purposes" (The Climate Group, 2008, p. 85; MacDonald, 2007). Several potential benefits to the consumer deriving from smart meters include the potential for a real-time indication of current and past electricity usage, "fraud reduction," the elimination of a human meter reader and the associated lost time waiting for the person to show, a "detailed consumption feedback to the utility," "easier supplier switching" for changing energy companies and the ability to incorporate renewable energy generation sources into the home electricity supply (Darby, 2010b, Table 1). Smart meters are not a new technology but rather an improvement over some technology that already exists called an advanced meter. There is a key difference between this new type of smart meter and an advanced meter in that a smart meter allows two-way communications between the consumer and the supplier while an advanced meter is one way (Darby, 2010b). The benefit is that the power company can send feedback to the consumer in the form of alerts, notifications of increased power usage, and other energy saving tips (Darby, 2010b). The main benefit of this increased feedback is that consumers tend to develop better conservation practices

and this ultimately reduces consumption (Darby, 2010b). As Sarah Darby points out, effective forms of feedback in the smart meter should include at least two of the following: "an interactive element," "detailed appliance-specific breakdown of [energy] usage," data in the form of "continuous [consumption information], daily load curves, or immediate [plotting of energy usage] after the action [of switching on or off and appliance]," and data "comparisons with previous periods" (Darby, 2010b). This information could be displayed on the meter itself or through a new display. This new display can be separate from the actual meter and if using some of these criteria can still provide decent trends toward energy conservation (Darby, 2010b). In order to quantitatively describe these in-home displays (IHDs) and the effect of real time feedback, it becomes necessary to develop grading criteria and to rank the effectiveness of each aspect of the device. Massimo Christaldi and Stefania Timpanaro describe extensively a set of criteria for evaluating "adaptive real-time environments" for the BeAware feedback systems (which range from displays to smartphone apps) (Cristaldi & Timpanaro, 2009). These criteria include many metrics ranging from ease of use to the availability of the feedback to testing of the timing of feedback to website login sections for the data and buttons on certain apps for a smartphone (Cristaldi & Timpanaro, 2009). This sort of grading scheme could be useful in developing criteria to rank pre-existing programs in the home.

It would seem that given the benefits from smart metering, consumers would flock to smart meters, but the major deterrent is cost. Some countries such as Italy and France already have relatively large smart meter implementations (85% and 25% implementation respectively), while the UK is still behind (Faruqui et al., 2010a). In order to bolster the use of smart meters, the UK has announced the installment of a smart meter in all UK homes by 2020 (Kearney, 2010). For the European Union (EU), as a whole, to implement smart meters the cost would be around €51 billion (Faruqui et al., 2010a). In the same paper Ahmed Faruqui et al. estimate the savings after implementing smart meters to be between "€26 and €41 billion, leaving a gap of €10-25 billion between benefits and costs" (Faruqui et al., 2010a). Obviously the consumers cannot be expected to make up the difference, but herein lies another benefit of smart metering: dynamic pricing (Faruqui et al., 2010a). A dynamic pricing system would essentially allow suppliers to change the cost of electricity on an hourly basis to change more during peak hours (Faruqui et al., 2010a). The major benefit from something like this is the ability to make up the gap in installation vs. savings costs; as the money saved from investing in future power plants to

support peak energy consumption is put toward lowering program costs (Faruqui et al., 2010a). On a much smaller consumer and supplier level, Mott MacDonald Limited (MML) in a 2007 report provides a very in depth analysis of the types of smart meters and the potential for implementation due to the cost of each one. In this report MML describes the difference between a clip-on meter display and a full out smart meter, with the difference being the clip-on meter is simply a portable display and has a much lower level of precision and a lack of communication capabilities (MacDonald, 2007). This style of program with in-home displays (IHDs) corresponds to the recommendations made by the Office of Gas and Electricity Markets (OFGEM) in their document outlining the smart metering implementation program where they recommend suppliers provide smart meters and the IHDs to increase consumer saving practices (OFGEM, 2010). In fact several suppliers have already started programs implementing smart meters for consumers (E.On, British Gas, ScottishPower). These programs are opt-in meaning that consumers must express interest in the program in order to receive a meter, reducing the overall cost of implementation. As the DECC says the costs of the program should not be large enough to deter consumers (DECC, 2012b). There are those who question the cost effectiveness of the current program though. Emily Gosden in her article for the Telegraph talks about how three of the six major energy suppliers for the UK have cited the need to revise the smart meter roll out plan (Gosden, 2014). In her article Gosden discusses how some companies have raised concerns over the higher costs associated with implementing smart meters and providing IHDs (Gosden, 2014). The main idea behind this call for review is to ultimately save the consumer more money in the long run and make the programs more cost effective (Gosden, 2014).

No form of technology or innovation is perfect. One of the first issues that has been raised concerning smart meters is the potential for adverse health effects. In order to relay information back to the smart grid and ultimately to utilities and consumers, the smart meter uses Radio Frequency (RF) waves (like those used for cell phone communications) (Monterey County Health Department, 2011). The main concern raised with these RF waves is the likelihood of contracting cancer, as the waves are electromagnetic radiation (Monterey County Health Department, 2011). The Monterey County Health Department also describes the lack of long term studies into the effects of low levels of RF radiation from smart meters on humans, but does study the effects of long term radiation from cell phones and microwaves on humans and concludes the danger is minimal (Monterey County Health Department, 2011). They, in fact,

find the levels of RF radiation produced by a smart meter are substantially lower power than the levels of the RF radiation from a cell phone and a microwave (Monterey County Health Department, 2011). The paper also considers the effect of RF interfering with medical devices and by comparison with RF from cell phones, finds no clear evidence of interference (Monterey County Health Department, 2011). The DECC's "First Annual Progress Report on the Roll-out of Smart Meters" also cites a study that shows the risk from RF waves from smart meters is minimal (DECC, 2012b). As Peter Valberg et al. describe in a report from the National Institute of Environmental Health Science:

> "[There is] little support for adverse health effects arising from RF exposure at levels below current international standards. Moreover, radio and television broadcast waves have exposed populations to RF for > 50 years with little evidence of deleterious health consequences. Despite unavoidable uncertainty, current scientific data are consistent with the conclusion that public exposures to permissible RF levels from mobile telephony and base stations are not likely to adversely affect human health" (Valberg et al., 2006).

While the health effects are important, another potential issue with smart meters is the security of data (i.e., consumption history, current peak usage or costs). Most smart meter programs already reassure consumers that the security is tight, but the issue of hacking into meters connected to a smart grid is always present. In order to improve the security of meters, it becomes necessary for advanced encryption schemes. One such approach is to use the encryption described by Costas Efthymiou and Georgios Kalogridis in which they describe the use of several ID numbers to code smart meter information (Efthymiou & Kalogridis, 2010). The ID numbers correspond to the various types of data the meter is trying to convey (such as high frequency/instantaneous consumption data or low frequency billing consumption data) and then a 3rd party such as the smart meter manufacturing company acts as a lookup table (Efthymiou & Kalogridis, 2010). The purpose of this lookup table is to associate the utility company with the meter data without the utility being able to see the real time data (Efthymiou & Kalogridis, 2010). The process also includes provisions to use certificates (registered using random time intervals after the meter is installed) to verify operation and to set up identification of the meter (Efthymiou & Kalogridis, 2010). The DECC has released its first report on the progress of the smart meter roll out which describes some additional security protocols and regulations the UK government has enacted (DECC, 2012b). This describes how the supplier is only able to access up to half-hourly data if the customer allows them to (DECC, 2012b). The DECC basically

outlines that “the consumers will have control over their energy consumption data, apart from where this is required for billing or other regulated duties” (DECC, 2012b). With these programs and benefits it becomes a matter of changing consumer behavior and watching how smart meters affect society. Therefore, a study of how consumer behavior is affected is needed.

Appendix B – Additional consumer behavior background

Within society itself, no matter how many different organizations offer energy efficient products or how many authors report on the benefits of energy conservation techniques, there will always be people who are skeptical, uncooperative, in denial, or opposed. However, by judging the situation from an expert point of view, changes to the technical energy consumption in a household will lead to a profitable outcome in relatively short payback time periods (Zundel, 2011). For the low-income occupants though, going after expensive but technologically advanced and energy-efficient products is not their first option.

Changing one's behavior with regard to energy use can be viewed as an energy saving technique. Such techniques are assumed to be beneficial to both the environment and to households in the long run. These programs can potentially pay back their costs through savings in less than 10 years. Naturally occupants desire low cost options for reducing energy consumption. Comfort, needs, status, and convenience may be factors in changing one's energy use behavior, but there is no argument that the economic aspects are the sole deciding points. As stated by Stefan Zundel in his 2011 journal article on consumer behavior, research finds that residents underestimate the vast potential of energy savings they can achieve within their homes by simply changing their consumption behaviors (Zundel, 2011). In particular, when residents change the way they use the hot shower, the furnace, or the kettle, the heating bill will be noticeably reduced. From a psychological point of view, though, a lack of personal engagement in energy efficiency will lead to anxieties such as "worrying that retrofits would cause too much dirt and stress," thus causing homeowners to not pursue energy refurbishments (Zundel, 2011).

Energy utilities need to realize that not all consumers will engage in energy retrofits changes inside their homes. It was found that in a study done on approximately 30,000 households, only 13.4% of them would try out energy efficient programs if they were allowed "to earn points for reducing [their] energy use - where points are redeemable for cash, merchandise" (Shaw, 2012). The other top ranking responses are both similar in that the consumers wish to see how much energy (i.e. money) they could be saving and are, at present, saving. In this regard it is to the advantage of utility companies to consider a more specialized consumer base and generate programs accordingly. A "rewards-based incentive program" is a good strategy to use to convince customers to change their energy consumption behaviors, but

companies should also consider education and engagement strategies aimed at encouraging consumers to change their habits by their own free will (Shaw, 2012).

If a company is seen as supporting practices that nurture the environment, consumers will think highly of the marketing campaigns and image of that particular company. Despite this there exist those who only intend to take advantage of the energy conservation community. According to Bram Van den Bergh, there are consumers who consider the "green" economy as an opportunity to create a fake image of altruism (2010). These consumers seize the more expensive green products, which may be of equal or low quality to the conventional counterparts, simply because such green products are portrayed as being beneficial to the environment (Van den Bergh, 2010).

Yet another important concept to consider for consumer perception of sustainable products is what "kind" of product that the consumer would purchase. In recent times manufacturers assume that if more energy efficient products are available on the market, then the public opinion and profit of the company will increase thanks to the demand for green products. But this is not always the case; "gentleness-related" attributes in products versus the "strength-related" attributes are found to be essential factors for the consumer base (Luchs, 2010). Examples of "gentle" products are baby shampoo, house-cleaning products, and hair care items where examples of "strong" products are tires, drills, and construction related products. The paper by Michael Luchs has demonstrated that consumers associate sustainability and efficiency with terms such as "clean," "gentle," and "mild," which is contrary to consumers associating a lack of sustainability with "power," "strength," and "toughness" (Luchs, 2010). A homeowner will most likely consider a green-version of a spray cleaner bottle over the normal brand; as a counterpoint a construction worker will probably reject an energy efficient, and potentially lower performance, power drill for a much stronger normal brand product, simply due to the labeling of "green." To this end, emphasizing the sustainable aspect for strong products can actually harm the image of these products and consumers may prefer the non-efficient counterparts; this is called "sustainability liability" (Luchs, 2010). Thus, marketers need to consider what features of green products they should promote in order to predict a consumer's choice.

Appendix C – Additional information regarding in-home displays and direct feedback

The Office of Gas and Electricity Markets (OFGEM) is a sub department within the Department of Energy and Climate Change (DECC) in the British Government. This group has performed and analyzed numerous studies on the implementation of smart meters and in-home displays (IHDs). In this context, an IHD is essentially a separate monitor with information regarding the current electricity usage, current pricing, and comparisons to past energy usage data (OFGEM, 2010). According to the OFGEM report "longer-term behaviour change [toward more energy conscientious practices] can be triggered by short-term use of an IHD" (OFGEM, p.17, 2010). In fact the OFGEM recommends mandating energy suppliers provide an IHD to consumers within a year of installation of a smart meter if the customer opts into the program (OFGEM, 2010). The main rationale behind this sort of program is the concept of "direct feedback." Direct feedback is a method where electricity consumption data is provided back to consumers in almost real time (Faruqui et al., 2010b). Direct feedback has the most immediate application with IHDs where the consumer can visualize their energy consumption on screen (Faruqui et al., 2010b). In their article on informational feedback on energy consumption, Faruqui et al., summarize 12 case studies on the use of direct feedback through IHDs and find an average energy savings ranging from 3% to 13%, with the average savings being 7% (Faruqui et al., 2010b). This further shows the need for some form of direct and quantitative feedback to the consumer (Faruqui et al., 2010b). Another study has shown the potential for direct feedback to reduce household electricity usage by 2% to 28% (Neenan, 2008).

On a broader topic of publicity campaigns and forms of behavior feedback, Hunt Allcott and Sendhil Mullainathan in their article on Behavioral Science and Energy Policy describe how many behavior programs fail because of a lack of feedback of some form (Allcott, 2010). Darby, in her 2006 literature review on the Effectiveness of Feedback on Energy Consumption, states that "without feedback it is impossible to learn effectively" (Darby, 2006b, p.17). This is a major consideration for publicity campaigns. In talking about forms of consumer feedback, Allcott and Mullainathan in their paper describe a company called OPOWER. OPOWER's program for reducing energy consumption through consumer feedback is mainly in the material realm with paper energy reports comparing the consumer to social norms and providing energy and sustainability tips (Allcott, 2010). The reports used the comparisons to social norms because consumers were better influenced by peer-related metrics rather than altruistic imagery or

pathetic appeals (Allcott, 2010). This sort of process could be included in the IHDs or adapted for a larger scale to provide greater results (Allcott, 2010).

The main lesson to be learned from this study of consumer behavior with feedback is that the most effective form of changing consumer behavior is direct feedback. In terms of application to this project, the form of direct feedback could be potentially incorporated into consumer surveys or publicity campaigns. As Darby points out in her Literature Review for the Energy Demand Research Project, she mentions that multiple interventions (i.e. advice, community involvement and/or local energy conservation competitions) coupled with feedback prove to be the most effective in altering behavior (Darby, 2010a). This is corroborated by Trilations in their white paper on increasing energy efficiency where the most effective forms of feedback and behavior change included "continuous personal interaction with the consumer" and enabling communication among consumers and utility companies to compare progress (Trilations, n.d., p. 4).

Appendix D – Additional information regarding energy-efficient lighting

According to the Energy Saving Trust website in the "Lighting" subsection, household light usage accounts for approximately 7% of a household's typical energy bill (Energy Saving Trust, 2014). On the topic of lighting, two actions are taken to tackle problems: replacing bulbs and turning lights off. For replacement of lighting, there are two types of bulbs available in the UK; compact fluorescent lamps (CFLs) and light emitting diode (LEDs) bulbs. While both bulbs are proven to be energy efficient countless times (Feng et al., 2012; Yuen et al., 2010), in the past many households especially in the USA used incandescent bulbs. For a case study that took place in the Meridian Charter Township in Michigan, USA, researchers evaluated the connection between a person's socio-demographic background and his or her perception of energy-efficient lighting (Park et al., 2013). These researchers' questionnaire contained three main topics: "energy efficient lighting perceptions in general, perceptions of CFLs, and environmental lighting behaviors" (Park et al., 2013, p. 1). Of the 2,000 randomly selected households who received the survey, only 326 actually responded (a response rate of 16.3%) (Park et al., 2013, p. 1). Naturally, surveys can be difficult to assess a person's opinion on lighting. Therefore the paper established categories for lighting perception; visual comfort, aesthetics, impression, cost, and technological attributes (Park et al., 2013). A wide category of respondents were surveyed: males and females, ages 25 to 65 and beyond, low income households (under $50,000 annually) to high income households (over $100,000 annually) and lastly small house sizes (2,000 square feet or less) to large house sizes (over 3000 square feet) (Park et al., 2013).

In terms of perceptions of energy efficient lighting, the results showed that males responded positively to visual comfort, aesthetics, impression, costs and technological attributes (Park et al., 2013). By comparison, females had a more negative response toward each of these attributes of CFLs. The female demographic may view the CFLs as unsuitable for their homes based on the negative responses on the attributes of CFLs. This seems to go against another study, in which the researchers expect females to find CFLs appealing "considering environmental concerns and impacts" (Hunter et al., 2004).

When identifying the consumers' perception of CFLs, it was found that inaccurate or insufficient information was available towards those who contemplating energy efficient lighting (Park et al., 2013). An example was provided by Linda Banwell et al. where a model household

was outfitted with CFLs and demonstrated to consumers (2004). This control group was then informed about the basics and benefits of energy efficient lighting (2004). Overall, roughly 90% of the participants answered that they would prefer easier to understand and simpler information available for energy efficient lighting on the market (Banwell et al., 2004). Another factor about CFLs is that they emit a white "cool" toned light while the previously available incandescent bulbs had a "warm" toned light (Park et al., 2013). Many people enjoy the warm glow of incandescent bulbs. Therefore these consumers feel skeptical and uncomfortable switching to the cold color of CFLs. For those with sensitivity to the blue-tone of many CFL/LED bulbs, there are other options that replicate incandescent lighting.

Looking at the habitual energy consumption behaviors of households, those that had a low income seemed to express more interest in pursuing, or continuing, energy efficient behaviors in comparison to high income households (Park et al., 2013). In fact it was seen that high income consumers were somewhat willing to practice energy efficient behaviors but had more opportunity to invest in expensive energy efficient technology due to their larger capital funds (Hunter et al., 2004). Therefore while low-income consumers are not able or willing to invest in an expensive green alternative, their behaviors tend to be greener than higher income consumers.

The case studies seemed to suggest that marketing strategies should offer simple, updated, and interesting facts about energy efficient lighting for all ages and genders. Researchers and publicists should work together to combat the misconceptions and inform the consumers concerning the benefits of new lighting technology (Park et al., 2013). With this collaboration and other additional energy efficient practices, society as a whole can reap the rewards of having a bright home while also being green (Park et al., 2013).

Appendix E – Landlord letter created by the University of Worcester

Dear Landlord

Energise Worcester Opportunity for Occupiers of Private Rented Property

We are getting in touch to let you know about an exciting innovative joint initiative which aims to train occupants to have a better understanding of energy use, to help keep houses adequately heated to prevent condensation and tackle poor energy efficiency in privately rented accommodation.

Building on a successful pilot, the **Energize Worcester** project encourages occupants of shared houses (students and in the Arboretum non-student shared houses) to use less energy by a bespoke online application to provide instant feedback on energy consumption mapped to similar property types, see below for examples of the reports.

Students have been trained to be energy assessors and provide home visits to encourage occupants to use their energy wisely and be shown how to set up their boiler controls and other energy saving habits. This includes providing bespoke reports to be left in houses.

The project is funded through Higher Education Funding Council for England's Student Green Fund, a £5m funding pot which is supporting 25 student led sustainability projects in universities across the country. Since being awarded funding in October 2014, the Students' Union has conducted extensive preparations to ensure the success of the project, including training students as accredited energy advocates and building bespoke software for energy consumption analysis. Eon and British Gas are on board with the project to have SMART meters supplied **free of charge** to some properties.

If you are interested in being involved in this project, by either having a free SMART meter fitted, or submitting energy meter readings and encouraging your occupants to take part in competitions and other activities to instil good energy use habits, then please get in touch with **Peng Li** the project manager, **p.li@worc.ac.uk** or phone **01905 543223**. More information can be found on the website **www.energize-worcester.com**

This is an exciting opportunity to make improvements to your houses; we hope you will get involved.

Yours sincerely

Sally Kelsall
Strategy & Partnership Manager
01905 722009
Sally.kelsall@worcester.gov.uk

Peng Li
Project Manager
01905 543223
p.li@worc.ac.uk

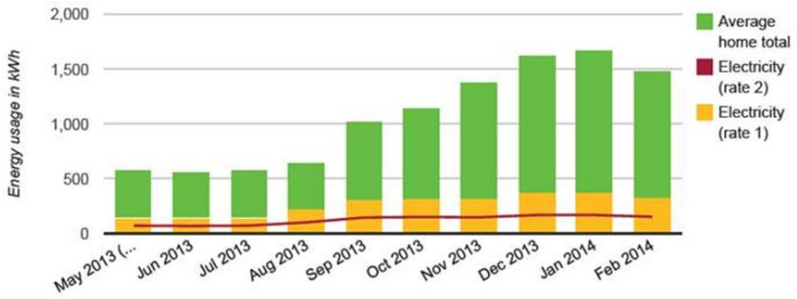
Examples of the reports that can be produced to help with energy saving behaviour

If you have any record for your past meter readings, you can easily input them against the date you took the reading.

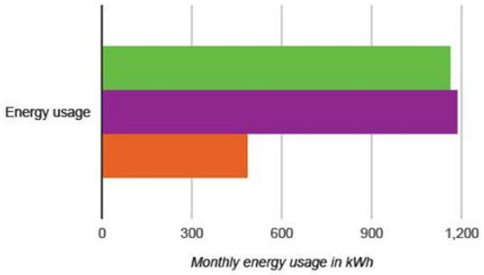
Check out how was your performance against national average!

Energy usage by month

This chart shows your energy usage per month, split into the different energy types. The average home total usage is also plotted for reference.



Energy usage for February 2014



Average home
This is the average energy consumption for the last month of a property with the same type and occupancy as yours. The figure shown is a benchmark based on typical annual energy consumption figures.

Similar home
This is a more detailed total energy consumption based on an approximated heat loss calculation. The inputs for this calculation are taken from the more detailed information about your property including features such as property age, insulation and heating systems at your property.

Your home
This is your total energy consumption for the last month based on your meter readings.

- The Red Bar is **YOUR** energy usage
- The Purple bar is energy usage for similar types of home
- The Green bar is energy usage against national average from last month

Appendix F – Leaflet notification slip for Arboretum residents

24th May 2014

To whom it may concern:

In the upcoming weeks a group of four students (Charles Frick, Alexander Shoop, Nicholas Lemere, Stefan Smith) from an engineering university in the United States are working in collaboration with the University of Worcester and the Worcester City Council to assess the levels of energy sustainability among the non-student shared residences in the Arboretum. This leaflet has been designed to inform the residents that in the following days and weeks the students will be knocking on doors in order to conduct surveys in the Arboretum. Your participation is greatly appreciated.

This survey will be conducted beginning the 27th of May and will run through to the 6th of June.

If you are interested in being involved in this project, then please get in touch with Peng Li the project manager, p.li@worc.ac.uk or phone 01905 543223 or contact the student team at energizeworcester@gmail.com. This is part of a larger student project taking place over 2 years. More information can be found on the website www.energize-worcester.com.

We hope you will get involved and appreciate your response and support!

Yours sincerely

Sally Kelsall
Strategy & Partnership Manager
01905 722009
Sally.kelsall@worcester.gov.uk

Peng Li
Project Manager
01905 543223
p.li@worc.ac.uk

Appendix G – Cards for when no resident was available

Hello! We are a group of university students working in collaboration with the University of Worcester and the City Council to assess the demographics and basic energy usage behavior in the Arboretum. This note indicates that we stopped by your home to try and speak with you, but were unable to. We would like to speak with you at your earliest convenience. Please write us an email (energizeworcester@gmail.com) of the best time to reach you and speak you with. Thanks!

Charles Frick, Alexander Shoop, Nicholas Lemere, Stefan Smith

Date: _____

Hello! We are a group of university students working in collaboration with the University of Worcester and the City Council to assess the demographics and basic energy usage behavior in the Arboretum. This note indicates that we stopped by your home to try and speak with you, but were unable to. We would like to speak with you at your earliest convenience. Please write us an email (energizeworcester@gmail.com) of the best time to reach you and speak you with. Thanks!

Charles Frick, Alexander Shoop, Nicholas Lemere, Stefan Smith

Date: _____

Appendix H – Door-to-door canvassing initial questionnaire and notes

Good Morning/Afternoon/Evening, our names are _____. We are a small group of engineering students from a US engineering university, completing a summer project here in the UK working in collaboration with the University of Worcester and the Worcester city council. Our project is focusing on energy efficiency here in the Arboretum, and we will be working in the area over the next few weeks. We were wondering if you had a minute or so to answer 5 questions that will help us gather some background information about the area.

If they say yes, say thank you and proceed with survey.

1. Do you own your home, or do you pay rent?
    a. What sort of renting do you do? (individual, group or family)

2. How many people currently live in your residence (Including you)?
    a. How many other people share the rent with you?

3. (If an HMO), would you be willing to fill out this survey with us regarding housing conditions and energy?

4. When was your property built **or could we take a picture** of the front of the residence? (For insulation purposes)

5. Would you be willing to give us your contact information to potentially participate in future research?

A Council house is a rented house NOT HMO
The definition of an HMO from the Worcester City Council is below:

- An entire house or flat which is let to **3 or more tenants** who form **2 or more households** and who share a **kitchen, bathroom or toilet.**
- A house which has been converted entirely into bedsits or other non-self-contained accommodation and which is let to **3 or more tenants w**ho form two or more households and who share kitchen, bathroom or toilet facilities.
- A converted house which contains one or more flats which are not wholly self contained (i.e. the flat does not contain within it a kitchen, bathroom and toilet) and which is occupied by **3 or more tenants who form two or more households.**
- A building which is converted entirely into self-contained flats if the conversion did not meet the standards of the 1991 Building Regulations and more than one-third of the flats are let on short-term tenancies.

Appendix I – Permission letter we carried when surveying

To Whom It May Concern:

This is a group of engineering students from a US engineering university. The students' names are Charles Frick, Alexander Shoop, Nicholas Lemere and Stefan Smith. Their research project is to survey the non-student shared houses in the **Arboretum**. Using this data, they will assess residences concerning energy consumption behaviour and energy efficiency.

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 has reviewed and approved of the materials that the team is using.

If you have any questions or concerns, please contact **Peng Li** the project manager at the University of Worcester, **p.li@worc.ac.uk** or phone **01905 543233**. 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.

Appendix J – Cover letter for main survey

Assessing the Arboretum

Dear resident of the Arboretum,

The University of Worcester and the City Council are working in collaboration with a team of four university students (Charles Frick, Alexander Shoop, Nicholas Lemere, Stefan Smith) from Worcester Polytechnic Institute (USA) to analyze demographics in the city. We have selected your neighborhood to conduct a study of the energy efficiency of local properties and basic energy usage.

We would greatly appreciate your participation in our study. Please find the attached survey concerning demographics and energy consumption habits. Our survey is voluntary, but your cooperation will be particularly helpful in understanding the community as a whole. With the information collected in this pursuit we can better tailor educational and outreach programs to the community to improve the Arboretum.

Any information you provide will be strictly confidential. There is an option at the end of the survey to participate in future research. If you choose to provide your contact information to enable us to schedule a follow-up with you at a later date, please be assured the two datasets will not be linked. The conclusions reached as a result of this survey will be generalized in nature and will not contain distinguishing features of your residence.

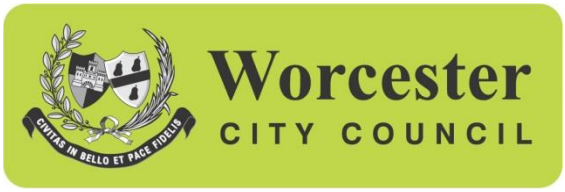
Please return all surveys by June 13th 2014

In order to return the survey, please choose one of the following options:
1. Email the students at energizeworcester@gmail.com to come collect the survey
2. Drop the completed surveys at 8 Arboretum Road via the mail slot. **Attention: Energize Worcester**
3. Free post the survey to the University of Worcester using the attached envelope

If you are interested in being involved in this project, please get in touch with **Peng Li** the project manager, **p.li@worc.ac.uk** or phone **01905 543223**. You can also contact the Director of Environmental Sustainability at the University of Worcester, **Katy Boom** at **k.boom@worc.ac.uk** or phone **01905 855243**. More information can be found on the website www.energize-worcester.com

#ENERGIZEWORCESTER

Appendix K – Main survey



Energy and Arboretum

This is a survey to establish a baseline profile of the properties and general community. Our team consists of four US students from an engineering university in Worcester, Massachusetts USA working here on this project. Any feedback from residents on the demographics and current conditions in the Arboretum helps better understand the region and better tailor community improvement programs.

The data gained through this project will be kept confidential and will not be revealed to third parties. Additionally any information revealed as a summary of the project will be anonymous and will not contain personal distinguishing characteristics. **All surveys should be filled in and collected by June 13th**

1. Which of these organizations have you heard of? *(Tick all that apply)*
   - ☐ University of Worcester (UW)
   - ☐ Worcester City Council
   - ☐ Energize Worcester
   - ☐ Transition Worcester
   - ☐ Arboretum Residents Association (ARA)
   - ☐ Worcester Polytechnic Institute (WPI) (US university)
   - ☐ National Landlords Association (NLA)
   - ☐ None of the above
2. Which organization do you prefer to receive more information on saving energy from? *(Circle one)*
   - ○ University of Worcester (UW)
   - ○ Worcester City Council
   - ○ Energize Worcester
   - ○ Transition Worcester
   - ○ Arboretum Residents Association (ARA)
   - ○ Worcester Polytechnic Institute (WPI) (US university)
   - ○ National Landlords Association (NLA)
   - ○ None of the above
   - ○ Other: _____

Property information

3. Are you a homeowner or do you rent? *(Circle one)*

Own Rent

4. If you do rent, do you: *(Circle one)*

Rent the property on your own Share the property with others Rent as a family

5. How many tenants or family members share your residence (including you)? *(Circle one)*

1 2 3 4 5 6+

6. Is damp occurring in the property? *(Circle one)*

Yes No Unknown

7. If yes, do you know why the dampness is occurring? *(Circle all that apply)*

No heating Poor heating Building issue Poor windows Leaks

Poor insulation I don't know Other _____

8. How do you feel about your energy bill? *(Tick one)*

- ☐ I think I spent too much
- ☐ I think I spent just enough
- ☐ I think I spend an insignificant amount compared to my income
- ☐ Other: _____

9. If you are a renter, how often do you communicate with your landlord? *(Circle one)*

Daily Weekly Monthly Yearly

No contact Contact through letting agency Other: _____

10. Please rank your knowledge of energy efficient techniques and technology *(Circle one)*

1	2	3	4	5	6	7	8	9	10
No knowledge				Average knowledge				Expert knowledge	

Lighting

11. Are energy saving light bulbs installed in your house? *(Circle one)*

Yes On most lights No On a few lights I don't know

12. Do you normally turn lights off when a room is no longer in use? *(Circle one)*

Always Usually Occasionally Rarely Never

Energy efficiency

13. Which of the following appliances in your home has an Ecofriendly label (see sidebar)? *(Circle all that apply)*

Washing machine Tumble dryer

Dishwasher Boiler

Refrigerator Television

None of the above Not sure

Other *(please specify)*_____

14. What is your primary source of fuel for heating? *(Circle one)*

Electric Gas Wood Unsure Other *(Please specify)* _____

15. What temperature setting do you usually keep your central heating thermostat set to during summer? *(Circle one)*

< 16°C 16°C to 21°C 22°C to 25°C > 25°C

I don't control my heating I don't have a thermostat

16. What temperature setting do you usually keep your central heating thermostat set to during winter? *(Circle one)*

< 16°C 16°C to 21°C 22°C to 25°C > 25°C

I don't control my heating I don't have a thermostat

17. Does your property have any of the following features? *(Tick all that apply)*

Energy efficient boiler (e.g. condenser boiler)	☐ Yes	☐ No	☐ Not sure
Electric space heaters	☐ Yes	☐ No	☐ Not sure
Wall insulation	☐ Yes	☐ No	☐ Not sure
Loft insulation	☐ Yes	☐ No	☐ Not sure
Energy saving light bulbs (compact fluorescent (CFL) or light emitting diode (LED) bulbs)	☐ Yes	☐ No	☐ Not sure
Double glazed windows	☐ Yes	☐ No	☐ Not sure
Renewable Energy generator (e.g. solar panels on the roof)	☐ Yes	☐ No	☐ Not sure
Other *(please specify)*_____	☐ Yes	☐ No	☐ Not sure

18. Do you do any of the following? *(Tick all that apply)*

- ☐ Turning off lights when you leave the room
- ☐ Taking shorter showers
- ☐ Turn down the thermostat when possible
- ☐ Wash clothes at 30 degrees or less
- ☐ Put appliances into a sleep or standby mode when not in use
- ☐ Other _____

19. Do any of the following descriptions fit your primary purpose to do the activities in question 18? *(Tick all that apply)*

- ☐ Saving money on bills
- ☐ Protecting the environment
- ☐ Becoming healthier
- ☐ Everyone else is, I should too
- ☐ I do not do any of those activities in the previous question
- ☐ Other *(please specify)* _____

20. What barriers are preventing you from doing the activities in question 18? *(Tick all that apply)*

- ☐ Expensive new appliances and retrofits
- ☐ One person has a very small impact
- ☐ I need more support to make an impact
- ☐ Too much work and not enough time
- ☐ Other _____

21. Do you regularly monitor your gas and electricity consumption (for heating, cooking, personal use etc.)? *(Circle one)*

Yes Occasionally No

22. If no, what are the possible reasons you do not? *(Tick all that apply)*

- ☐ Too busy with other activities
- ☐ Unaware of the process
- ☐ No access to the meter
- ☐ My consumption does not matter to me
- ☐ Other: _____

23. If yes, roughly how much money do you spend on your monthly energy bill per person? (*Circle one)*

£0 to £20 £21 to £30 £31 to £40 £41 to £50 £51 to £60 over £60 Prefer not to say

Please tick the corresponding box	YES	NO
24. Do you know what a smart meter is? *(Smart meters are meters which have a modern digital display with the capability of wireless communication of energy usage to an energy supplier or an in-home display)*		
25. Do you want to have a smart meter installed in your property?		
26. Do you know the location of your electricity meter?		
27. Do you have access to the electricity meter?		
28. Who is your energy supplier? *(Optional)* _____		

29. Which aspect is most important to you when purchasing cleaning products (e.g. bleach, washing gels, bathroom cleaner)? *(Circle one)*

An eco-friendly sticker or label Cost Convenience

Brand recognition Other _____

Energy Audits		
Please tick the corresponding box	YES	NO
30. Do you know what an Energy Performance Certificate (EPC) is?		
31. Does your property have an EPC?		
32. Have you heard about the Green Deal? *(The Green Deal is a financial plan to assist energy retrofits for properties)*		
33. Have you taken the Green Deal plan?		
34. Do you think the Green Deal would be beneficial to you?		
35. If you have taken the Green Deal plan, we would be interested in speaking with you. If possible please provide your contact information below (it will not be disclosed to third parties).		

Educational programs		
Please tick the corresponding box	YES	NO
36. Would you be interested in learning more about how to save energy?		
37. Do you believe there are sufficient education programs in place for teaching energy saving behaviours?		
38. If you answered yes to question 36, how would you prefer to receive this information? *(Circle all that apply)* Leaflet Consultation Poster Online video Class or lecture Radio ad Other *(please specify)*_____		

Demographics *(This section is optional)*

39. How would you like to consider yourself? *(Circle one)*

Male Female Other Prefer not to say

40. Which would the following age group would you fit in to? *(Circle one)*

< 18 18 to 24 25 to 35 36 to 45 46 to 55 56 to 65 > 65 Prefer not to say

41. Which of the following ethnic groups do you belong to? *(Circle one)*

- White English/ Welsh/ Scottish/Northern Irish/British
- White Irish
- White Eastern European
- Gypsy or Irish Traveller
- Any other White background
- Mixed: White & Black Caribbean
- Mixed: White & Black African
- Mixed: White & Asian
- Any other Mixed background
- Asian or Asian British: Indian
- Asian or Asian British: Pakistani
- Asian or Asian British: Bangladeshi
- Asian or Asian British: Chinese
- Any other Asian background
- Black or Black British: Caribbean
- Black or Black British: African
- Any other Black background
- Arab
- Other_____

42. Which of the following annual income ranges do you fit in the most? *(Circle one)*

< £10,000 £10,001 to £20,000 £20,001 to £30,000 £30,001 to £50,000

£50,001 to £75,000 ≥ £75,001 Prefer not to say

43. Would you like to be contacted by us for future research? *(Circle one)*

Yes No

44. If you answered yes to the last question, please fill in the best way to contact you:

Name:

Address:

Email address:

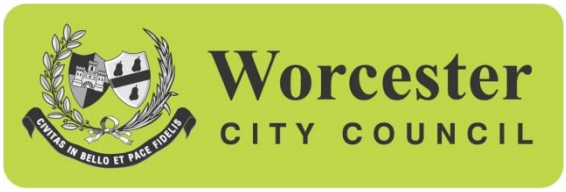
Phone number:

45. Is there anything else you want to share with us regarding the project? *(Please include another page if needed)*

Your participation is greatly appreciated! Thank you for taking the time to complete our survey!

If you have any questions, concerns or for further clarification on our initiative, please contact our team at energizeworcester@gmail.com or contact Peng Li, project manager at p.li@worc.ac.uk

Appendix L – Landlord survey



Assessing the Arboretum

This is a survey to establish a baseline profile of the properties and general community. Our team consists of four US students from an engineering university in Worcester, Massachusetts working here on this project. Any feedback from residents on the current conditions in the Arboretum helps better understand the region and better tailor community improvement programs.

The data gained through this project will be kept confidential and will not be revealed to third parties. Additionally the information revealed as a summary of the project will be anonymous and will not contain personal distinguishing characteristics. **All surveys should be filled out and collected by June 13th.**

1. Which of these organizations have you heard of? *(Tick all that apply)*
   - ☐ University of Worcester (UW)
   - ☐ Worcester City Council
   - ☐ Energize Worcester
   - ☐ Transition Worcester
   - ☐ Arboretum Residents Association (ARA)
   - ☐ Worcester Polytechnic Institute (WPI) (US university)
   - ☐ National Landlords Association (NLA)
   - ☐ None of the above
2. Which organizations do you prefer to receive more information from? *(Circle one)*
   - ○ University of Worcester (UW)
   - ○ Worcester City Council
   - ○ Energize Worcester
   - ○ Transition Worcester
   - ○ Arboretum Residents Association (ARA)
   - ○ Worcester Polytechnic Institute (WPI) (US university)
   - ○ National Landlords Association (NLA)
   - ○ None of the above
   - ○ Other: _____

3. How would you like to consider yourself? *(Circle one)*

Male Female Other Prefer not to say

4. How many rental properties within the Arboretum do you own? *(Circle one)*

1 2 3 4 5 6+

5. Do you know what an energy performance certificate (EPC) is? *(Circle one)*

Yes No

6. Of the rental properties you own within the Arboretum, how many do you have EPCs for?

0 1 2 3 4 5 6+

If you own more than one rental property in the Arboretum please only consider one of these rentals for the following questions.

7. Please give the address of the property you have selected:

_____

8. When was the rental property you own built? *(Circle one)*

Before 1900 1901 to 1930 1931 to 1950 1951 to 1990 after 1990 not sure

9. What is the size of your rental property in square meters? *(Please indicate)* _____

10. What types of lighting are installed in your rental property? *(Circle all that apply)*

Incandescent Compact fluorescent (CFLs) Light emitting diode (LED) Fluorescents

Other *(Please specify)* _____

11. What is the main type of wall in the property? *(Circle one)*

Solid wall Solid wall with insulation Cavity wall Cavity wall with insulation

Unknown Other *(Please specify)* _____

12. What level of insulation exists in the loft? *(Circle one)*

0 to 100 mm 101 to 270 mm 271 + mm Unknown No insulation

13. What types of windows are installed in your rental property? *(Circle all that apply)*

Single glazed windows Double glazed windows Secondary glazed windows

Other *(Please specify)* _____

14. Do you have a draft-proof front door? *(Circle one)*

Yes No Unknown

15. What is your primary source of fuel for heating in your property? *(Circle one)*

Electric Gas Wood Unsure Other *(Please specify)* _____

16. How many washers and clothes dryers are installed in your rental property? *(Please indicate)*

_____ Washers _____ Dryers

17. How many washers and dryers have a High Efficiency Label? *(Please indicate)*

_____ Washers _____ Dryers

18. Which of the following features have you installed in your rental property? *(Tick all that apply)*

☐ Energy efficient boiler (e.g. condenser boiler)	☐ No	☐ Not sure
☐ Electric space heaters	☐ No	☐ Not sure
☐ Energy saving light bulbs (compact fluorescent (CFL) or light emitting diode (LED) bulbs)	☐ No	☐ Not sure
☐ Double glazed windows	☐ No	☐ Not sure
☐ Renewable Energy generator (e.g. solar panels on the roof)	☐ No	☐ Not sure
☐ Other *(please specify)*_____	☐ No	☐ Not sure

Energy Audits

Please tick the corresponding box	YES	NO
19. Have you heard about the Green Deal? *(The Green Deal is a financial plan to assist energy retrofits for properties)*		
20. Have you taken the Green Deal plan?		
21. Do you think the Green Deal would be beneficial to you?		

22. If you have taken the Green Deal plan, we would be interested in speaking with you. If possible please provide your contact information below (it will not be disclosed to third parties).

23. Please rank your knowledge of energy efficient techniques and technology *(Circle one)*

1	2	3	4	5	6	7	8	9	10
No knowledge				Average knowledge					Expert knowledge

Educational programs		
Please tick the corresponding box	YES	NO
24. Would you prefer your tenants to learn more about how to save energy?		
25. Do you believe there are sufficient education programs in place for teaching energy saving habits to your tenants?		
26. If you answered yes to question 23, what would be the best way to educate current and future tenants? *(Circle all that apply)* Leaflet Consultation Poster Online video Class or lecture Radio ad Other *(please specify)*_____		

27. Do you regularly monitor your gas and electricity consumption (for heating, cooking, personal use etc.)? *(Circle one)*

Yes Occasionally No

28. If no, what are the possible reasons you do not? *(Tick all that apply)*

- ☐ Too busy with other activities
- ☐ It's my tenant's responsibility
- ☐ Other: _____

29. If yes, roughly how much money do you spend on your rental property's monthly energy bill? (*Circle one)*

£0 to £50 £51 to £75 £76 to £100 over £100 Prefer not to say I don't pay the bill

30. How do you feel about your energy bill for your property as a whole? *(Tick one)*

- ☐ I think I spent too much
- ☐ I think I spent just enough
- ☐ I spend enough but I want to save more
- ☐ Other: _____

Please tick the corresponding box	YES	NO
31. Do you know what a smart meter is? *(Smart meters are meters which have a modern digital display with the capability of wireless communication of energy usage to an energy supplier or an in-home display)*		

32. Do you want to have a smart meter installed in your property?		
33. Do you know the location of your electricity meter for your property?		
34. Do you have access to the electricity meter(s)?		

35. How many properties have smart meters installed on them? *(Circle one)*

0 1 2 3 4 5 6+

36. Have you experienced any problems with smart meters, if so please explain

37. Who is your electricity supplier? *(Optional)* _____

38. Who is your gas supplier? *(Optional)* _____

39. How often do you communicate with your tenants? *(Circle one)*

Daily Weekly Monthly Yearly No contact

Contact through letting agency Other *(Please specify)*_____

40. Would you like to be contacted by us for future research? *(Circle one)*

Yes No

41. If you answered yes to the last question, please fill in the best way to contact you:
    Name:
    Address:
    Email address:
    Phone number:
42. Is there anything else you want to share with us? *(Please use the back for any further comments)*

Your participation is greatly appreciated! Thank you for taking the time to complete our survey!

If you have any questions, concerns or for further clarification on our initiative, please contact our team at energizeworcester@gmail.com or contact Peng Li, project manager at p.li@worc.ac.uk

Appendix M – Worcester News article on project

Students from Worcester USA travel across the pond for sustainability project

12:35pm Friday 6th June 2014 in News

Worcester Polytechnic Institute students Chas Frick, Alex Shoop, Nick Lemere and Stefan Smith with University of Worcester director of environmental sustainability Katy Boom (middle)

A GROUP of students from a Worcester more than 3,000 miles away have travelled across the pond to help residents save money on their electricity bills.

The four students from Worcester Polytechnic Institute in Massachusetts are visiting the city to take part in the Energize Worcester project coordinated by the University of Worcester.

The scheme is a wide-ranging project working to bring down electricity bills for students in the city living in Houses of Multiple Occupancy (HMOs) through increasing efficiency and encouraging sustainable ways of living.

The group have been meeting with residents in the Arboretum area of the city, which group member Nick Lemere said had proved a challenge.

"We were planning on focusing on the HMOs and working with landlords but due to a serious lack of response we decided to expand it to all residents in the Arboretum," he said.

Alex Shoop said they had come across a language barrier with many of the Arboretum's foreign residents.

"Earlier on we did a leaflet notifying people we would be going around knocking on doors and that really helped us out," he said.

Worcester
19.5°c
76% chance of rain
Weather Forecast

FEATURED JOBS
Catering Manager Tenbury Wells
Carers Worcester
Fork Lift Driver Cinderford
Multi Drop Drivers Worcester
Bricklaying Gangs Worcester
Cleaner Worcester
See 3,333 jobs in and around Worcester

MOST READ
1. Park and ride to be scrapped
2. Dramatic pictures as thunderstorms sweep over Worcestershire and Herefordshire
3. Two taken to hospital after crash involving four cars in Worcestershire
4. Thousands flock to Worcester Racecourse for Ladies' Day
5. Rescue boats deployed for injured man in Worcester
6. Good deed cost me £100 fine
7. Hundreds take part in Worcester's Dragon Boat race
8. Lap-dance club in Worcester needs sex licence or will be forced to shut
9. He's put his holidays before service
10. Guardian storage scandal – director banned for five years but NO criminal charges brought
11. Woman dies after being hit by car
12. Motorist crashes into telephone pole
13. It's official – Worcester has third worst rush-hour traffic in the country
14. Three men arrested in Worcestershire
15. New Mayor of Worcester fending off calls to quit
16. Female stalker from Worcester terrorised married man she "fancied"
17. Tributes paid to man killed in Worcester crash
18. City reprieve is a thing of the past
19. New Worcestershire County Council chief executive pledges to make a difference
20. Star Taylor makes Lions switch

MOST READ YESTERDAY
1. Two taken to hospital after crash involving four cars in Worcestershire
2. Rescue boats deployed for injured man in Worcester
3. Thousands flock to Worcester Racecourse for Ladies' Day
4. Good deed cost me £100 fine
5. He's put his holidays before service

About cookies
We want you to enjoy your visit to our website. That's why we use cookies to enhance your experience. By staying on our website you agree to our use of cookies. Find out more about the cookies we use.
I agree

1. Ditching the cup cakes proved inspired choice for top architect

Chas Frick said they had faced a range of reactions when speaking to residents.

"We've had a whole range of things from people not even opening the door to some inviting us in for a cup of tea," he said.

Nick said: "We've had people say 'I don't know what what you're selling but I don't want it'," he said.

But Stefan Smith said people were starting to open up to them.

"We know people to say hello to in the street now and people recognise us too," he said.

The University of Worcester's director of environmental sustainability Katy Boom, who is working closely with the group, said she had been greatly impressed by their work.

"This is probably one of the hardest areas to look at as part of the project," she said.

"It's a fantastic resource for us to have such keen students doing this project."

The four will present their findings later this month before returning home on Thursday, June 26.

For more information on Energize Worcester visit www.energize-worcester.co.uk.

People who read this article also read

(27 minutes ago in Business)
2. Powers to sack badly-behaving MPs backed by county parliamentarian (31 minutes ago in News)
3. Film music concert (55 minutes ago in News)
4. Sack councillors involved in mayor deal (1 hour ago in Read)
5. Best of English drama in grand final (1 hour ago in News)
6. More from today »

MOST COMMENTED

1. New Mayor of Worcester fending off calls to quit (85)
2. Drama at the Guildhall as Tories snatch power amid angry scenes (52)
3. It's official – Worcester has third worst rush-hour traffic in the country (47)
4. Golden chains of mayor's office tarnished by political horse trading (43)
5. He's put his holidays before service (41)

MOST SHARED

1. Thousands flock to Worcester Racecourse for Ladies' Day
2. Worcester Dragonboat Racing Clubs Race The Dragon Regatta on 8 June at 10:00
3. Young carers hold conference
4. W. Villages – 2 bed – £625 – Town & Country – Worcester (Lettings)
5. As a music fan, I know my place

WHAT'S ON *LIVE* TRAVEL

Last updated 13.11 with 1 incidents

A4184 High Street / Vine Street Evesham »
Busy but moving

Local & UK traffic & travel news »

Appendix N – Our prototype booklet

What is a smart meter?

Smart meters are a new technology aimed at helping the consumer (you!) save money. Smart meters are a new digital electricity meter which allow measures real time energy usage and has the option to display this data on an in-home display. What this means is that you have the option to see exactly how much electricity is costing you whenever you want on the in-home display! If you are looking to save money you can determine the times where you are paying the most and can take action to reduce your consumption. Another plus about the smart meter is that you don't have to fuss about with a meter reader coming every month. Instead the meter automatically relays the most accurate energy usage information to your supplier, so the bill is the most accurate as possible. The best part is that you may even be able to have a smart meter installed for free depending on your energy supplier!

What is an EPC and why should I care?

An energy performance certificate (EPC) is an assessment of the energy usage and efficiency of your home. After the assessment is concluded you should have a good estimation of the cost of energy bills in your home and the extent to which the efficiency can be improved (through different retrofit options noted in the EPC). This EPC also gives you tips to improve the home and save money. The retrofit options are to maximally improve the efficiency of your home and may cost quite a bit to install, but fortunately several payment assistance plans exist, such as the Green Deal.

Why should I care about the Green Deal?

While a number of retrofit options do exist, many people worry about the costs involved or the payback period of a certain technology. In order to reduce the costs to consumers, the UK government has instituted a financial programme to help fund retrofits so you don't have to the large upfront costs to deal with. This programme, if you qualify, will allow you to receive the most efficient retrofits and have them installed in your property. Since these retrofits save you money, your bills will decrease. In order to payback the cost of the retrofit, the Green Deal makes it so the savings pays the technology off and your monthly bill stays roughly the same as before. Therefore your bills stay about the same, but you have more efficient technology and a more comfortable home!

Tips for saving energy

- Turn lights off when a room is no longer in use
- Wash clothes at 30 Centigrade or less
- Dry clothes on a line when it is warm
- Turn off thermostat during the summer
- Turn down the thermostat when possible
- Turn off appliances when not in use (e.g. TV, radio, any other appliance)

Retrofits to improve efficiency

- Install energy efficient lighting CFLs or LEDs
- Replace old boilers with new condenser boilers
- Install solid wall insulation
- Double glaze windows
- Install loft insulation
- Caulk and seal windows and doors to reduce draft
- Install fan-assisted storage heaters

Solid wall insulation

Solid walled houses were generally built before the 1930's and have no insulation. Cavity walls contain an air gap where as solid walls do not have this air gap. Thus, solid walled homes are amongst the coldest and are often very expensive to heat. The nature in the way the walls were built means that it is very easy for heat to escape leaving the house cold and highly inefficient. In order to rectify this heat loss, either internal wall insulation or external wall insulation can be applied.

Who we are:

We are a group of engineering university students from the other Worcester in the United States who have come over to work with the University of Worcester and City Council to help improve energy conservation in the Arboretum. As part of our project we canvassed the Arboretum and spoke to many residents regarding their energy consumption and energy saving behaviors and to gain support for our project. We designed this educational leaflet to teach some of the most pressing issues in the community and to help everyone living in the Arboretum to try and save more money on energy bills. If you have questions about our project or want to learn more please consult www.enegizeworcester.co.uk

Worcester CITY COUNCIL

#ENERGIZEWORCESTER

Appendix O – Summarized survey responses

Please note that for all questions besides question 28, 35 and 45, the percentage of total responses is based on the number of responses to the question. For questions 28, 35 and 45 the percentages are calculated from the total responses to the question divided by the 102 total responses to the survey.

Question 1. Which organizations have you heard of? (Tick all that apply)	Number of responses	Percentage of total responses
Worcester City Council	101	99.02%
University of Worcester (UW)	100	98.04%
Arboretum Residents Association (ARA)	77	75.49%
National Landlords Association (NLA)	34	33.33%
Transition Worcester	20	19.61%
Energize Worcester	17	16.67%
Worcester Polytechnic Institute (WPI) (US university)	17	16.67%
None of the above	0	0.00%
Total number of people who answered question:	102	

Question 2. Which organization do you prefer to receive more information on saving energy from? (Circle one)	Number of responses	Percentage of total responses
*Note several times people indicated multiple responses and we counted all of them		
Worcester City Council	42	42.86%
University of Worcester (UW)	27	27.55%
None of the above	24	24.49%
Arboretum Residents Association (ARA)	17	17.35%
Transition Worcester	11	11.22%
Energize Worcester	10	10.20%
National Landlords Association (NLA)	2	2.04%
Other: _____	1	1.02%
Worcester Polytechnic Institute (WPI) (US university)	0	0.00%
Total number of people who answered question:	98	

Question 3. Are you a homeowner or do you rent? (Circle one)	Number of responses	Percentage of total responses
Own	62	62.00%
Rent	38	38.00%
Total number of people who answered question:	100	

Question 4. If you do rent, do you: (Circle one)	Number of responses	Percentage of total responses
Rent as a family	17	45.95%
Share the property with others	16	43.24%
Rent the property on your own	4	10.81%
Total number of people who answered question:	37	

Question 5. How many tenants share your residence (including you)? (Circle one)	Number of responses	Percentage of total responses
*Homeowners answered this as well		
1 person	18	21.95%
2 people	31	37.80%
3 people	22	26.83%
4 people	8	9.76%
5 people	2	2.44%
6+ people	1	1.22%
Total number of people who answered question:	82	

Question 6. Is damp occurring in the property? (Circle one)	Number of responses	Percentage of total responses
Yes	36	36.36%
No	53	53.54%
Unknown	10	10.10%
Total number of people who answered question:	99	

Question 7. If yes, do you know why the dampness is occurring? (Circle all that apply)	Number of responses	Percentage of total responses
Building issue	24	58.54%
Poor insulation	9	21.95%
Other _____	9	21.95%
Poor windows	7	17.07%
Leaks	5	12.20%
I don't know	5	12.20%
Poor heating	4	9.76%
No heating	0	0.00%
Total number of people who answered question:	41	

Question 8. How do you feel about your energy bill? (Tick one)	Number of responses	Percentage of total responses
I think I spent just enough	47	47.47%
I think I spent too much	44	44.44%
I think I spend an insignificant amount compared to my income	5	5.05%
Other: _____	4	4.04%
Total number of people who answered question:	99	

Question 9. If you are a renter, how often do you communicate with your landlord? (Circle one)	Number of responses	Percentage of total responses
Daily	4	10.53%
Weekly	1	2.63%
Monthly	11	28.95%
Yearly	3	7.89%
No contact	1	2.63%
Contact through letting agency	9	23.68%
Other _____	9	23.68%
Total number of people who answered question:	38	

Question 10. Please rank your knowledge of energy efficient techniques and technology (Circle one)	Number of responses	Percentage of total responses
1 (No Knowledge)	4	4.12%
2	3	3.09%
3	7	7.22%
4	4	4.12%
5 (Average Knowledge)	30	30.93%
6	13	13.40%
7	19	19.59%
8	16	16.49%
9	2	2.06%
10 (Expert Knowledge)	0	0.00%
Total number of people who answered question:	97	

Question 11. Are energy saving light bulbs installed in your house? (Circle one)	Number of responses	Percentage of total responses
Yes	37	37.00%
On most lights	38	38.00%
On a few lights	17	17.00%
No	7	7.00%
I don't know	2	2.00%
Total number of people who answered question:	100	

Question 12. Do you normally turn lights off when a room is no longer in use? (Circle one)	Number of responses	Percentage of total responses
Always	52	51.49%
Usually	45	44.55%
Occasionally	2	1.98%
Rarely	1	0.99%
Never	1	0.99%
Total number of people who answered question:	101	

Question 13. Which of the following appliances in your home has an eco-friendly label? (Circle all that apply)	Number of responses	Percentage of total responses
Not sure	33	33.00%
Washing machine	29	29.00%
None of the above	26	26.00%
Refrigerator	25	25.00%
Boiler	18	18.00%
Television	17	17.00%
Dishwasher	9	9.00%
Tumble dryer	9	9.00%
Other	2	2.00%
Total number of people who answered question:	100	

Question 14. What is your primary source of fuel for heating? (Circle one)	Number of responses	Percentage of total responses
Gas	87	87.00%
Electric	18	18.00%
Wood	1	1.00%
Other (Please specify) _____	1	1.00%
Unsure	0	0.00%
Total number of people who answered question:	100	

Question 15. What temperature setting do you usually keep your central heating thermostat set to during summer? (Circle one)	Number of responses	Percentage of total responses
< 16 C	42	44.68%
16 to 21 C	27	28.72%
22 to 25 C	4	4.26%
> 25 C	0	0.00%
I don't control my heating	4	4.26%
I don't have a thermostat	18	19.15%
Total number of people who answered question:	94	

Question 16. What temperature setting do you usually keep your central heating thermostat set to during winter? (Circle one)	Number of responses	Percentage of total responses
< 16 C	12	12.24%
16 to 21 C	50	51.02%
22 to 25 C	18	18.37%
> 25 C	1	1.02%
I don't control my heating	3	3.06%
I don't have a thermostat	17	17.35%
Total number of people who answered question:	98	

Question 17. Does your property have any of the following features? (Tick all that apply)	Number of responses	Percentage of total responses
Energy efficient boiler (e.g. condenser boiler)		
Yes	51	51.52%
No	28	28.28%
Not sure	18	18.18%
Electric space heaters		
Yes	18	18.18%
No	67	67.68%
Not sure	7	7.07%
Wall insulation		
Yes	27	27.27%
No	53	53.54%
Not sure	17	17.17%
Loft insulation		
Yes	63	63.64%
No	12	12.12%
Not sure	22	22.22%
Energy saving light bulbs (compact fluorescent (CFL) or light emitting diode (LED) bulbs)		
Yes	82	82.83%
No	11	11.11%
Not sure	7	7.07%
Double glazed windows		
Yes	85	85.86%
No	12	12.12%
Not sure	3	3.03%
Renewable energy generator (e.g. solar panels on the roof)		
Yes	1	1.01%
No	94	94.95%
Not sure	2	2.02%
Other (please specify)_____	2	
Total number of people who answered question:	99	

Question 18. Do you do any of the following? (Tick all that apply)	Number of responses	Percentage of total responses
Turning off lights when you leave the room	96	96.97%
Put appliances into a sleep or standby mode when not in use	76	76.77%
Turn down the thermostat when possible	68	68.69%
Wash clothes at 30 degrees or less	54	54.55%
Taking shorter showers	52	52.53%
Other _____	6	6.06%
Total number of people who answered question:	99	

Question 19. Do any of the following descriptions fit your primary purpose to do the activities in question 18? (Tick all that apply)	Number of responses	Percentage of total responses
Saving money on bills	85	86.73%
Protecting the environment	66	67.35%
Becoming healthier	15	15.31%
Other (please specify) _____	10	10.20%
Everyone else is, I should too	3	3.06%
I do not do any of those activities in the previous question	2	2.04%
Total number of people who answered question:	98	

Question 20. What barriers are preventing you from doing the activities in question 18? (Tick all that apply)	Number of responses	Percentage of total responses
Expensive new appliances and retrofits	27	46.55%
Other _____	14	24.14%
Too much work and not enough time	13	22.41%
One person has a very small impact	7	12.07%
I need more support to make an impact	7	12.07%
Total number of people who answered question:	58	

Question 21. Do you regularly monitor your gas and electricity consumption (for heating, cooking, personal use etc.)? (Circle one)	Number of responses	Percentage of total responses
Yes	45	45.45%
Occasionally	28	28.28%
No	27	27.27%
Total number of people who answered question:	99	

Question 22. If no, what are the possible reasons you do not? (Tick all that apply)	Number of responses	Percentage of total responses
Too busy with other activities	16	47.06%
Unaware of the process	8	23.53%
Other: _____	8	23.53%
My consumption does not matter to me	7	20.59%
No access to the meter	1	2.94%
Total number of people who answered question:	34	

Question 23. If yes, roughly how much money do you spend on your monthly energy bill per person? (Circle one)	Number of responses	Percentage of total responses
£0 to £20	4	4.76%
£21 to £30	11	13.10%
£31 to £40	9	10.71%
£41 to £50	14	16.67%
£51 to £60	8	9.52%
Over £60	25	29.76%
Prefer not to say	13	15.48%
Total number of people who answered question:	84	

Question 24. Do you know what a smart meter is? (Smart meters are meters which have a modern digital display with the capability of wireless communication of energy usage to an energy supplier or an in-home display)	Number of responses	Percentage of total responses
Yes	69	68.32%
No	32	31.68%
Total number of people who answered question:	101	

Question 25. Do you want to have a smart meter installed in your property?	Number of responses	Percentage of total responses
Yes	48	55.17%
No	40	45.98%
Total number of people who answered question:	87	

Question 26. Do you know the location of your electricity meter?	Number of responses	Percentage of total responses
Yes	96	96.96%
No	3	3.03%
Total number of people who answered question:	99	

Question 27. Do you have access to the electricity meter?	Number of responses	Percentage of total responses
Yes	97	98.98%
No	1	1.02%
Total number of people who answered question:	98	

Question 28. Who is your energy supplier? (Optional)	Number of responses	Percentage of total responses
Total number of people who answered question:	83	81.37%

Question 29. Which aspect is most important to you when purchasing cleaning products (e.g. bleach, washing gels, bathroom cleaner)? (Circle one)	Number of responses	Percentage of total responses
Cost	40	42.11%
An eco-friendly sticker or label	22	23.16%
Brand recognition	19	20.00%
Convenience	15	15.79%
Other _____	11	11.58%
Total number of people who answered question:	95	

Question 30. Do you know what an Energy Performance Certificate (EPC) is?	Number of responses	Percentage of total responses
Yes	56	54.90%
No	46	45.10%
Total number of people who answered question:	102	

Question 31. Does your property have an EPC? (Did not count "don't know" responses)	Number of responses	Percentage of total responses
Yes	28	34.15%
No	54	65.85%
Total number of people who answered question:	82	

Question 32. Have you heard about the Green Deal? (The Green Deal is a financial plan to assist energy retrofits for properties)	Number of responses	Percentage of total responses
Yes	43	42.16%
No	59	57.84%
Total number of people who answered question:	102	

Question 33. Have you taken the Green Deal plan?	Number of responses	Percentage of total responses
Yes	2	2.04%
No	96	97.96%
Total number of people who answered question:	98	

Question 34. Do you think the Green Deal would be beneficial to you?	Number of responses	Percentage of total responses
Yes	35	42.68%
No	47	57.32%
Total number of people who answered question:	82	

Question 35. If you have taken the Green Deal plan, we would be interested in speaking with you. If possible please provide your contact information below (it will not be disclosed to third parties).	Number of responses	Percentage of total responses
Total number of people who answered question:	2	1.96%

Question 36. Would you be interested in learning more about how to save energy?	Number of responses	Percentage of total responses
Yes	49	49.00%
No	51	51.00%
Total number of people who answered question:	100	

Question 37. Do you believe there are sufficient education programs in place for teaching energy saving behaviours?	Number of responses	Percentage of total responses
Yes	31	32.29%
No	65	67.71%
Total number of people who answered question:	96	

Question 38. If you answered yes to question 36, how would you prefer to receive this information? (Circle all that apply)	Number of responses	Percentage of total responses
Leaflet	45	77.59%
Online video	18	31.03%
Consultation	11	18.97%
Class or lecture	9	15.52%
Poster	5	8.62%
Radio ad	4	6.90%
Other (please specify) _____	3	5.17%
Total number of people who answered question:	58	

Question 39. How would you like to consider yourself? (Circle one)	Number of responses	Percentage of total responses
Male	52	51.49%
Female	49	48.51%
Other	0	0.00%
Prefer not to say	1	0.99%
Total number of people who answered question:	101	

Question 40. Which would the following age group would you fit in to? (Circle one)	Number of responses	Percentage of total responses
< 18	1	1.00%
18 to 24	12	12.00%
25 to 35	16	16.00%
36 to 45	12	12.00%
46 to 55	19	19.00%
56 to 65	11	11.00%
> 65	28	28.00%
Prefer not to say	1	1.00%
Total number of people who answered question:	100	

Question 41. Which of the following ethnic groups do you belong to? (Circle one)	Number of responses	Percentage of total responses
White English/Welsh/Scottish/Northern Irish/British	84	84.00%
White Eastern European	8	8.00%
Any other White background	3	3.00%
Asian or Asian British: Pakistani	2	2.00%
Black or Black British: African	2	2.00%
White Irish	1	1.00%
Mixed: White & Black African	1	1.00%
Asian or Asian British: Bangladeshi	1	1.00%
Gypsy or Irish Traveler	0	0.00%
Mixed: White & Black Caribbean	0	0.00%
Mixed: White & Asian	0	0.00%
Any other Mixed background	0	0.00%
Asian or Asian British: Indian	0	0.00%
Asian or Asian British: Chinese	0	0.00%
Any other Asian background	0	0.00%
Black or Black British: Caribbean	0	0.00%
Any other Black background	0	0.00%
Arab	0	0.00%
Other_____	0	0.00%
Total number of people who answered question:	100	

Question 42. Which of the following annual income ranges do you fit in the most? (Circle one)	Number of responses	Percentage of total responses
< £10,000	28	28.28%
£10,001 to £20,000	22	22.22%
£20,001 to £30,000	18	18.18%
£30,001 to £50,000	10	10.10%
£50,001 to £75,000	2	2.02%
>= £75,001	3	3.03%
Prefer not to say	16	16.16%
Total number of people who answered question:	99	

Question 43. Would you like to be contacted by us for future research? (Circle one)	Number of responses	Percentage of total responses
Yes	51	50.50%
No	50	49.50%
Total number of people who answered question:	101	

Question 44. If you answered yes to the last question, please fill in the best way to contact you	Number of responses	Percentage of total responses
Name:	46	88.46%
Address	44	84.62%
Email address:	36	69.23%
Phone number:	28	53.85%
Total number of people who answered question:	52	

Question 45. Is there anything else you want to share with us regarding the project? (Please include another page if needed)	Number of responses	Percentage of total responses
Total number of people who answered question:	6	5.88%