Developing Comprehensive Recommendations for Friendly House to Improve Thermal Comfort and Increase Energy Efficiency

An Interactive Qualifying Project Report
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Authorship Statement

Throughout the course of this project, each member of our group contributed to researching, writing, and editing each section of the report. The credit belongs to no one individual, but all the members of this team.

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It has been a pleasure working with Friendly House in Worcester, Massachusetts for the past 8 weeks. Our group has gained many great experiences and would like to express our thanks to all that have helped us along our journey.

Appendix A: Project Introduction

The most recent global survey found that 1.6 billion people on the planet lacked adequate housing (Homeless World Cup Foundation, 2019). Millions of families across the globe are impoverished and lack the luxury of having a shelter over their heads (Homeless World Cup Foundation, 2019). In modern society everyone has the right to live in a home and feel a certain amount of comfort, both in the sense of safety and general living conditions (UN News, 2016). Many aspects of people's lives are impacted by their stature of wealth or economic impoverishment, including family separation and education limitations.

Homelessness is also an issue on a local scale within the city of Worcester, Massachusetts. In 2017, there were 1,507 homeless people recorded in Worcester County (Central Massachusetts Housing Alliance, 2018). Homelessness in Worcester is especially problematic because of a low median household income paired with a high cost of living in the city. (Data USA, 2018). This not only can bring people into homelessness, but also can prevent current homeless people from working their way out of it.

For almost 100 years, Friendly House has been providing shelter and daily care for families and individuals of need in Worcester, Massachusetts. They primarily provide for families, expectant mothers, and emergency shelter for those in need (Friendly House). Friendly House spends all of their resources on helping the homeless of Worcester and they want to continue to help them by increasing the comfort of their shelter and reducing energy costs.

Friendly House is also looking for ways to cool the house in the summer and improve the temperature consistency throughout the house.

The goal of our project was to make recommendations for increasing the comfort of the housing unit at 87 Elm Street, while increasing its energy efficiency. The building has experienced uneven heating in the winter and no cooling system for the hot summers, both of which can cause discomfort. Additionally, it is beneficial to increase the energy efficiency of the building to lower energy costs, especially when cooling elements are added to the building.

There are several ways in which the comfort of residents have been addressed. Addressing air flow solutions within a home is one possible way to improve the comfort. Locating and sealing leaks in windows, doors, ductwork, and ventilation pipes reduce the amount of air infiltration and energy used by temperature systems (American Council for an Energy-Efficient Economy, 2015). Adding heating and cooling systems within the home also increases comfort. Central air and heat pumps are systems designed to cool large areas of the home, with heat pumps having an additional benefit of having heating capabilities for the winter (Energy Saving Tips, 2018). Several other solutions were considered during the duration of the project.

In the following chapters our group discusses background research on homelessness and energy efficient solutions. Our methodology provides a detailed outline of the steps taken to gather the information necessary to make informed recommendations regarding the improvement of the house. Finally, based on the raw data collected in the methodology, we compile and evaluate our findings into easy to understand recommendations that Friendly House could take to improve the comfort of their home.

Appendix B: Project Background

This chapter investigates necessary background information to understand the issue of homelessness and the value of safe and comfortable housing. The following sections discuss overarching issues of homelessness leading to local issues of homelessness. The first section discusses homelessness' impact on families and youth education, and the programs in place to address these issues. The focus shifts to the scope of homelessness at the national, state, and local level. The third section introduces the project sponsor and their goals. The fourth section includes energy conservation and temperature regulation strategies. The fifth section discusses the project's direction.

Section 1: Impact of Homelessness

Homelessness is defined as any individual who lacks fixed, regular, and adequate nighttime residence (National Health Care for the Homeless Council, Inc., 2019). Homelessness can have a large impact on society and on the individual. Not having a shelter or home could easily mean that families have a hard time sending their children to school. Finding shelter and a place to live is considered a basic need of humans moving towards self-actualization (McLeod, 2007). Families with children are estimated to be one of the fastest growing percentages of the homeless population (National Coalition for the Homeless, 2007). In the U.S. over the course of a year, about 1.35 million children are likely to experience homelessness which is roughly 2 percent of all children in the United States (National Coalition for the Homeless, 2007). The

sections that follow discuss the varying impacts of homelessness including family separation and educational achievement.

1.1 Family Separation due to Homelessness

One problem that comes from homelessness is potential family separation. According to a study done by Marybeth Shinn, Scott Brown, and Daniel Gubits who work for the Department of Human and Organizational Development at the University of Vanderbilt in Nashville, Tennessee, 23.7% of families that enter homeless shelters had been separated from a child (2017). After spending 20 months at the shelter an additional 15.4% of families become separated from a child (Shinn et al., 2017). While separations due to foster care were present, most separations were informal (Shinn et al., 2017). An informal separation means the child and parents were separated without government or shelter intervention. The study also indicates that returning to homelessness leads to an increased risk of family separation. Reducing the likelihood that a family returns to homelessness would decrease the amount of separations (Shinn et al., 2017).

Families facing homelessness can be caught between choosing to stay together, or going into a homeless shelter (Kandill, 2018). For many families, it is important to keep the family together, but certain shelter regulations may not allow that to happen. This means families must try to find accommodations that also keep the family intact. Certain shelters don't allow either males or females, or children above a certain age (Kandill, 2018). This is done to protect victims of domestic violence and sexual assault, but it can put more trauma and stress on families (Kandill, 2018). Families are put into a position where they separate from a significant other or

child or continue to be without shelter. Along with the risk of separation from their families, children face additional challenges with education.

1.2 Impacts of Homelessness on Educational Achievement

Homelessness is a disruptive experience for young children and families around the world. In 2017, 1 in 5 children resided in families which had income below the poverty line (Children Trends, 2019). Unpredictable and undesired moves from one's home adversely affect the family support system and the children's development and well-being. Homelessness, a severe form of residential instability, disproportionately occurs among young children from low-income families. Eight percent of children from low-income families experience homelessness in the course of a year, and young students who are homeless are more likely than their housed peers to have instability and difficulty in their respective school environments (Fantuzzo et al., 2012). The vulnerability associated with homelessness among young children, particularly in relationship to their educational success, has become of great concern to policymakers in the education, housing, and child welfare public service systems, (Fantuzzo et al., 2012). Homelessness greatly impacts youth and opportunity for an education. Residency requirements, guardianship requirements, delays in transfer of school records, lack of transportation, and lack of immunization records often prevent homeless children from enrolling in school (National Coalition for the Homeless, 2007). Around 87% of homeless youth are enrolled in school and only 77% attend school regularly (National Coalition for the Homeless, 2007).

All too often, homeless children must change schools because shelters or other temporary accommodations are not located in their school district. In recent years, 42% of homeless children transferred schools at least once, and 51% of these students transferred at least one additional time (National Coalition for the Homeless, 2007). Every time a child must change schools, his or her education is disrupted. According to some estimates, 3-6 months of education are lost with every move (National Coalition for the Homeless, 2007). A study in New York found that 23% of homeless children had to repeat a grade, and 13% were inappropriately placed in special education classes (National Coalition for the Homeless, 2007). This increases the risk of children falling behind in school and increases the likelihood that children do not develop the skills necessary to overcome poverty as adults (National Coalition for the Homeless, 2007). Families and children are likely to have a more positive experience in education if they have access to shelter.

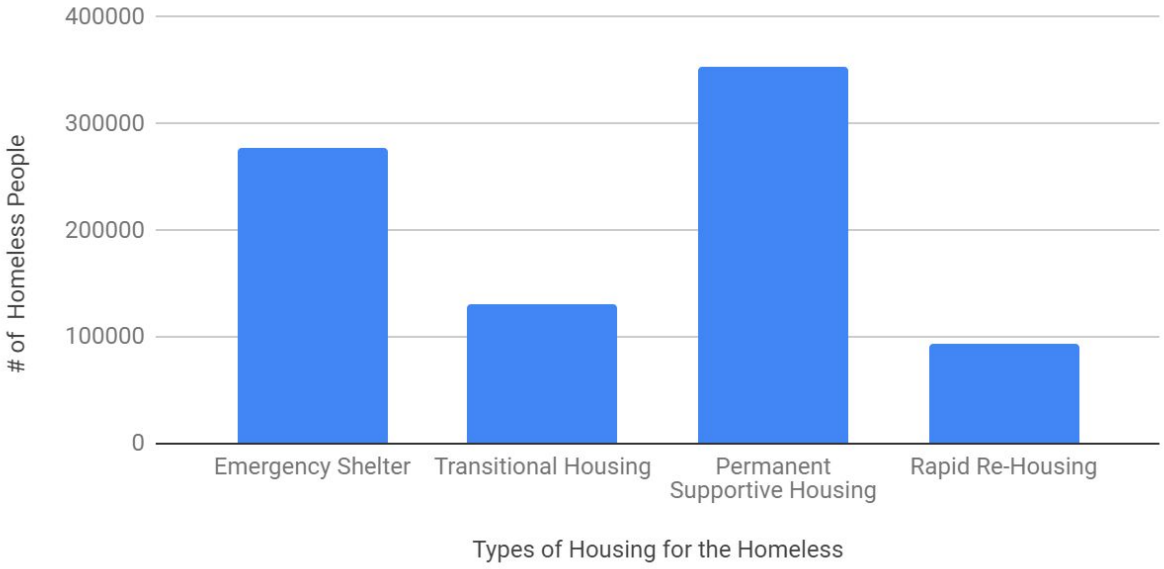
Section 2: Homelessness by the Numbers

The United Nations performed a global survey in 2005 and found that an estimated 100 million people were homeless globally and about 1.6 billion lacked adequate housing (Homeless World Cup Foundation, 2019). These numbers vary nation to nation, changing because each nation may define homelessness differently. This section further discusses the issue of homelessness in the United States, Massachusetts, and the City of Worcester along with support programs for the homeless.

2.1 United States Homelessness

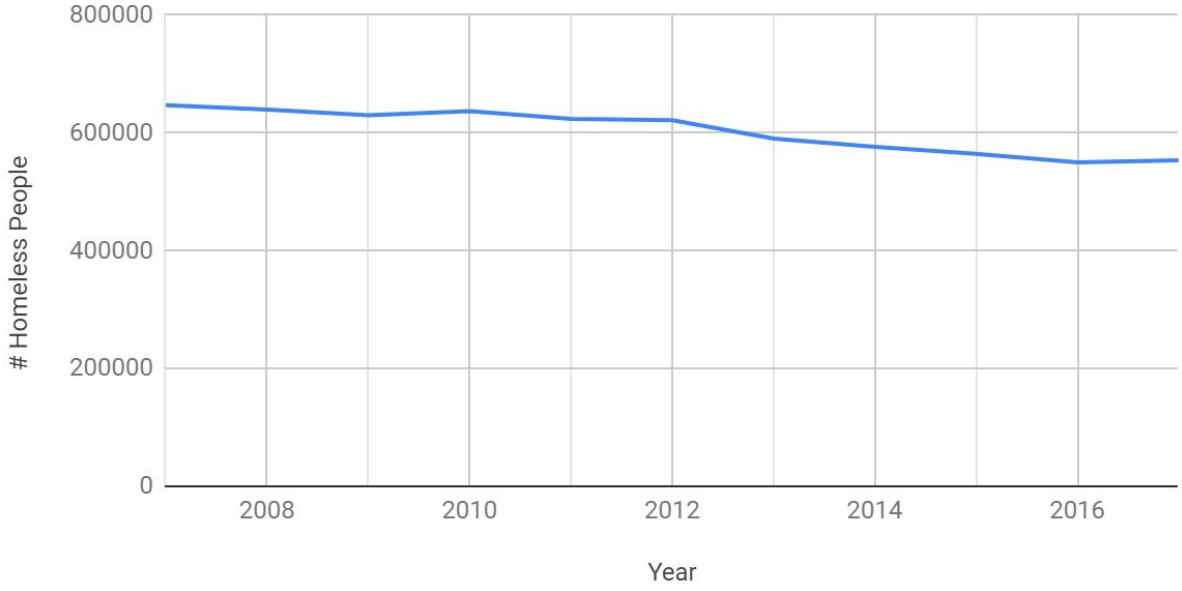
Homelessness is a significant problem in the United States, affecting over 500,000 people per night, with only about 72 percent of the homeless population able to find some non-permanent shelter (National Alliance to End Homelessness, 2018). The department of Housing and Urban Development (HUD) serves over 1 million people through emergency, transitional, and permanent housing programs each year (U.S. Department of Housing and Urban Development, 2018). The United States Department of Health and Human Services is the U.S. government's principal agency for protecting the health of all Americans and supporting the delivery of essential human services, especially for those who are least able to help themselves (U.S. Department of Health and Human Services, 2018). In the past 10 years, homeless assistance has become a greater priority in the United States due to the focus on permanent housing solutions (End Homelessness, 2019). In the United States, over half of the occupied beds are due to permanent housing interventions (End Homelessness, 2019). Permanent housing currently represents 41.8 percent of all homeless assistance beds. The second greatest intervention is emergency shelters which account for 32.8 percent of homeless beds (End Homelessness, 2019). The figure below represents the type of homeless assistance methods and the number of homeless people sheltered in the year 2017.

Figure 1. Number of People Homeless In the U.S. and Types of Shelters in 2017 (National Alliance to End Homelessness, 2019)



From 2007 through 2017, the number of homeless people in the United States slightly decreased on average. There have been two years where the number has slightly increased. In 2007 there were 647, 258 people who were homeless. There were about 553,742 homeless people in the United States in 2017 (National Alliance to End Homelessness, 2019). Homelessness has dropped about 14% from 2010 to 2016, when the Obama administration launched Opening Doors, the first nationwide effort to aid and prevent homelessness (Serlin, 2016). The Department of Housing and Urban Development and Veterans Affairs together have contributed to the 50% decrease in homeless veterans from 2010 to 2016 (Serlin, 2016). While the decrease over the last 10 years has been significant, there are still hundreds of thousands of people who are homeless annually. The number of homeless people in the United States from 2007-2017 can be seen below in Figure 2.

Figure 2. Number of Homeless People in United States From 2007-2017 (National Alliance to End Homelessness, 2019).

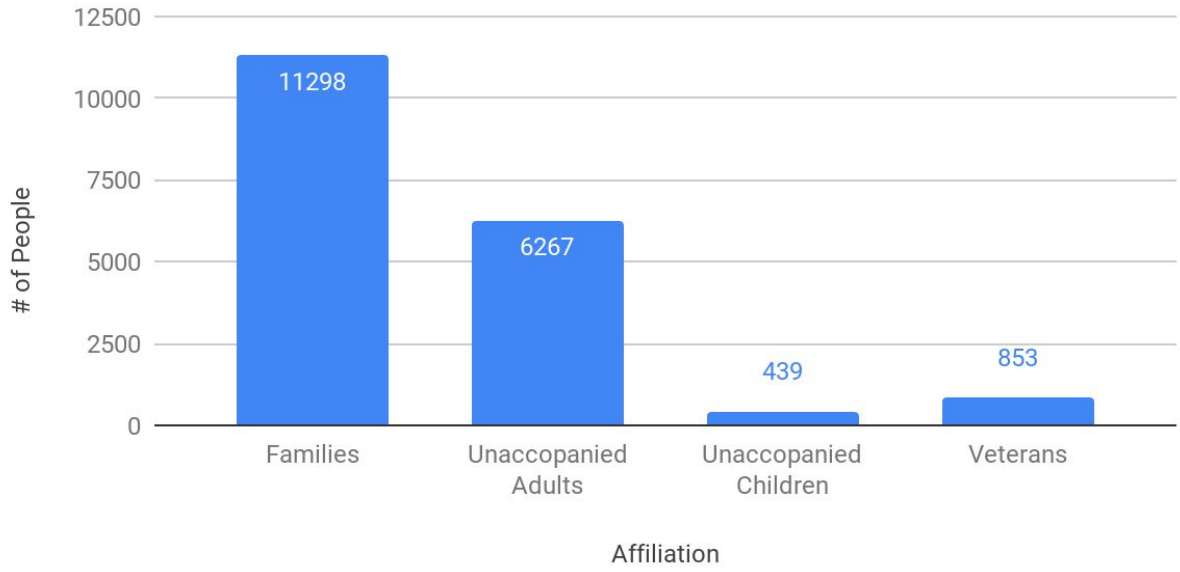


2.2 Massachusetts Homelessness

Homeless support organizations in Massachusetts provide shelter to the majority of the homeless population. Only 6% of the homeless population go without shelter (National Alliance to End Homelessness, 2018). While these numbers may seem low, homelessness is still a prominent issue in Massachusetts, affecting 25.8 people per 10,000 each night (National Alliance to End Homelessness, 2018). During the January 2018 point-in-time count conducted by the HUD Continuum of Care across the state it was estimated that roughly 20,000 people in Massachusetts experienced homelessness (Massachusetts Coalition for the Homeless, 2019). Most homeless people in Massachusetts are families, followed by unaccompanied adults,

unaccompanied children, and veterans as can be seen in Figure 3 (Massachusetts Coalition for the Homeless, 2019).

Figure 3. Number of People Homeless by Affiliation (Massachusetts Coalition for the Homeless, 2019)



2.3 Homeless Support Programs in Massachusetts

Massachusetts has several housing programs which assist the homeless population. Emergency Assistance (EA) is a program which is run by the Department of Housing and Community Development (DHCD). Emergency Assistance allows eligible families with children or pregnant women access to temporary emergency shelter when they don't have a safe place to live (Mass Gov, 2018). The Local Housing Authority Transition Housing Program (LHATHP) is another homeless program in Massachusetts. The LHATHP shelters provide housing and support services to families with children, runaway teens and teen parents, women and children fleeing domestic violence, and single adult men and women without children (Mass Gov, 2018).

The Residential Assistance for Families in Transition (RAFT) provides short-term financial assistance in the form of rent for the first/last month and moving expenses to families who are homeless or at risk of becoming homeless (Mass Gov, 2018). These support programs contribute to providing shelter for the many people who are homeless in Massachusetts. While these programs and shelters provide shelter for thousands, there are still so many people who lack a home.

2.4 Homelessness in Worcester

While homelessness in Worcester has declined slightly since 2015, it is still an issue that needs to be addressed (Central Massachusetts Housing Alliance, 2018). According to the Central Massachusetts Housing Alliance, in 2017 there were 1,507 homeless persons in Worcester County while there were 1,572 homeless people in 2016. Families make up 61% of the homeless population and children (persons under 18) account for 34% of the homeless population in Worcester County (Central Massachusetts Housing Alliance, 2018). Since last year, there has been a 12% drop in the number of people per homeless family which contributes to the decrease in homeless population (Central Massachusetts Housing Alliance, 2018). However since 2012, homelessness in Worcester has increased about 20% (RCAP Solutions, 2014). In addition, roughly 56% of people in Worcester who rent, are unable to afford their 2 bedroom average monthly rent of $966 (RCAP Solutions, 2014).

The median household income in Worcester, $44,020, coupled with the high cost of living is a barrier to finding and keeping housing (Data USA, 2018). A family looking for a two-bedroom apartment would need two full time jobs at minimum wage to keep their housing costs around 30% of their income (Central Massachusetts Housing Alliance, 2018). According to

Mary Schwartz and Ellen Wilson with the US Census Bureau, spending more than 30% of after-tax income on housing expenditures is a housing affordability problem (2007). This was set as the number in 1981 after being raised from 20% (Schwartz & Wilson, 2007). With 57.9% of residents living in rented units, not even 50% of renters can afford the median cost of rent, $1060, in addition to utilities (Central Massachusetts Housing Alliance, 2018).

In Worcester, many organizations exist to aid the homeless. There are several resources in the Worcester area that either provide family housing, public housing, transitional housing or senior housing. A few of these include Abby's House, Homeless Prevention Center, and Friendly House Inc. Families have the ability to apply in order to have the chance to gain access to these resources (Diocese of Worcester, 2019).

Section 3: Friendly House

Friendly House is one of the oldest nonprofit organizations in Worcester. The main reason for its conception was to better the residents of Worcester educationally, socially, and familially (Friendly House, 2018). To adequately aid the people of Worcester, Friendly House offers several programs, ranging from temporary housing for families, single mothers, and mothers expecting, to youth recreation activities, afterschool programs, food services, and immigration assistance (Friendly House, 2018). The following sections discuss Friendly House's history, the organization today, their goal of improvement, and the barriers to that improvement.

3.1 The Past and Present of Friendly House

Friendly House was founded in Worcester in 1920. The organization began with a focus on helping immigrants acclimate to American life. Many of the immigrants were taught useful

skills to assist them in their new life in the United States, including job training, cooking, and cleaning. The original settlement house was on 37 Norfolk Street but once the organization began expanding, Friendly House moved to 38 Wall Street which was a much larger house with more rooms. When the Great Depression started, the importance of Friendly House rose as there were more struggling families looking for help in the city. Friendly House began to have many more programs for youth development. These useful life training and youth programs continued to help many people through the Twentieth Century and was a core focus of the Friendly House Organization. The amount of people Friendly House helped continued grow to as they provided more services for emergency shelter, food, medical care, day care, after school programs, senior programs, and counseling (Friendly House, 2018).

The modern-day Friendly House served over 10,000 children in 2016 alone. With various after school programs, summer swim and basketball programs, emergency food and shelter, immigration support, clothing distribution, community feeding sites, and the Elm Street shelter (as well as other apartment shelters), Friendly House was able to help thousands of families throughout Worcester. The organization continues to be a pillar of support for the inner city of Worcester in a variety of different ways, whether it be keeping kids off the street, or supporting families in need with their shelters and food pantries. Friendly House also provides many services for immigrants as well, helping them fill out applications for citizenship and translating documents, along with their standard services of providing shelter and food (Delgado, 2016).

3.2 Friendly House's Goal

Friendly House believes that everyone should have a comfortable and safe shelter environment. Friendly House is working to provide a comfortable, temperature-controlled

environment for their residents at 87 Elm St, in Worcester, MA. Most of the discomfort in the house can be attributed to the varying temperature throughout the building as well as how hot it gets in the summers. Along with potentially adding some cooling elements to the house, Friendly House is looking to make their heating more efficient so that they can have more resources to spend on the residents. Friendly House's main concern is the comfort of its residents and allow them to have the ability to live Friendly House puts all their resources towards helping their residents and are seeking ways to save money while improving the comfort of residents (M. Dejesus, personal communication, January 25, 2019). It is Friendly House's main focus to provide a safe environment for its residents. "We try not to turn anyone away", said Gordon Hargrove who is the Executive Director of Friendly House. Some may even say that Friendly House tries to do too much. Friendly House tries to do the best they can for all the families.

3.3 Effects of Resource Constraint

All funding that Friendly House receives is directly put towards the care of its residents. Every dollar that does not go into mandatory building maintenance goes directly to the programs and resources available to their residents and other homeless persons. This includes programs, new linens, furniture, and any other essential living items. Like many non-profit organizations, they are not able to save money for future use or updates within the house (M. Dejesus, personal communication, January 25, 2019).

Nonprofit organizations in the United States rely heavily on private donations. Nonprofit organizations utilize several sources of income to assist them in serving their mission: grants and funding, tax revenue, loans, investors, and corporate contributions (Foundation Center, 2019). In 2014, a study found that nearly 95% of funding for nonprofits in the US were from grants,

contributions, donations and other outside sources (Foundation Center, 2019). Friendly House specifically gets their appliances and other equipment from donations. Fundraising is more easily achieved when they have a clear goal and price-point to show their donors. Explaining how the money will be spent and how much is required, is the easiest way to attract donors (M. Dejesus, personal communication, January 25, 2019). To better take care of the homeless population, Friendly House is looking for ways to spend less resources on utility bills and improve comfort of the house.

Section 4: Improving Energy Efficiency and Thermal Comfort

Financial savings and energy conservation, through effective temperature regulation, can be achieved by using simple everyday techniques and low-cost solutions. In the winter, opening south-facing window curtains during the day can help to heat a person's home, and closing them at night will insulate the chill from the cold windows (U.S. Department of Energy, a). Finding and sealing leaks in window panes, doors, chimneys, and plumbing with caulking helps to reduce the amount of heat lost in the winter, and cool air lost in the summer (U.S. Department of Energy, a). The following sections discuss how an energy audit is conducted and ways that energy can be conserved through simple solutions such as updating light fixtures, switching to energy efficient appliances, adding insulation, controlling air flow, and updating heating and cooling systems.

4.1 Energy Audit

Energy audits can be effectively performed both by a professional and by an average homeowner. A professional energy audit gives the full picture of a home’s energy usage, while a

self-energy assessment can pinpoint problem areas and help to prioritize efficiency upgrades. A home energy audit can be done by following the steps detailed in Appendix M. Both methods can be done at little-to-no cost because the professional audit is offered for free by most energy providers as well as government organizations like Mass Save (U.S. Department of Energy, b). In both cases, once the audit is performed, solutions can then be prioritized before being applied. These solutions include installing or replacing insulation, renovating ventilation ducts, sealing leaks in doors and windows, inspecting and replacing heating and cooling elements, updating lighting fixtures, and replacing old appliances with more energy efficient alternatives (U.S. Department of Energy, b).

4.2 Insulation

Insulation is an affordable solution to maintaining the temperature of a household. Adding insulation to a building is proven to reduce the flow of heat out of the house therefore reducing heating and cooling costs (Department of Energy, 2018). An average residential house can save more the $600 per year by upgrading the insulation in the attic (Huber, 2018). This means that for a larger building with no insulation to begin with, especially in harsh climates like New England, adding insulation to the attic can save much more money per year and help the building become more comfortable. Insulation in the attic can also help cool a building in combination with reflecting roofing and proper ventilation (Blue, 2016). According to a study that investigated this pairing, as the amount of roofing insulation increases cooling costs decrease, when also paired with reflective roofing (Lucero-Álvarez, J., Rodríguez-Muñoz, N., & Martín-Domínguez, I, 2016).

Whether or not a particular home needs insulation can be partially determined by when the house was built. Anytime before 1970, or even as late as 1980, insulation in buildings was not standardized, so if the house was built prior to 1980, it is likely that retrofitting insulation will be beneficial. A further step to take is to have a utility company perform an energy audit on the house to determine where a house is losing heat. This can help determine whether or not a house is properly insulated.

There are two ways insulation can be installed to retrofit a house. The most invasive, but cheapest is to use some sort of rolled up insulation. To install this, the insulation is laid between the outer boards of a wall and the drywall. To retrofit the insulation, drywall would have to be torn down and replaced once the insulation has been installed, which in many cases is not a viable option. This form of insulation is most useful for an application where drywall has not yet been installed, such as when building a house or installing it in an unfinished attic. Another type is injection foam, which is the least intrusive, as you only need to create small holes, either on the inside or outside of the exterior walls, so you can spray the foam into the wall where it will expand to fill the space (Wallender, 2018). These holes need to be patched and repainted, but it is significantly less invasive than fully removing drywall, however the material tends to be more expensive.

Insulation is rated by its thermal resistance, or R-value, which is a measurement of the materials resistance to conductive heat flow. To determine the approximate effectiveness of a specific thickness of insulation, the base R-value is multiplied by the depth of insulation in inches (Lipford, 2015). Depending on where the house is located and the general climate, different R-values are recommended to adequately insulate the building. For a building in

Massachusetts, wall insulation should be between R-49 to R-60 due to the consistently low temperatures in the winter months (ENERGY STAR).

4.3 Outsulation

Another option instead of installing insulation is a new and innovative process called outsulation. Outsulation is the practice of installing a layer of insulation to the exterior side of a building. The term used is rigid foam sheathing or insulation. (ECHOtape,2018). Rather than being used in the interior of walls, outsulation, also known as rigid foam insulation. is used on the outer shell of the exterior of buildings. Outsulation has multiple features which range from design freedom and versatile to cost effectiveness and durability.

There are three main types of rigid foam insulation: expanded polystyrene, extruded polystyrene, and polyisocyanurate. Expanded polystyrene has the lowest R value but it is the cheapest to implement. Polyisocyanurate is the most insulative and expensive, but it becomes less insulative in colder environments (ECHOTape, 2018). If the exterior siding is being removed, it is recommended that R-5 or R-6 sheathing is placed below the new siding (ENERGY STAR). The pricing for outsulation can be very expensive. Primarily, the cost of the material itself if roughly $20 per square-foot (Dryvit, 2019). Outsulation is generally more expensive than installing insulation within the interior of homes.

4.4 Air Flow Related Solutions

The movement of air through a home plays a major role in the temperature regulation of the home. Since all homes exchange air from inside the home with air from outside, it is harder for the heating and cooling systems to do their job. Constant infiltration of outdoor air causes air

conditioners to run longer, which uses more energy. In colder conditions, the heating system must heat more air as cold air enters the building, which wastes more energy. Locating and sealing leaks in windows, doors, ductwork, ventilation pipes, and any other breach, significantly reduces the amount of air infiltration and energy used by the temperature regulating systems (American Council for an Energy-Efficient Economy, 2015). Properly directed airflow within the home also helps to regulate the temperature of rooms. Having heating and air conditioning directed to specific places, like bedrooms, within the home rather than attempting to manage the entire homes temperature is much more efficient and cost effective. In addition, by having properly fitted doors, unobstructed vents, and air circulators, like fans, the temperature of a given room is easily managed to the desired thermal comfort level of the resident of the room. Simple technologies such as ceiling fans, if turned counter clockwise, pull hot air down, which is a low-cost method to heating rooms, especially during the colder winter months (Stephenson D., 2009).

4.5 Cooling and Heating Efficiently

Most older houses with a lot of sun exposure struggle with keeping the internal temperature down during the summer months and up in the winter months. Solutions that are considered effective in cooling these houses are central air conditioning and ductless mini-split system air-conditioners. Ductless mini-split heating systems are used in homes that do not have ductwork (Energy Saver, b). These systems are beneficial to add onto existing heating elements because they can take the some of the load off of the pre-existing system. (Compact Appliance, 2015.) The advantages include their small size and their flexibility for zoning or heating specific rooms within a building (Energy Saver, b). Mini-split air conditioners also require very little

renovations and work to install because they require no ductwork (Energy Saver, b). However, there are a few disadvantages of using these systems. The cost of mini-split heat pumps can range anywhere from $1,500 to $2,000 dollars per ton (12,000 Btu per hour) of cooling capacity (Energy Saver, c). In addition it may be difficult to find qualified installers and service companies to install and give quotes on mini-split heating systems (Energy Saver, b).

Another cooling system is central air conditioning. Central air conditioners circulate cool air through a system of supply and return ducts (Energy Saver, a). The ducts within a home will carry the cooled air from the air conditioner to areas in the home. As the cooled air gets warmer after circulating throughout the home, it then flows back to the central air conditioner through the ducts and registers to start the process again (Energy Saver, a). Central air conditioners are one of the most effective and efficient ways for cool air to flow within a home when compared to other systems like window systems (Go Green Express, 2019). In addition, central air allows for the air in a home to be filtered which can limit stagnant air within a home (Go Green Express, 2019). While there are many benefits to central air, the installation is difficult and can be very pricey. If a home does not have ductwork, the ability to install central air will be even more difficult because ductwork will need to be done in the home (Energy Saver, a).

Programmable Thermostats are an effective tool for regulating temperature and energy efficiency within a building. For daily temperature settings, it is recommended that the temperature is set to 78° F in the summer and 68° F in the winter when people are in the building (Energy Saver, 2017). Additionally, if the temperature is set back by 7-10° from its daily setting for about 8 hours a day, a household can save up to 10% on their normal heating or cooling bill (Energy Saver, 2017). Energy savings can be achieved by adjusting the temperature when

people are at work, at school, or sleeping without sacrificing comfort. Programmable thermostats can be used so that the temperature returns to normal before people arrive home or wake up decreasing the small discomfort period when the house is heating/cooling (Energy Saver, 2017). When the temperature is setback throughout the day, the house is slowly losing less energy to the environment because the house is getting closer to the outside temperature (Energy Saver, 2017). Programmable Thermostats can be a crucial tool for homeowners to save money and regulate the comfort of residents.

Section 5: Energy Efficiency and Comfort at Friendly House

Friendly House puts all their financial resources towards helping the homeless population in Worcester and wants to find ways to improve the comfort of their house. To assist them, we conducted a comprehensive evaluation of Friendly House to give recommendations to improve the comfort of the building and reduce energy costs. To achieve this goal, we performed a comprehensive energy audit of Friendly House and gathered feedback from stakeholders such as the employees and residents of the house to learn more about the most important thermal comfort concerns at Friendly House. Then, we identified the most feasible solutions and analyzed their costs and benefits. Finally, we presented our recommendations to Friendly House so they could make more informed decisions on how to best use their resources to improve the comfort of their home and reduce energy costs.

Appendix C: Project Methodology

We conducted a comprehensive evaluation of Friendly House to give recommendations to improve thermal comfort and reduce energy costs in their housing unit at 87 Elm Street, Worcester, MA. To achieve this goal, we conducted and facilitated an energy audit of Friendly House and gathered feedback from stakeholders to assess thermal comfort needs. Then, we identified feasible solutions, and weighed their costs versus benefits. Finally, our team presented recommendations to Friendly House to improve comfort and reduce energy costs. In the following sections we discuss each objective, why it was necessary, the methods for meeting those objectives, and any difficulties we addressed when completing our objectives.

Objective 1: Complete a self-energy assessment and facilitate a professional energy audit of Friendly House

Performing or facilitating an energy audit would provide our group with energy usage and energy efficiency data of the Friendly House Shelter. Mass Save provides free energy assessments for multi-family homes, and we planned on using them as a resource for the energy audit of Friendly House. Self-energy assessments are an alternative to the professional energy audit and will be performed by a homeowner. The information from the energy audit supplies homeowners with possible solutions for more affordable and thermally comfortable units (Mass Save, 2019).

For the first step of this objective we contacted Mass Save to schedule an appointment for a free energy audit of Friendly House. We called a couple weeks before the project started to plan for waiting times Mass Save may have. They contacted us and let us know they would not be able to schedule us for an appointment within the time frame of the project, though. Since we were not able to get Mass Save to do a professional energy audit, we performed a self-energy audit of the house. To perform the self-energy audit, we followed the directions laid out by Energy Saver in appendix M, and gathered the information the auditing program, SnuggPro, required. SnuggPro is a software tool that takes information about the house and its appliances and generates energy saving recommendations for the house. Before entering any rooms, we notified staff that we would like to examine rooms at least 24 hours in advance. Then we were accompanied by a staff member as we examined residential rooms. We located air leaks within the house from windows and doors. We examined the walls, attic, and roof for insulation to determine if any more needed to be added and took pictures with a thermal imaging camera to find areas where the house is particularly inefficient. It was determined that there is currently no insulation in any part of the home. Additionally, we examined the appliances to determine if they were energy star appliances and determined the quality of lightbulbs in the house. We examined their current heating and cooling equipment in the house and the thermostat setpoints. The information we gathered was put into the SnuggPro app, so that the app could generate possible energy saving solutions which could be used in our third objective.

Objective 2: Gather feedback from stakeholders to assess the most critical comfort needs.

We held focus groups with both employees and residents to discuss their concerns with the comfort of the building. A focus group is a collective group of individuals that discuss a specific topic (Devault, 2018). The first focus group included only adults who reside in Friendly House in different areas of the house, and the second was comprised of the employees who have experienced both winters and summers at Friendly House. These focus groups allowed our group to gather diversified information from people with firsthand experience in the house in all parts of the year.

Gathering feedback from the residents allowed our group to understand the living experience of Friendly House. All stakeholders are directly affected by the potential changes to Friendly House, so their input is crucial in our decision-making process. Focus groups specifically allow participants to bounce ideas off each other and share their personal experiences to form more collective responses when compared to interviews or surveys (Lune, 2016). This also allows us to ask different questions, if we are getting answers that don't bring us closer to our objective (Lune, 2016). The stories the participants share may differ in a group setting from a one on one setting. Purposeful sampling to select members for a focus group involves selecting specific individuals from a larger group that, based on a previously established criteria, will most likely provide the most accurate and applicable information to the study (Lune, 2016). Using purposefully sampled groups allowed our team to learn about the comfort of

specific sections of the house. If we randomly sampled the people in the house, we might have encountered only residents that live on the same floor, thus not giving information about the other floors.

In order to determine which residents and employees would be beneficial to our research, we contacted Maria Dejesus, the director of shelter services for Friendly House. Ms. Dejesus has the most experience working within the organization and has the largest scope of the Elm Street inhabitants, so her advice was highly valuable to our results. Based on Ms. Dejesus's recommendations for good candidates, we asked residents and employees if they would participate in our study. We also printed out flyers that were posted around the house to attract any additional participants. The participants knew they could contribute to improving the house which encouraged their participation. From there we formed our focus groups based on the available meeting times of the residents and employees. During the focus group, we provided refreshments including cookies and water for the participants to establish rapport. We began the focus group with informed consent procedures, informing participants that contribution is voluntary, their participation will not affect their standing in the organization, they may withdraw at any time, their responses are anonymous, and results will be made available for viewing. We proceeded to ask questions focusing on the comfort in specific areas of the house, to get perspectives and concerns. We asked for improvement recommendations from each participant. See Appendix J for the focus group script and see Appendix K for the notes from each focus group. Each focus group also had a designated scribe and facilitator to make sure all information was collected and the focus group stayed on topic.

We also spent time observing the house and how the space was being used in regards to how much time was spent in common spaces versus rooms so we could better prioritize and recommend which space would require the most attention. We spoke with Maria Dejesus about how she sees the house operating and where we should prioritize our recommendations. The findings from this observation and discussion can be found in Appendix I.

Objective 3: Compiling solutions and associated costs that will improve thermal comfort and energy efficiency

After looking at the needs of the residents and the building, we gathered possible solutions by researching options and then contacting external contracting companies for price estimates. Once a contracting company was contacted, a representative was sent to Friendly House to tour the facility and gather enough information to provide us with a rough estimate for their particular trade. In addition to price, the contractors also provided us with information that helped us to get an idea of exactly how feasible each potential solution would be. The full list of potential vendors that were contacted can be seen in Appendix T.

We also contacted Professor Steven Van Dessel, the director of WPI's architectural engineering program. We reached out to Professor Van Dessel to help us explore how the houses design could be used to improve the thermal comfort at a low cost. He provided us with information in regard to low-cost, creative solutions and their impact on the houses thermal comfort and energy usage. These solutions were then compiled into a list where price and

number of units needed were recorded. The feasibility, thermal comfort rating, and energy efficiency rating of each solution were left unanalyzed until all potential options were gathered and recorded.

Objective 4: Presenting Friendly House with prioritized recommendations to improve comfort and reduce energy costs

Once we gathered possible solutions and had their general prices, we used a feasibility analysis and weighed whether or not the solutions were valuable enough to justify their cost. A feasibility analysis determines whether a business venture is worth the risk and possible to complete (Marino, 2012). The feasibility analysis is an important part of determining the possibility of each solution, in our case it helped us determine which solutions were feasible to implement based on their cost, how much renovation they would require, and their applicability to our problem.

Determining the costs and benefits of each solution were also critical in comparing different solutions. This allowed us to compare each solution and decide which were worth recommending. We gathered all of our solutions into a chart and rated each solution based on cost, thermal comfort improvement, and energy savings as seen in Appendix F.

These ratings were agreed upon amongst the group to compare each solution. Energy savings values can be generally quantified, estimated using the building simulation software BEOpt, which allowed us to make a model of Friendly House and show how variables such as

changing insulation will affect their energy costs. The data generated by BEOpt can be found in Appendix N. Comfort levels were given based on group consensus and the input of the professionals we contacted. The stakeholders helped us determine the value we assigned to each solution with their input during weekly meetings and focus groups.

Using the data and analysis above, we developed recommendations that we presented to Friendly House which detailed the possible solutions. The solutions were then packaged together to optimize their resources. We ranked all potential solutions in all three parameters: cost, energy efficiency improvement, and thermal comfort improvement. Then, we grouped together solutions that would pair well together and accomplish our goal. These packaged solutions were done in four categories: Status Quo Recommendation, Attic Expansion Package, Budgeted Renovations Package, and Bottomless Wallet Package. All packages are designed to improve the thermal comfort and energy efficiency of the house. The Attic Expansion package accommodates for their plan to potentially make their attic a livable space, which would change where the insulation is installed in the attic. Bottomless Wallet and Budgeted Renovations are the two extreme options, either with an exceedingly high budget and a low budget, to give the board an idea of what options are available per price point.

The purpose of the packaging is to get the most improvement out of each option for renovation, as well as focusing what part of the house needs addressed most. We took the information from our meetings with Maria Dejesus and observing the goings on in the house, to prioritize where to target with our recommendations. The conclusions we reached from this information in Appendix I. While some solutions make sense to do regardless of any others (i.e. insulation, replacing windows), some solutions make the most sense to be performed together,

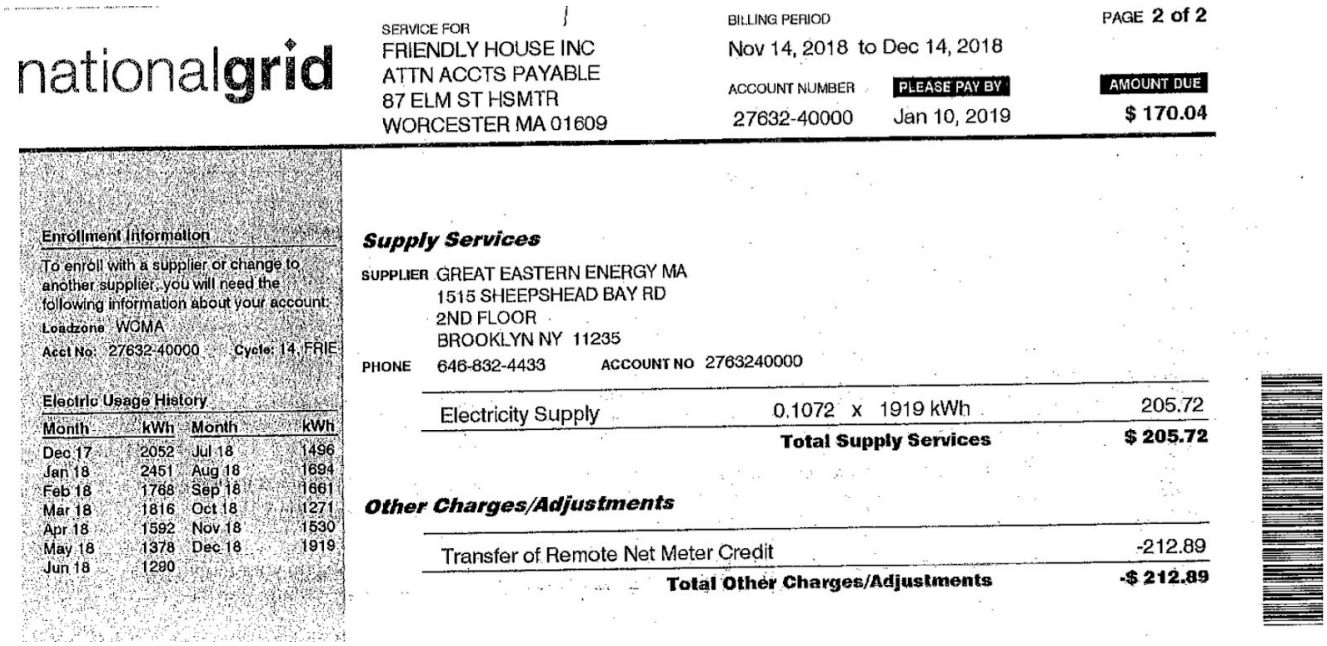
such as retrofitting insulation and adding air conditioning; adding air conditioning would be a wasteful endeavor if all this newly cooled air is lost from an uninsulated.

Appendix D: Project Timeline

Gantt Chart Tasks Timeline

Tasks/Week	1	2	3	4	5	6	7
Contact MassSave							
Perform Self Energy Audit							
Contact Potential Vendors for Estimates							
Resident and Employee Focus Groups							
Determine Solutions							
Determine Feasible Solutions							
Analyze Solutions Effectiveness and Cost							
Package Solutions for Presentation							

Appendix E: 2018 Energy Usage Data



nationalgrid

SERVICE FOR
FRIENDLY HOUSE INC
ATTN ACCTS PAYABLE
87 ELM ST HSMTR
WORCESTER MA 01609

BILLING PERIOD
Nov 14, 2018 to Dec 14, 2018

PAGE 2 of 2

ACCOUNT NUMBER 27632-40000

PLEASE PAY BY Jan 10, 2019

AMOUNT DUE $ 170.04

Enrollment Information

To enroll with a supplier or change to another supplier, you will need the following information about your account:

Loadzone WCMA

Acct No: 27632-40000 Cycle: 14 FRIE

Electric Usage History

Month	kWh	Month	kWh
Dec 17	2052	Jul 18	1496
Jan 18	2451	Aug 18	1694
Feb 18	1768	Sep 18	1661
Mar 18	1816	Oct 18	1271
Apr 18	1592	Nov 18	1530
May 18	1378	Dec 18	1919
Jun 18	1290		

Supply Services

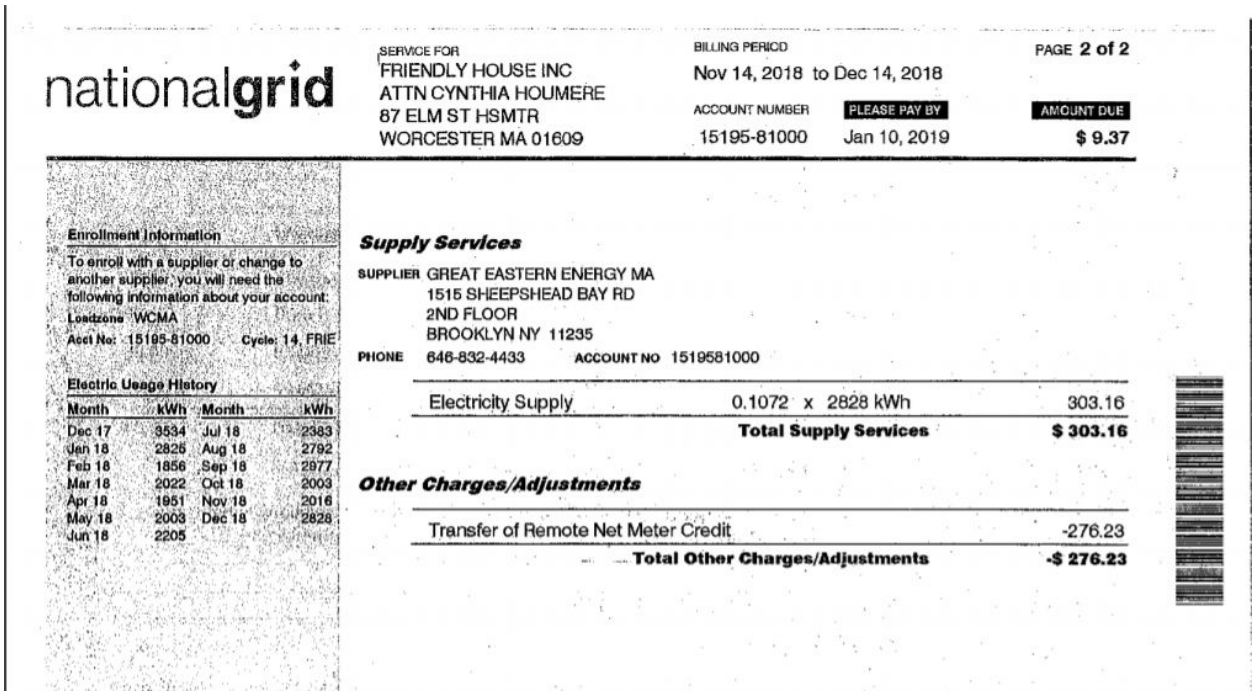
SUPPLIER GREAT EASTERN ENERGY MA
1515 SHEEPSHEAD BAY RD
2ND FLOOR
BROOKLYN NY 11235

PHONE 646-832-4433 ACCOUNT NO 2763240000

Electricity Supply	0.1072 x 1919 kWh	205.72
	Total Supply Services	**$ 205.72**

Other Charges/Adjustments

Transfer of Remote Net Meter Credit		-212.89
	Total Other Charges/Adjustments	**-$ 212.89**



nationalgrid

SERVICE FOR
FRIENDLY HOUSE INC
ATTN CYNTHIA HOUMERE
87 ELM ST HSMTR
WORCESTER MA 01609

BILLING PERIOD
Nov 14, 2018 to Dec 14, 2018

PAGE 2 of 2

ACCOUNT NUMBER 15195-81000

PLEASE PAY BY Jan 10, 2019

AMOUNT DUE $ 9.37

Enrollment Information

To enroll with a supplier or change to another supplier, you will need the following information about your account:

Loadzone WCMA

Acct No: 15195-81000 Cycle: 14 FRIE

Electric Usage History

Month	kWh	Month	kWh
Dec 17	3534	Jul 18	2383
Jan 18	2826	Aug 18	2792
Feb 18	1856	Sep 18	2977
Mar 18	2022	Oct 18	2003
Apr 18	1951	Nov 18	2016
May 18	2003	Dec 18	2828
Jun 18	2205		

Supply Services

SUPPLIER GREAT EASTERN ENERGY MA
1515 SHEEPSHEAD BAY RD
2ND FLOOR
BROOKLYN NY 11235

PHONE 646-832-4433 ACCOUNT NO 1519581000

Electricity Supply	0.1072 x 2828 kWh	303.16
	Total Supply Services	**$ 303.16**

Other Charges/Adjustments

Transfer of Remote Net Meter Credit		-276.23
	Total Other Charges/Adjustments	**-$ 276.23**

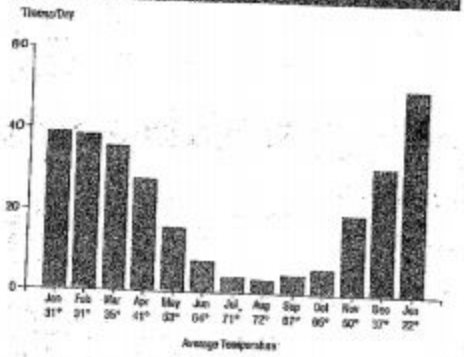
EVERSOURCE

Account Number: 1045 227 0068
Statement Date: 01/18/18

FRIENDLY HOUSE INC
87 ELM ST 1
WORCESTER MA 01609

Total Amount Due by 02/12/18	$2,592.06
Amount Due On 01/09/18	$1,405.37
Last Payment Received On 12/28/17	-$543.87
Balance Forward	$861.50
Total Current Charges	$1,730.56

Gas Usage History - Therms



Gas Usage Summary

This month your average daily gas use was **50.7 Therms**

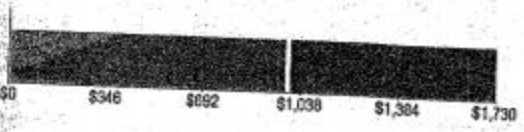
This month you used **29.7% more** than at the same time last year

29.7 % USAGE ↑

Current Charges for Gas

Supply
$986.36
Cost of gas from Eversource

Delivery
$736.79
Cost to deliver gas from Eversource



Your gas supplier is

Eversource
247 Station Drive
Westwood, MA 02090

RECEIVED

News For You

Go paperless with E-Bill and receive an email reminder instead of a paper bill each month. It's easy, convenient and secure. Log into your account at Eversource.com and select 'My Profile' to enroll in E-Bill today.

Remit Payment To: Eversource, PO Box 660753, Dallas, TX 75266-0753

Appendix F: Preliminary Solution Data

Solution	Feasible	Cost	Thermal Comfort (Rating of 1-5)	Energy Savings (Rating of 1-5)
Wall insulation	Yes	$18,000.00	3	3
Attic floor insulation	Yes	$11,000.00	3	4
Central Air/ Pump Combo	No	TBD	NA	N/A
Attic Roof Insulation	Yes	$15,970.00	3	4
All heat pump HVAC	Yes	$21,000 (not labor)	5	0
Exhaust Fan in Attic	Yes	$60-300	2	0
House Plants	Yes	$12 for 30 Cacti ($30 per larger succulent)	1	0
Chimney Heat Vent	No	$0.00	NA	N/A
Solar Panels	maybe	$35,000.00	0	5
Reflective Blinds	Yes	$22.50 per blinds	2	1
Blackout Curtains	Yes	$10/window ~ $520	2	1
Insulation Covers for Windows (Attic)	Yes	$36 4'x8'x2"	1	2
Thermostat setpoints	Yes	$0.00	2	3
Wall mounted dehumidifiers	Yes	$950 (1500 square feet)	3	0
Replace Windows	Yes for Some No for all	$900 per window	3	2
Replace Doors	Yes	$900 per door	1	1
Ceiling Fans	Yes	$30-$60 per fan (no labor)	2	0
Window Fans	No	$22/fan	NA	N/A
Outsulation	No	$120,000 (no labor)	NA	N/A

Appendix G: SnuggPro Data

Friendly House

Your Energy Audit

Home
Sample Job for testing
5555 Walnut Blvd.
Boulder CO, 80302
555-555-5555
test@example.com

Audit Date
Jan 1, 2015
01:00 pm

Audited By
Nicholas Pacheco
nepacheco@wpi.edu

Friendly House
87 Elm St
Worcester MA, 01609

Inside Your Report

Powered by Snuggpro # 133473

Friendly House

Concerns

We listened to you!

As our client, we want to make sure we are addressing all of your concerns for your home. If we have missed any concerns in this report, please let us know right away.

Friendly House

Solutions for Your Home

Totals

Approximate Cost

$ 141,100

This is a ballpark guess. Ask your contractor for a detailed bid.

Estimated Savings

$2,856 per year

This is an estimate of how much you could save starting in Year 1. Savings will only increase as energy prices rise over the years.

Savings to Investment Ratio

For Package: 0.4

SIR is the Savings to Investment Ratio. Simply put, if the SIR is 1 or greater, then the energy savings from the item will pay for itself before it needs to be replaced again. This metric is used to help prioritize the recommendations by financial merit.

Impact of upgrades

Energy Reduction	41%
Carbon (CO2) Savings	21 tons
Equivalent cars removed from the road	4.4/yr

Call us today at 555-222-1111 to ask a question or discuss the next step!

DETAILS	APPROXIMATE INSTALLED COST	APPROXIMATE ANNUAL SAVINGS	SIR *
Insulate Attic	$ 11,000	$ 480	0.9
Upgrade Lighting	$ 100	$ 118	12.6
Thermostat Set Points	$ 0	$ 684	100
Insulate Walls	$ 18,000	$ 649	0.7
Upgrade Windows	$ 96,000	$ 493	0.1
Insulate Vault	$ 16,000	$ 431	0.5

* SIR is the Savings to Investment Ratio. Simply put, if the SIR is 1 or greater, then the energy savings from the item will pay for itself before it needs to be replaced again. This metric is used to help prioritize the recommendations by financial merit.

Friendly House

Insulate Attic

ATTIC

Approximate installed cost

$11,000

Energy Savings

Approx. $480

Savings to Investment Ratio

0.9

Why it matters

Adding insulation to your attic can lead to a significant reduction in your utility bills. This process is often combined with careful air sealing of the ceiling from the attic side to ensure the new insulation perform at its maximum level.

Notes to Homeowners

Your attic needs some insulation! It's poorly distributed in a few places and is causing comfort problems.

Now & Goal

DETAILS	NOW	GOAL
Attic		
Attic 1		
Modeled Area	3200 ft²	3200 ft²
Insulation		49 R Value
Radiant Barrier?	No	No
Has Knee Wall?	No	No
Cool Roof?	No	No

Friendly House

Upgrade Lighting

LIGHTING

Approximate installed cost

$100

Energy Savings

Approx. $118

Savings to Investment Ratio

12.6

Why it matters

Compact Florescent Lightbulbs (CFLs) use 1/4 of the energy of regular incandescent light bulbs and last 8 to 15 times as long. Light Emitting Diode (LED) bulbs use 12% of the energy of regular incandescent light bulbs and last up to 50 times as long. Replacing incandescent bulbs with CFLs or LEDs will save significant energy and replacement costs over time.

Now & Goal

DETAILS	NOW	GOAL
Lighting		
# of CFLs	66	95
# of LEDs		
# of incandescents	39	10

Friendly House

Thermostat Set Points

THERMOSTAT

Approximate installed cost

$0

Energy Savings

Approx. $684

Savings to Investment Ratio

100

Why it matters

Installing a programmable thermostat (or correctly setting the one you currently have) will help you to use less energy when you're not at home or when you're sleeping.

Replace your manual thermostat with programmable one like this one or if you already have a programmable thermostat, be sure it is programmed correctly.

Now & Goal

DETAILS	NOW	GOAL
Thermostat		
Heating Setpoint High	85 °F	75 °F
Heating Setpoint Low	75 °F	75 °F
Cooling Setpoint High	85 °F	85 °F
Cooling Setpoint Low	85 °F	85 °F

Friendly House

Insulate Walls

WALLS

Approximate installed cost

$18,000

Energy Savings

Approx. $649

Savings to Investment Ratio

0.7

Why it matters

Now & Goal

DETAILS	NOW	GOAL
Walls		
Wall 1		
Modeled Area	4617 ft²	4617 ft²
Siding	Metal/vinyl siding	
Construction	2x4 Frame	
Cavity Insulation		16 R Value
Continuous Insulation		

Friendly House

Upgrade Windows

WINDOWS

Approximate installed cost

$96,000

Energy Savings

Approx. $493

Savings to Investment Ratio

0.1

Why it matters

Now & Goal

DETAILS	NOW	GOAL
Windows		
Window 1		
ENERGY STAR	No	No
U-Value	0.81 U Value	0.27 U Value
Solar Heat Gain Coefficient	0.67 SHGC	0.31 SHGC
Window Area: North (Back)	106.4 ft²	106.4 ft²
Window Area: East (Right)	236.55 ft²	236.55 ft²
Window Area: South (Front)	243.2 ft²	243.2 ft²
Window Area: West (Left)	370.59 ft²	370.59 ft²
Exterior Treatment: North (Back)	No Treatment	No Improvement
Exterior Treatment: East (Right)	No Treatment	No Improvement
Exterior Treatment: South (Front)	No Treatment	No Improvement
Exterior Treatment: West (Left)	No Treatment	No Improvement

Friendly House

Insulate Vault

VAULTED CEILING

Approximate installed cost

$16,000

Energy Savings

Approx. $431

Savings to Investment Ratio

0.5

Why it matters

Now & Goal

DETAILS	NOW	GOAL
Vaulted Ceiling		
Vault 1		
Modeled Area	1526.24 ft²	1526.24 ft²
Cavity Insulation		36 R Value
Continuous Insulation		
Cool Roof?	No	No

Friendly House

Metrics

About the metrics

These metrics are for the whole house in a pre and post-retrofit state.

The 'Baseline' savings numbers will likely not be the same as the actual energy consumption of the home. These numbers are weather normalized and then projected based on the Typical Meteorological Year for the past 30 years (TMY30). In other words, this is the energy consumption of the home for a typical year, not the year that the utility bills were from.

FUELS	BASELINE	IMPROVED	SAVED
Total Fuel Energy Usage therms/year	7,562	3,796	3,766
Natural Gas Energy Usage therms/year	7,562	3,796	3,766

METRIC	BASELINE	IMPROVED	SAVED
Electric Energy Usage kWh/year	47,876	46,708	1,168
Total Energy Usage MMBtu/year	920.00	539.00	381.00
Fuel Energy Cost $/year	$ 5,445	$ 2,733	$ 2,712
Electric Energy Cost $/year	$ 5,893	$ 5,749	$ 144
Total Energy Cost $/year	$ 11,337	$ 8,482	$ 2,855
CO2 Production Tons/year	69.3	48.6	20.7
Payback years			0
Total Energy Savings			41%
Total Carbon Savings			30%
Net Savings to Investment Ratio SIR			0.4
Net Annualized Return MIRR			0%

HEATING & COOLING LOAD CALCULATIONS		
Heating Load Btu/hr	Base: 309,624	Improved: 215,031
Cooling Load: Sensible Btu/hr	Base: 365,690	Improved: 287,582
Cooling Load: Latent Btu/hr	Base: 2,800	Improved: 2,800
Winter Design Temperature	Outdoor: 4°	Indoor: 70°
Summer Design Temperature	Outdoor: 89°	Indoor: 75°

Friendly House

Tech Specs

Property Details

Year Built:	1909
Conditioned Area:	8453 ft²
Includes Basement:	Yes
Average Wall Height:	9 ft
House Length:	80 ft
House Width:	41.5 ft
Floors Above Grade:	2
Number of Occupants:	52
Number of Bedrooms:	13
Type of Home:	Don't Know
Front of Building Orientation:	South
Shielding:	Normal

Thermostat

Programmable Thermostat Installed:	No
Heating Setpoint High:	85 °F
Heating Setpoint Low:	75 °F
Cooling Setpoint High:	85 °F
Cooling Setpoint Low:	85 °F

Heating & Cooling

Heating Design Load:	309624 Btu/hr
Hvac: 1	
System Name:	Hvac System 1
Equipment Type:	Boiler
Upgrade action:	Keep an existing system as is
Heating Energy Source:	Natural Gas
% of Total Heating Load:	100%
Heating Capacity:	400000 BTU/h
Heating System Efficiency:	65 AFUE
Heating System Manufacturer:	Unknown
Heating System Model:	FTX400N

Appliances

Range: 1	
Range Fuel Type:	None
Oven: 1	
Oven Fuel Type:	Electricity
Clothes Dryer: 1	
Dryer Fuel Type:	Electricity

Clothes Washer

Type:	Top Load
Integrated Modified Energy Factor:	0.64 IMEF
ENERGY STAR:	No
Manufacturer:	Amana
Model #:	D2351B31

Dishwasher

Dishwasher Installed?:	Yes
Energy Factor:	0.43 EF
ENERGY STAR:	No

Freezers

Freezer: 1	
Name:	Basement Chest Freezer
Usage:	483.51 kWh/yr
ENERGY STAR:	No
Freezer: 2	
Name:	Freezer 2
Usage:	533.45 kWh/yr
ENERGY STAR:	Yes
Freezer: 3	
Name:	Freezer 3
Usage:	592.72 kWh/yr
ENERGY STAR:	No

Refrigerators

Refrigerator: 1	
Name:	Kitchen
Refrigerator Age:	0-14
Refrigerator Size:	22+
ENERGY STAR:	No
Usage:	826 kWh/yr
Refrigerator: 2	
Name:	Garage
Refrigerator Age:	0-14
Refrigerator Size:	22+
ENERGY STAR:	No
Usage:	826 kWh/yr
Refrigerator: 3	
Name:	Kitchen Wine Cooler
Refrigerator Age:	15-21
Refrigerator Size:	22+
ENERGY STAR:	No
Usage:	826 kWh/yr

Lighting

% CFLs or LEDs:	51-75%
Total # of Light Bulbs:	105
# of CFLs:	66
# of LEDs:	0
# of Incandescents:	39

Doors

Door: 1

Friendly House

Tech Specs

Type:	Wood
Area:	21 ft²
ENERGY STAR:	No
U Value:	0.46 U Value

Exterior Walls

Wall: 1	
Modeled Area:	4617 ft²
Insulated?:	No
Siding:	Metal/Vinyl siding
Construction:	2x4 Frame
Cavity Insulation:	0 R Value
Continuous Insulation:	0 R Value

Attic & Vaulted Ceiling

Attic: 1	
Modeled Area:	3200 ft²
Insulation Depth:	0
Insulation Type:	Don't Know
Insulation:	0 R Value
Radiant Barrier?:	No
Has Knee Wall?:	No
Cool Roof?:	No
Vault: 1	
Modeled Area:	1526.24 ft²
Insulated?:	No
Cavity Insulation:	0 R Value
Continuous Insulation:	0 R Value
Cool Roof?:	No

Foundation - General

Foundation: Basement:	100%
Foundation: Crawlspace:	0%
Foundation: Slab:	0%
Foundation Above Grade Height:	2 ft

Foundation - Basement

Modeled Basement Floor Area:	2817.67 ft²
Basement Wall Insulation:	Finished wall without Insulation
Basement Rim Joist Treatment:	Same as Basement Wall
Basement Cooling:	None or Undesired Incidental

Frame Floors

Modeled Floor Area:	0 ft²

Windows

Window: 1	
Window Area: North (Back):	106.4 ft²
Window Area: East (Right):	236.55 ft²
Window Area: South (Front):	243.2 ft²
Window Area: West (Left):	370.59 ft²
Type:	Double pane
Frame:	Metal
ENERGY STAR:	No
U-Value:	0.81 U Value
Solar Heat Gain Coefficient:	0.67 SHGC
Window Area: North (Back) Overhang Depth:	0 ft
Window Area: East (Right) Overhang Depth:	0 ft
Window Area: South (Front) Overhang Depth:	0 ft
Window Area: West (Left) Overhang Depth:	0 ft
Exterior Treatment: North (Back):	No Treatment
Exterior Treatment: East (Right):	No Treatment
Exterior Treatment: South (Front):	No Treatment
Exterior Treatment: West (Left):	No Treatment

Skylights

Skylight Area:	1653 ft²

Air Leakage

Blower Door Test Performed:	Estimate
Blower Door Reading:	12740 CFM50
Conditioned Air Volume:	78894.67 ft³
Wind Zone:	2
N-Factor:	14.99
Equivalent NACH:	0.65 NACH
Effective Leakage Area:	649.98 in²
Equivalent ACH50:	9.69 ACH50
Kitchen Fan:	0 CFM
Bathroom Fan 1:	0 CFM
ASHRAE 62.2 Required mechanical ventilation rate:	N/A CFM

Water Heating

Water Heating: 1	
Fuel:	Natural Gas
Type:	Tank Water Heater
Age:	0-5
Location:	Garage or Unconditioned Space
Temperature Settings:	Low (120-130 F)
Energy Factor:	61 EF

Pool & Hot Tub

Pool:	No
Hot Tub:	No

PV

Pv: 1	
Has PV?:	No

Utilities

Utility Price: Natural Gas:	0.72 $/Therm

Friendly House

Tech Specs

Utility Price: Propane:	2.17 $/Gallon
Utility Price: Fuel Oil:	2.53 $/Gallon
Utility Price: Electricity:	0.12 $/kWh
Utility Price: Wood:	0 $/cord
Utility Price: Pellets:	0 $/Ton

Utility Bills

Electric

Electric Utility Provider Name	National Grid
Electric Account Number	27632-40000
1. 01/17/2018	5276 kWh
2. 02/17/2018	3624 kWh
3. 03/17/2018	3638 kWh
4. 04/17/2018	3543 kWh
5. 05/17/2018	3831 kWh
6. 06/17/2018	3495 kWh
7. 07/17/2018	3879 kWh
8. 08/17/2018	4486 kWh
9. 09/17/2018	4638 kWh
10. 10/17/2018	3274 kWh
11. 11/17/2018	3543 kWh
12. 12/17/2018	4747 kWh

Fuel

Fuel Utility Provider Name	Eversource
Fuel Account Number	1045 227 0068
1. 01/16/2018	1725 Therms
2. 02/13/2018	1235 Therms
3. 03/18/2018	1144 Therms
4. 04/15/2018	846 Therms
5. 05/14/2018	460 Therms
6. 06/13/2018	149 Therms
7. 07/15/2018	97 Therms
8. 08/14/2018	77 Therms
9. 09/12/2018	87 Therms
10. 10/15/2018	196 Therms
11. 11/14/2018	674 Therms
12. 12/13/2018	1073 Therms

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About This Report

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Job ID: 133473
Report & modeling software: Snugg Pro™ 5.0

Friendly House

Glossary

Annual Fuel Utilization Efficiency (AFUE) The measure of seasonal or annual efficiency of a residential heating furnace or boiler. It takes into account the cyclic on/off operation and associated energy losses of the heating unit as it responds to changes in the load, which in turn is affected by changes in weather and occupant controls.

Annualized Return The return an investment provides over a period of time, expressed as a time-weighted annual percentage. This is the equivalent annual interest rate you would get if you put the same amount of money spent on the energy upgrade into a savings account.

Asbestos Asbestos is a mineral fiber that has been used commonly in a variety of building construction materials for insulation and as a fire-retardant, but is no longer used in homes. When asbestos-containing materials are damaged or disturbed by repair, remodeling or demolition activities, microscopic fibers become airborne and can be inhaled into the lungs, where they can cause significant health problems.

British Thermal Unit (Btu) The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit; equal to 252 calories.

Carbon Monoxide (CO) A colorless, odorless but poisonous combustible gas with the formula CO. Carbon monoxide is produced in the incomplete combustion of carbon and carbon compounds such as fossil fuels (i.e. coal, petroleum) and their products (e.g. liquefied petroleum gas, gasoline), and biomass.

Cashflow When financing energy efficiency improvements, cashflow is the difference between the average monthly energy savings and the monthly loan payment.

Combustion Appliance Zone (CAZ) A contiguous air volume within a building that contains a combustion appliance such as furnaces, boilers, and water heaters; the zone may include, but is not limited to, a mechanical closet, mechanical room, or the main body of a house, as applicable.

Compact Fluorescent Light bulb (CFL) A smaller version of standard fluorescent lamps which can directly replace standard incandescent lights. These highly efficient lights consist of a gas filled tube, and a magnetic or electronic ballast.

Cubic Feet per Minute (CFM) A measurement of airflow that indicates how many cubic feet of air pass by a stationary point in one minute.

Carbon Dioxide (CO_2) A colorless, odorless noncombustible gas that is present in the atmosphere. It is formed by the combustion of carbon and carbon compounds (such as fossil fuels and biomass). It acts as a greenhouse gas which plays a major role in global warming and climate change.

Energy Efficiency Ratio (EER) The measure of the energy efficiency of room air conditioners: cooling capacity in Btu/hr divided by the watts consumed at a specific outdoor temperature.

Energy Factor (EF) The measure of efficiency for a variety of appliances. For water heaters, the energy factor is based on three factors: 1) the recovery efficiency, or how efficiently the heat from the energy source is transferred to the water; 2) stand-by losses, or the percentage of heat lost per hour from the stored water compared to the content of the water; and 3) cycling losses. For dishwashers, the energy factor is the number of cycles per kWh of input power. For clothes washers, the energy factor is the cubic foot capacity per kWh of input power per cycle. For clothes dryers, the energy factor is the number of pounds of clothes dried per kWh of power consumed.

Heating Seasonal Performance Factor (HSPF) The measure of seasonal efficiency of a heat pump operating in the heating mode. It takes into account the variations in temperature that can occur within a season and is the average number of Btu of heat delivered for every watt-hour of electricity used.

Heat Recovery Ventilator (HRV) / Energy Recovery Ventilator (ERV)
A device that captures the heat or energy from the exhaust air from a building and transfers it to the supply/fresh air entering the building to preheat the air and increase overall heating efficiency while providing consistent fresh air.

Light Emitting Diode (LED) Lighting An extremely efficient semiconductor light source. LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved physical robustness, and smaller size.

Modified Internal Rate of Return (MIRR) This is your return on investment. Roughly speaking, if you invested the same amount of money for this project (listed on this report as the total cost) into a bank account, your equivalent interest rate from all of the energy savings would be the MIRR.

N-Factor A factor of how susceptible your house is to wind, influenced by weather patterns, location, and the number of floors in the home. Used in the calculation of NACH.

Natural Air Changes per Hour (NACH) The number of times in one hour the entire volume of air inside the building leaks to the outside naturally.

Payback Period The amount of time required before the savings resulting from your system equal the system cost.

R-Value A measure of the capacity of a material to resist heat transfer. The R-Value is the reciprocal of the conductivity of a material (U-Value). The larger the R-Value of a material, the greater its insulating properties.

Radon A naturally occurring radioactive gas found in the U.S. in nearly all types of soil, rock, and water. It can migrate into most buildings. Studies have linked high concentrations of radon to lung cancer.

Rim Joist In the framing of a deck or building, a rim joist is the final joist that caps the end of the row of joists that support a floor or ceiling. A rim joist makes up the end of the box that comprises the floor system.

Seasonal Energy Efficiency Ratio (SEER) A measure of seasonal or annual efficiency of a central air conditioner or air conditioning heat pump. It takes into account the variations in temperature that can occur within a season and is the average number of Btu of cooling delivered for every watt-hour of electricity used by the heat pump over a cooling season.

Savings to Investment Ratio (SIR) A ratio used to determine whether a project that aims to save money in the future is worth doing. The ratio compares the investment that is put in now with the amount of savings from the project.

Appendix H: Door and Window Data

Doors

*** Door needs to be replaced**
Location:

Door To Backyard: This door has gaps all around it. Light can be seen coming in around the door (***Window should be replaced)**

Door to TV Room: This door is sealed properly

Door to Driveway: This door is sealed relatively well

Door to Elm Street (front door): The door is sealed well and does not need to be replaced

Door next to Basement: This door is sealed well

Windows

***When you are standing facing the room from the doorway, that determines windows that are furthest left and right**

**** Window should be replaced**

Location:

Room 1: No broken windows, the 3 windows from right to left cannot lock

Room 2: Two windows from right to left are open from top and should be fixed. Losing heat. Window to furthest left has a broken lock. No cracks in any windows.

Room 3: Window to most left has opening on top and could be screwed in. The window to the most right closes and locks. Neither window is cracked

Room 4: These is a gap between the top and bottom window pane which is resulting in losing heat **(**Window should be replaced)**

Room 5: Window to most left is in good condition. Window to furthest right is in poor condition. Top is open at top and could be screwed in. Could be fixed.

Room 6: Two windows from furthest left can lock and are not cracked. In good condition. The window to the furthest right is open on the top and is losing heat. None of windows are cracked

Room 7: Windows are in good condition.

Room 8: All windows can lock and are in good condition

Room 9: Window to most left is open and is losing heat. Windows to furthest right and middle window are slightly open. No windows have any cracks.

Room 10: Windows are in good condition

Room 11: Windows are in good condition

Room 12: WIndows are in good condition

Room 13: Windows are in good condition

Play Room: Windows cannot lock but are not losing heat and are not open.

Dining: There is a slight draft from the most left and most right windows in the dining room if you were facing the window from the room.

Kitchen: The one window in the kitchen cannot lock. The window is loose and is open. (**Should be replaced**.)

Fridge Room: Windows are in good condition.

Left Main Stairway: Window to most left, when facing windows, has no cracks. Window to right has a slight crack on second pane. **(**Should be replaced)**

Appendix I: House Observation

Along with the input from Maria Dejesus, we were able to determine that while everyone did use the common spaces for cooking and eating, there was not a lot of time spent socializing in the common spaces, especially not during peak hours, which in the case of Friendly House is after about 4 pm. Any time spent in the common areas throughout the day was generally just to pass through. Some families, especially those with children under the age of 5, will eat breakfast/lunch in the kitchen but spend only about 30 minutes at a time. The residents spend most of their time in their rooms while they are at the house. Another point of concern that we were unable to observe, as Ms. Dejesus told us many families have young children and the rooms get so hot in the summer many children struggle with sleeping. She has recommended that cooling the rooms be made a priority because of this. We also were not able to witness the conditions of the house during the summer, so we are relying on our meetings with Ms. Dejesus.

Appendix J: Focus Group Consent Script and Questions

Opening Statement of Focus Group

Informer Consent: Hello and welcome to our focus group.We are part of a group of 5 WPI students working with Friendly House to gather information to help improve the comfort level of the facility. (Each member then introduces themselves). We are going to ask you a series of questions about your experiences living in Friendly House. We would like to assure you that this is a voluntary focus group, you can leave at any time, and if you do not want anything you say to be included in our study, tell us and we will remove it. With that being said, any personal information will be kept completely confidential and anonymous in our report. We will make sure that the results of our project are available for your review at the completion of the project.

Focus Group Questions (Residents)

1. Where do each of you live in the house?
2. How old are you?
3. How many of you live in a room with more than two other people?
4. How many of you have been living at Friendly House less than a month, more than a month, and over 3 months?

   *If over 3 months, were you living here during the summer?

5. Could your comfort relating to the temperature of the house since you've been here?
6. What concerns do you have with the current temperature conditions of the house?
7. What improvements to comfort in regards to comfort would you like to see?
8. How often are you in the house? How much time do you dedicate time to job search, etc?

Focus Group Questions (Employees)

1. How long have you each worked at Friendly House?
2. What parts of the house do you think are most uncomfortable?
3. Do any of you have recommendations of ways to improve the comfort within the house? (During summer? During Winter?)
4. Would you say it is more comfortable during the winter months or summer months at Friendly House?
5. Could you describe your comfortability satisfaction in your experience working here?
6. Does your comfort working here change with the seasons?
7. How long per day do you work in the Friendly House facility and what times?

Appendix K: Focus Group Feedback

Employee Feedback

- One employee has worked for 18 years at Friendly House - has worked both the night shift and day shift
- The second employee has worked for 6 years at Friendly House
- The temperature varies throughout the day
- The employees have the option to work with thermostat
- In the summer there is a window air conditioning unit in the office for employees
- More comfortable at night in the summer
- Can get very cold during winters during the night
- Some rooms get hot and cold - very inconsistent
- In the summer the basement is the coolest
- 2nd and 3rd floor gets very uncomfortable in the summer
- Humidity is extremely high in summer during the day, especially in the basement
- The thermostats are programmable
- Dehumidifiers were mentioned to possibly help with humidity in the summer
- The employees were not aware that the temperature reads higher than it actually is set to in certain rooms

- In some rooms in the house, there are more base heaters than other rooms. This makes it hotter in certain rooms when the heat is on.

Resident Feedback

- No current resident has been living at the house for more than 4 months (no summer/fall months)
- Rooms can vary temperature greatly
    - Can get very hot right before bed and then really cold in the mornings
    - The Residents spend most of their time in the rooms
- Basement is really stuffy
- Some rooms have issues with windows being broken or letting air in from the top
- Main concern is a consistent temperature in the room
    - Residents feel like as soon as they adjust to a warmer temperature the room goes cold and as soon as they adjust to a colder temperature the room gets really warm
- Residents did not have a major concern with the temperatures of the common areas
- Residents with young children found that children also have difficulty sleeping with the inconsistent temperature
- Not all but most residents spend the working hours outside of the house as children go to school and adults partake in training or have jobs

Appendix L: Friendly House Description

From their website, Friendly House is a three-story shelter home at 87 Elm St in Worcester, Massachusetts. The organization takes in families and expecting mothers who are homeless and helps not only by sheltering them but also by helping them get back on their feet. They provide short term housing, assistance searching for long term housing, and employment training to promote self-confidence and an ability to support themselves when they leave the Friendly House.

Friendly House was founded in 1920 as a settlement house at 37 Norfolk Street. The house began primarily as support for the city's immigrants, introducing them to the ways of the United States and helping them integrate into American life. The girls were trained in skills for housekeeping like cooking, basket weaving, and making clothing, and boys in the house were given work training. Friendly House also provided dental care. As the organization expanded and took on more people to care for, they moved to 38 Wall Street, a significantly larger, two floor, ten room house. Throughout the Depression, Friendly House and its services became more and more critical to the community, as more families were struggling and looking to them for support. They provided services for children like sewing and cooking classes, culturally based activities like theater, music, and arts, a Dental Clinic and a nursery school program. The house was a place for children to have productive programming through clubs and social gatherings. Throughout the mid-twentieth century, the Friendly House was mostly designed around helping the youth of Worcester and promoting cultural advancement in the younger generation, as well as providing useful life training. As the organization approached the turn of the century, their

services expanded to include more of the community. They began programs to provide food for hungry children, social services for seniors, and after school programs for special needs children. In 1983, the organization opened a shelter for homeless families and began distributing food to needy families. In the 1990's they became, if they were not already, a key figure for inner city family support because they provided emergency shelter, food, medical care, day care, senior programs, and counseling. They also were as involved as ever in extensive after school programs including athletics and summer programs. The organization was crucial in keeping children off the streets throughout the 1980's and 90's by providing opportunities for creative and recreational activities after school and during summer vacations.

As Delgado writes in the article, the modern-day Friendly House served over 10,000 children in 2016 alone. With various after school programs, summer swim and basketball programs, emergency food and shelter, immigration support, clothing distribution, community feeding sites, and the Elm Street shelter (as well as other apartment shelters), the Friendly House was able to help thousands of families throughout Worcester. The organization continues to be a pillar of support for the inner city of Worcester in a variety of different ways, whether it be keeping kids off the street, or supporting families in need with their food pantries and shelters. The Friendly House also provides many services for immigrants as well, including helping them fill out their applications for citizenship and translating documents, along with their standard services of providing shelter and food.

To keep providing the best support possible, Friendly House is looking to increase the comfort of its building by looking for additional ways to heat and cool the building consistently. Additionally, they want ways that they can reduce their energy usage so that they can still

provide the services they do to other people. If money starts getting wasted on energy bills, they may not have the funds to support their wide array of programs.

Appendix M: Self Home Energy Audit

1) Locate Air Leaks
    a) Identify and create a list of air leaks within the home. Check for leaks both within the home and leading to outside the home.
    b) This should involve checking for gaps in baseboards, walls, floors, ceilings, windows, doors, lighting, plumbing fixtures, electrical outlets, and switches.
2) Seal Air Leaks
    a) Caulk and plug holes and gaps after they have been identified. Especially seal cracks and holes found in the foundation, siding, mortar, doors and windows.
3) Consider Ventilation
    a) Be certain that enough air is supplied to combustion appliances to avoid backdrafts that pull combustion gases back into the homes living space. This is especially important for homes where fuel is burned for heating.
    b) Indications of poor ventilation and air supply can be seen as burn marks or soot around the appliance burner or vent collar. The general rule for adequate air supply is one square inch of vent opening for every 1,000 Btu of appliance input heat.
4) Check Insulation
    a) Check areas where heat can be lost from the house, most important of which being the attic. Look to see if there is a vapor barrier placed under the attic insulation. If no vapor barrier is found, consider painting the interior ceilings with

vapor barrier paint. This will help to minimize the amount of water vapor that passes through the ceiling, which will help to increase the effectiveness of the insulation.

b) Be sure to avoid blocking attic vents with insulation and check to see if electrical boxers in the ceiling have been sealed with caulk.

c) Be sure that the entire attic floor is covered with insulation to avoid heat being lost from the rest of the home.

d) Check if walls are properly insulated by turning off the power to an outlet in the wall, unscrewing the cover, and prodding with a screwdriver or long stick until some form of insulation material has been hit. In order to fully check if the wall has been completely insulated to the desired level, a thermographic inspection would have to be conducted.

5) Inspect Heating and Cooling Equipment

a) Conduct an inspection of the heating and cooling equipment within the home. Check and replace filters of forced-air furnaces as needed. If needed, contact a professional to clean and check the equipment's condition.

b) Consider replacing any heating or cooling units over 15 years old with newer, more energy efficient models.

c) Check for dirt streaks in the seams of the ductwork, as this indicates air leaks and should be sealed with duct mastic.

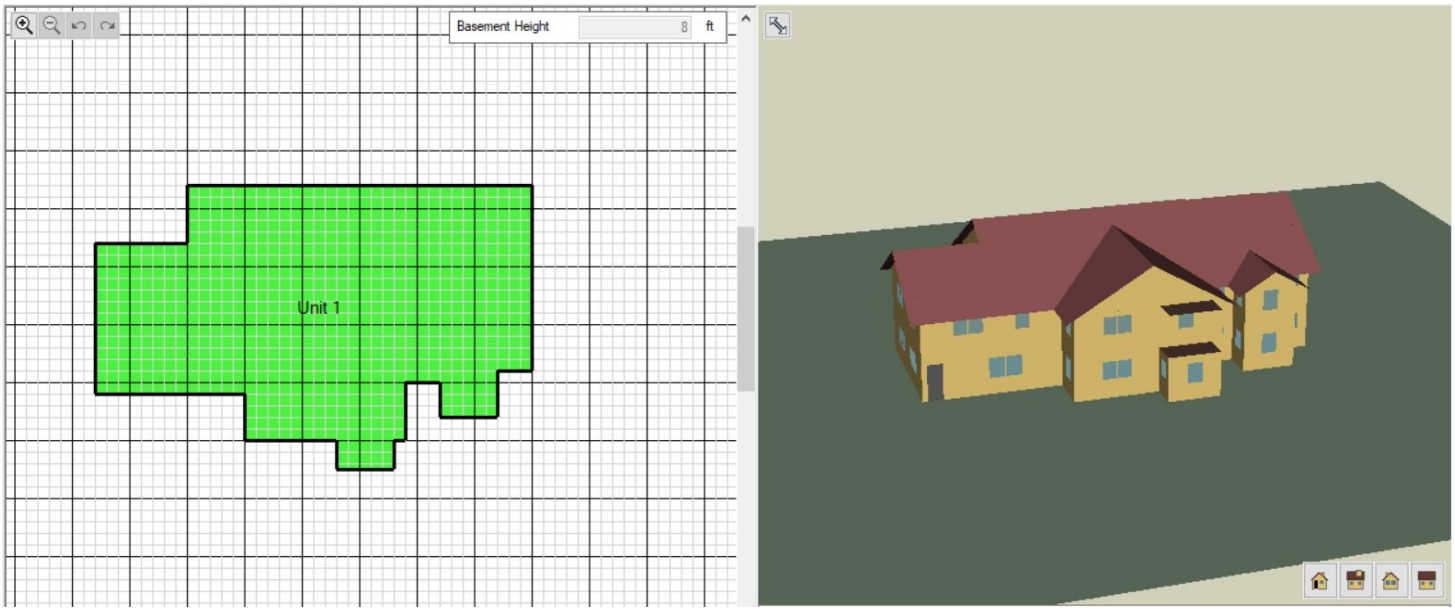
d) Insulate any pipes or ducts that pass through unheated spaces within the home.

6) Lighting
    a) Consider replacing inefficient light bulbs with ones that use less energy
    b) Rebates and incentives for purchasing energy-efficient lighting may be offered by your electrical utility provider.
    c) Consider installing dimmers, timers, or motion sensors to reduce energy cost from lighting
7) Appliances and Electronics
    a) Estimate the energy usage of the current appliances in your home. Based on this estimate consider replacing old or outdated models to improve efficiency, reducing the usage of certain appliances, or unplugging equipment that is not in use to prevent phantom energy use.
8) Create a Whole-House Plan
    a) Once the sources of energy usage and loss have been identified, create a plan of action based on prioritized need and cost to identify what improvements will be implemented.

Appendix N: BEOpt

Option	Initial Energy Cost	Energy Cost with Option	Savings	Percent Saving	BEOpt Estimated Cost	Quote Cost	Payoff Period (Rounded Years)
Attic (R-49 Cell.)	$6,229	$5,480	$749	12.02%	$6,793	$11,180	15
Roof(R-38)**	$6,229	$6,219	$10	0.16%	$268	$15,890	1589
Walls (R-16.5)	$6,229	$5,645	$584	9.38%	$9,369	$18,150	31

**Not an accurate simulation



Appendix O: Status Quo Recommendation

The Status Quo Recommendation section is meant to provide comfort improvements and energy efficiency improvements at a reasonable cost. The status quo recommendation assumes that Friendly House will not change the way that 87 Elm Street is used on a daily basis. This package hits the main issues brought up by residents and employees of the house. The first thing is to insulate the attic floorboards; this will help keep the heat in the house in the winters and keep the attic outside the building envelope. During the summer, the sun will heat the air in the attic, but the floor insulation will keep the heat from entering the lower floors. The insulation will also aid in keeping the cool air, which comes from the heat pumps, in the rooms during the summer months.

Putting a heat pump in every residential room will provide the house with a cooling system for the residents without cooling the entire building. In addition to this, a heat pump will be added to both the employee office and the playroom to replace the inefficient window units. In this case, there will be a total of 15 heat pumps in this package. This will provide a better environment for residents with children especially during the night, because the building can get extremely hot in the summers. The heat pumps can also supplement the heating system, and with a heat pump in each room residents can adjust the heat to their preference without affecting other rooms. The individual heat pumps will also help keep the temperature consistent because each one will regulate the temperature for an individual room, instead of multiple rooms like the existing heating system.

There are three windows that are in need of replacement because of either cracks in the window pane, or gaps between the windows (Appendix H). Replacing these critical windows will help insulate the building and keep the heat contained during the winters. There is also one door that needs to be replaced because it no longer fits properly in the frame allowing air to escape or come in the house (Appendix H).

The Status Quo Recommendation is the one that our group believes to be the best option for Friendly House to pursue. This recommendation will increase the comfort within the 87 Elm Street location while also increasing energy efficiency. However, it is not the most costly recommendation and allows for the possibility of using many of the options from the A La Carte menu (Appendix S).

Appendix P: Attic Expansion Package

The Attic Expansion Package is for displaying the comfort and energy improvements available if Friendly House were to renovate the attic within the next 15 years. Based on our simulations it would take roughly 15 years to save the amount of money that it would cost to implement insulation in the roof of the attic. To insulate the roof, there can be a moisture problem. This means there will be additional costs to properly waterproof the roof to avoid moisture buildup in the insulation. If Friendly House decides that renovating the attic is a main priority, this package would be the best option as it does not insulate the attic floor, which would be made obsolete by making the attic a livable space. The purpose of insulating the attic at all is to close the building envelope and keep the heat generated trapped within the house, so insulating the floor and then heating on top of it would be superfluous.

This package would include insulating the roof and walls of the attic and replacing all critical windows and doors in the house outlined in Appendix H. This package would not include the insulation of the attic floors due to the roof and walls being insulated. Just like the Status Quo Recommendation, heat pumps would be added to each of the 13 resident rooms within the house. In addition another single pump would be added to both the employee office and playroom. Heat pumps are seen as one of the most important aspects of the packages that are presented due to the feedback during our second objective. They will allow residents to keep cooler in the summer, especially in their rooms, as well as try and limit the humidity as well.

There are several additional costs associated with renovating the attic for residential use. These renovations are not included in our cost estimates for the Attic Expansion package. This

would include adding ventilation or moisture barrier to avoid moisture or mold problems, replacing the roof and adding temporary insulation covers to the windows in the attic. Eventually all windows would need to be replaced, another exit like a fire escape would need to be added to the attic, and the floor may need to be replaced as well.

Appendix Q: Budgeted Renovations Package

This set of options focuses on only the most needed thermal comfort improvements while heavily weighing the costs of the options. This package can also be used as a preliminary to other options or be added upon with options from the A La Carte menu depending on the budget. By Insulating just the attic floor, the total heated area of house will be reduced to only the two floors below and the basement. The attic would essentially be treated as being outside of the home. Combining this with placing heat pumps in the hottest rooms on the sun facing side of the house and the rooms in the basement will still allow for prioritized residents to sleep and live in a comfortable temperature, but also not overspend on attempting to cool all the bedrooms. In addition, by replacing the windows and doors that are deemed as being in the most critical condition, the house will be further insulated while not over spending on unnecessary improvements or replacements. A full list of critical windows can be viewed in Appendix H. The money saved from this package could also be saved and put towards other periodic renovations such as replacing a certain number of windows every year or adding a heat pump to a bedroom that does not have one.

Appendix R: Bottomless Wallet Package

The Bottomless Wallet Package gives a recommendation for the most ideal thermal comfort and energy efficiency improvements. This package is expensive and would be implemented if there was a huge budget. This package can also be worked toward in the distant future after a lower cost package if first pursued. Insulating the attic roof while ventilating the attic and replacing all windows would make the attic safely insulated and with the addition of a second exit, can make the attic a livable space as well. Insulating the walls would also be great for energy efficiency and thermal comfort of the house. To pursue this option safely, either interior drywall or exterior siding would need to be removed to add a moisture barrier. For both the attic rafter and wall insulations, these expensive precautions must be taken to avoid any issues with moisture or mold. All windows throughout the house would be replaced to get the most efficiency. Solar Panels would be added to the roof to greatly help energy efficiency. Although this comes with a high upfront cost, the energy savings along with incentives would be significant (Appendix U). Mini Split Heat pumps would be added to every residential room in order to give a boost to thermal comfort as well as being added to both the employee office and the playroom.

Overall, the Bottomless Wallet Package would create the most thermally comfortable and efficient Friendly House. If a large amount of funding can be obtained, either quickly or accumulated in the long term, this would be the best option.

Appendix S: A La Carte Explanation

This menu of additional solutions is designed to work as add on improvements to the other larger packages. They are smaller, low impact but low cost improvements that can be used strategically for the betterment of the living conditions of the house.

Modifying the thermostats is a no cost solution that will increase the energy efficiency of the house. This includes strategically locating the thermostats to certain rooms to make sure the thermostats are not reading higher than they need to, and programming them to drop the temperature during the day when there are less people in the house or at night when residents are sleeping.

Blackout curtains and reflective blinds serve similar purposes, which are to reduce heat transfer caused by the sun through the window. The curtains also helps reduce air flow through any cracks in the window sills and will help with insulating the residents' windows. These would be best used on the street side of the house to limit the amount of sun exposure into the rooms and keep the overall temperature of the house lower in the summer.

The door grille and exhaust fan together will help with circulating air within the house. By opening a window on a lower floor and running the exhaust fan in the attic, air will be moved from the lower floors, up through the stairwells, and out of the attic. The door grille would be installed in the attic door to allow air flow up the stairs and into the attic, with a way to close the vent for the winter when you would ideally seal away any air flow to the attic.

House plants, particularly succulents and other low water consumption plants, will help to absorb moisture from the air and reduce general humidity in the house. It is difficult to quantify how much of an effect this might have, however it is very low cost and therefore low risk. Additionally, plants will improve the overall air quality of the house.

Appendix T: Potential Vendors

- Tolman Insulation
    - (508) 767-1140
- Garabedian Heating and Plumbing (Heat Pumps)
    - (508) 757-4803
- Home Depot (Windows, Doors, Miscellaneous)
    - (508) 852-6260 (Chad)
- Bright Planet Solar (Solar Panels)
    - (508) 498-4838
    - mishag@brightplanetsolar.com
- HVAC Direct (Exhaust Fan)
    - https://hvacdirect.com/canarm-ax24-2-24-inch-shutter-mounted-direct-drive-single-speed-exhaust-fan-ax24-2.html?gclid=Cj0KCQjw4fHkBRDcARIsACV58_H7iYJ-172_CNiIWkPxI7xh09c7RIfOcMpB1ABqG-KfUf1GpVqghQ4aAuKDEALw_wcB
- Door Grille (Amazon)
    - https://www.amazon.com/dp/B0753LR257/ref=sspa_dk_hqp_detail_aax_0?psc=1
- Walmart (Curtains, Blinds)
    - https://www.walmart.com/ip/Mainstays-Blackout-Energy-Efficient-Grommet-Single-Curtain-Panel/53753298 (Curtains)
    - https://www.walmart.com/ip/Mainstays-Cordless-1-Vinyl-Room-Darkening-Blinds-White-Multiple-Sizes/55505833 (Blinds)
- Succulents for sale
    - https://mountaincrestgardens.com/succulent-sets/?gclid=CjwKCAjwndvlBRANEiwABrR32KrRWuRAxo1_hgGHSoiPQLYeDeCrcohKGVBEVBkLY3RA7cucYO9tMRoCi-AQAvD_BwE

Appendix U: Quotes from Vendors

- Garabedian Heating and Plumbing (Heat Pumps)
    - $18,000 for 13 indoor units and 4 outside. Labor cost is not included
- Home Depot (Windows, Doors, Miscellaneous)
    - $600-$1,000 per window, same for doors
- Bright Planet Solar (Solar Panels)
    - From an email from Misha Glazomitsky (Employee at Bright Planet Solar):

"So here is what they would be looking at:

1. System Size and Annual Production - this one is tough as this is not the ideal site for solar, the roof is very cut up with a bunch of obstructions and shading but this is close - 11.2 KW system that would produce 11,728 kWh per year

2. System Cost - $35,168

3. Utility Bill Savings - $2,580 per year or average out to $215 per month, keep in mind that this will fluctuate month by month with the production of the system, so July will be closer to $300 per month vs December would be closer to $100 per month.

4. SMART Incentive - this would be cash that Friendly house would receive monthly from NGRID for 10 years as part of the SMART program - $1,161 per year or $96.75 per month and again is a production based incentive so closer to $150 in July and $50 in December."

- Tolman Insulation

Tolman Insulation And Home Improvements
76 Union St.
Barre, MA 01005
Phone:5082770120
Contact:Mathew Tolman
Email:tolmaninsulationco@gmail.com

Customer Address
Mike Montano
87 Elm St
Worcester, MA 01605
2036410019
mpmontano@wpi.edu

Quote #: 177
Date: Mar 25, 2019

Description	Total
Blow in cellulose Outside walls Drill threw Customer has stated the siding does not need to go back on due to building getting sided 6600 sqft	**$18,150.00**
Option 1 , attic floor Remove floor boards and replace Blow in 12" cellulose under attic floor = r-49 3440 sqft	**$11,180.00**
Option 2. Attic slants and walls and attic space Proper vent every other bay Insulate slants with finger glass r-30. 2398 sqft Insulate walls with fiber glass. R- 15. 872 sqft Net and blow attic space above with 12" of blow in cellulose. 920 sqft Vapor barrier over all fiberglass where needed	**$15,970.00**
Siding, demo Remove old siding 1 weeks labor	**$8,000.00**
New siding 88 sq All new vynil	**$46,500.00**

Items continued...

New vented soffit
New exterior trim around windows and door, rakes and fascias

Permit		**$1,200.00**
Dumpster Rubbish removal		**$2,000.00**
	Subtotal	**$103,000.00**
	Discount	**$5,150.00**
	Total	**$97,850.00**

Notes

There is a 5% discount added to this quote and will be applied if the contract and deposit are in hand before April 5th as incentive to move forward on the project. After April 5th the 5% discount will be removed . We look forward to working with you on this project and hope to hear from you soon. Thank you.
Mathew Tolman
Owner/ operator

Terms and Conditions

Scope of Work: Company will provide services as described in the attached quote. Company will provide all services, materials, labor, tools, and equipment needed for completion of services.

Payment Terms: A down payment of 50% is due upon acceptance of quote. The balance of the contract is due the day of project completion.

Change Order: Any deviation from the above quote involving a change in the scope of work or any additional costs will be executed only with a written change order signed and dated by both the Company and Customer.

Warranty: Company warrants all work will be performed in a good and workmanlike manner. Any warranties for parts or materials are subject to manufacturer terms on such products.

Conditions: This proposal is valid for 30 days. Company reserves the right to withdraw this proposal or re-quote the project if contract acceptance is beyond 30 days.

Name _____ Date _____

Appendix V: Funding

Below there is a list of possible funding options that Friendly House may look further into after they decide which recommendation to pursue. The possible funding options include grantmakers in the Worcester Massachusetts area. We recommend that a representative of Friendly House look more into the possible funding options within the Worcester Public Library. Our group was in contact with an employee named Jackie Dzugan. Jackie is the Business and Grants Research Librarian. Each month she holds a seminar to help facilitate non-profit organizations into applying for grants and researching possible grant options. You can set up appointments with her as well. The contact information for Jackie is below.

Telephone: 508-799-1701

Email: https://mywpl.org/staff-contacts

Mass Save

Telephone: 800-594-7277

Mass Save will be able to provide rebates and incentives to residential homes including Friendly House. The first step for Friendly House should be to contact Mass Save and have them come to 87 Elm Street. This should be done before deciding on any larger cost renovation due to the fact that Mass Save may be able to rebate certain renovations.

Lewis M. & Esther Perlstein Family Foundation (Independent Foundation)

EIN: 046351051

Telephone: 508-791-0901

Bridge Number: 2445835753

Melvin S. Cutler Charitable Foundation (Independent Foundation)

EIN: 042733957

Telephone: 508-791-0901

Bridge Number: 0180799418

Fred Harris Daniels Foundation

EIN: 046014333

Telephone: 302-7759-964

E-mail: info@danielsfoundation.org

Bridge Number: 6387875400

Fels Family Foundation

EIN: 200477156

Contact Information: N/A

Bridge Number: 7386466237

J. Irving & Jane L. England Charitable Trust

EIN: 046836265

Bridge Number: 7263157163

Telephone: 508-756-2423

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