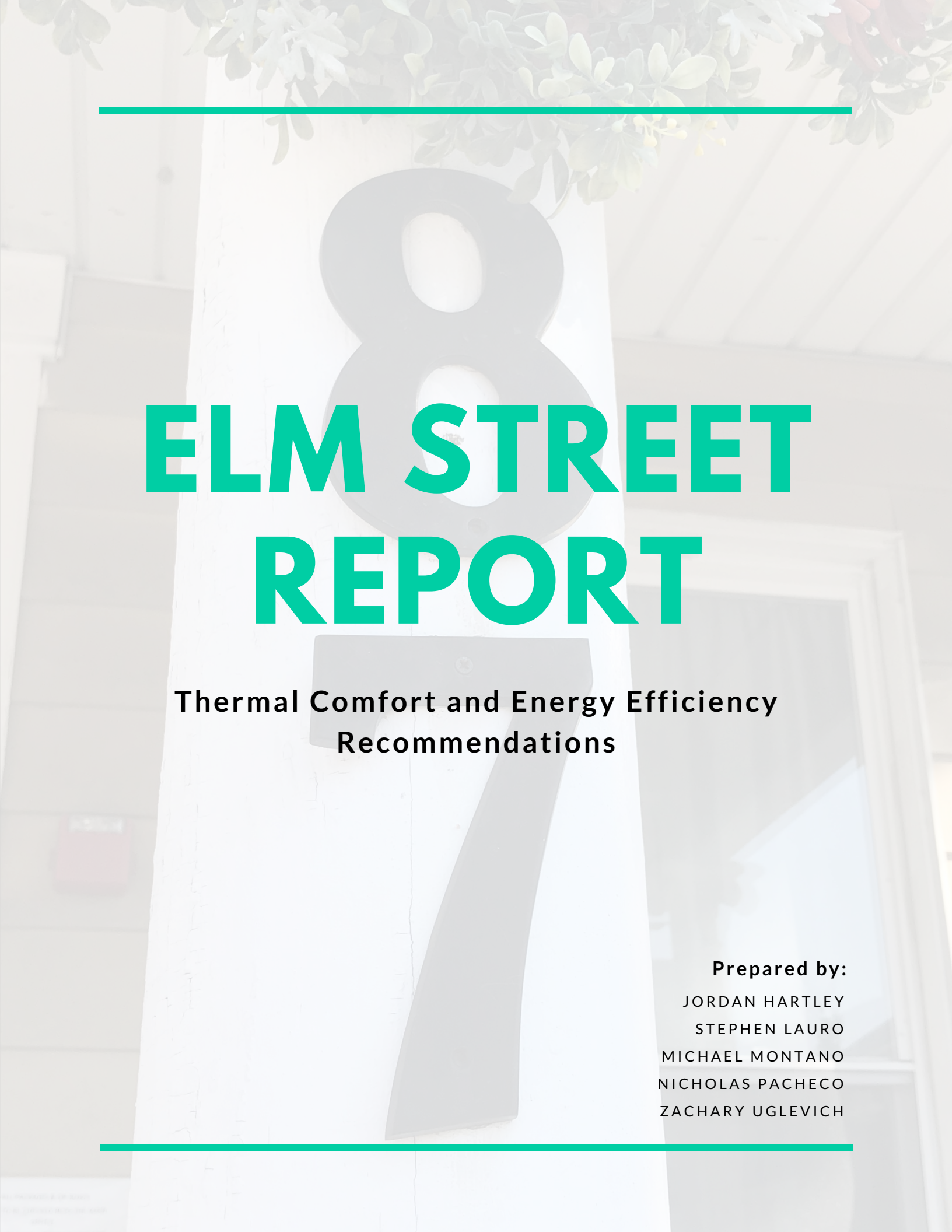

ELM STREET REPORT

Thermal Comfort and Energy Efficiency Recommendations

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"FOR THE EDUCATIONAL, SOCIAL, AND FAMILY BETTERMENT OF RESIDENTS OF THE CITY OF WORCESTER"

The most recent global survey found that 1.6 billion people lacked adequate housing (Homeless World Cup Foundation, 2019). According to the UN (2016), everyone should have access to a safe and comfortable living environment. While government programs attempt to provide this, they are insufficient in assisting the homeless. The onus then falls on non-profit organizations, like Friendly House. Friendly House provides housing and social services for the impoverished in Worcester and is looking to improve the conditions at their 87 Elm Street shelter. To assist Friendly House, our group provided recommendations that would improve the thermal comfort and energy efficiency of its property at 87 Elm Street.

* See Appendix B for more information

EVALUATION PROCESS

- Performed an energy assessment to determine areas of need
- Conducted focus groups with residents and employees to learn their concerns
- Contacted contractors and other professionals to get input on possible solutions

* See Appendix C for more information

CURRENT CONDITIONS

The Friendly House building at 87 Elm Street was originally built in 1909, making it over 100 years old. The house has eight bedrooms on the second floor, one on the first floor, and four in the basement. The house is occupied 24/7 by both residents and employees. Because of this, large and intrusive renovations would create problems.

The **temperature consistency** of the house is the main concern of the residents. The temperature varies in individual rooms throughout the day. Some of these rooms get hot enough that residents open windows in the winter while other residents are cold in their rooms.

The **thermostats** are also not being used effectively to regulate the temperature of the rooms when residents are out during the day or sleeping.

Implementing a cooling system for the hot summers is the primary interest of the employees. In the summers, the lack of a cooling system can also cause issues with residents with small children or respiratory illnesses.

The heating system has recently been redone, which is distributed throughout the house using baseboard. This means there is **no existing duct work** that could be used for ventilation or cooling.

Energy costs are very high in the winter, there is presently **no insulation in the house**, and there are a few windows that are in need of replacement. The attic is also uninsulated and is where a large portion of the energy losses are coming from, based on both our audit and building simulation.

* See Appendix F-I for more information

NOT RECOMMENDED BY OUR TEAM

- **Insulating the exterior walls**
  The house is not designed to have insulation in the walls. The walls need the open space inside to be able to dry in case moisture gets in, so if those spaces are packed with insulation the walls will develop a mold problem.

- **Insulating the attic roof**
  Similar to the walls, the roof was not designed to handle insulation, so insulation would simply change the problem from energy efficiency to mold. If the roof were redone, however, the attic roof could be insulated and the attic could still potentially be used as a livable space.

- **Renovating the attic**
  The full renovation of the attic is not within the scope of the project, so we did not pursue quotes for anything besides insulating either the roof or the floor. The expenses related to adding another exit, replacing the windows and redoing the floor have not been gathered.

- **Cooling with central air conditioning**
  Installing Central AC requires ductwork. After talking to an HVAC contractor, putting ductwork in the second floor may be feasible, but ductwork would be difficult to put in the basement and ground floor. Renovating the house to install ductwork may also bring more complications because of the age of the house.

THE FOLLOWING PACKAGES

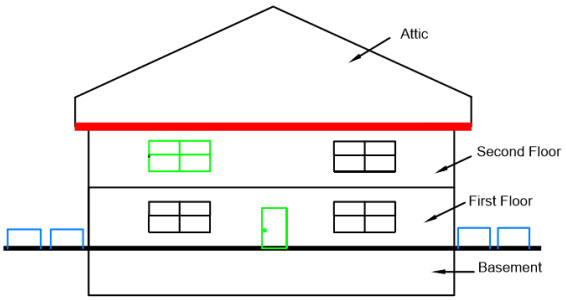
The following packages each have different sets of recommendations based on their relative thermal comfort improvements, energy efficiency improvements, cost, and the concerns of the residents and employees of the house. The cost for each package is estimated and other costs that we did not predict may be required. The final set of options are low cost options that can be combined with any of the other packages.

THE STATUS QUO

Comfort:

Cost:

Efficiency:



Total Cost $49,500

Renovations	Cost Per Unit	Units	Total
Insulate Attic Floor • *Attic floor insulation will reduce the heated area of the house, which will lower heating expenses* • It will also help keep heat out of the home in the summer	$11,180	1	$11,180
Heat Pumps in Every Room ** • *Cool individual rooms instead of the entire house.* • *Each room can also be set to different temperatures depending on comfort and needs of the residents*	$2,300	15	$34,500
Replace Critical Windows *** • *Three windows are either broken, or not sealed properly* • *Replacing all windows would be extremely expensive so we focus on only the critical windows*	$800	3	$2,400
Replace Critical Doors *** • *A door is not sealed properly, letting air escape* • *Replacing the door will keep heat in the home in the winter, and out in the summer*	$800	1	$800

* See Appendix O for more information

** Heat pump cost includes the cost for the units as well as an estimated labor cost

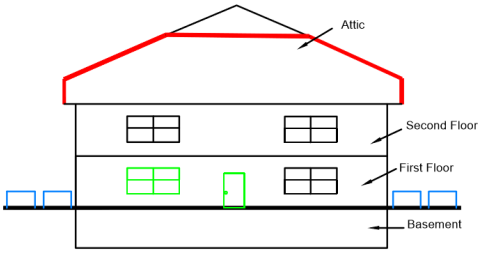
*** See appendix H for more information on which windows and doors are in bad shape

ATTIC EXPANSION

Comfort:

Cost: $ $ $

Efficiency:



Total Cost $53,670+

Renovations	Cost Per Unit	Units	Total
Insulate Attic Roof *** • *If an attic renovation is planned* • *Attic roof insulation will prevent heat from escaping from attic into the environment* • It will also help keep heat out of the home in the summer	$15,970	1	$15,970
Heat Pumps in Every Room ** • *Cool individual rooms instead of the entire house.* • *Each room can also be set to different temperatures depending on comfort and needs of the residents*	$2,300	15	$34,500
Replace Critical Windows **** • *Three windows are either broken, or not sealed properly* • *Replacing all windows would be extremely expensive so we focus on only the critical windows*	$800	3	$2,400
Replace Critical Doors ***** • *A door is not sealed properly, letting air escape* • *Replacing the door will keep heat in the home in the winter, and out in the summer*	$800	1	$800

* See Appendix P for more information

** Heat pump cost includes the cost for the units as well as an estimated labor cost

*** This will also incur additional costs to avoid moisture and mold problems: ventilating the attic, replacing the roof, and installing temporary insulation covers over the windows. Further costs to make the attic livable include creating another exit like a fire escape, replacing all windows and possibly replacing the floor.

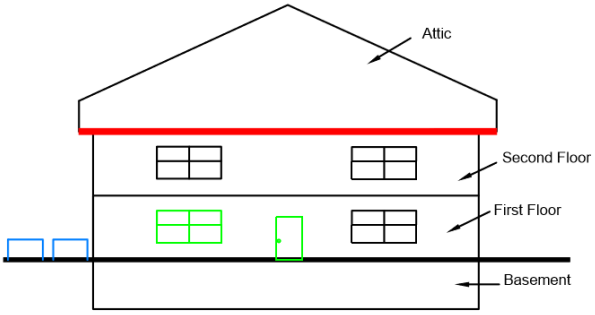
**** See appendix H for more information on which windows and doors are in bad shape

BUDGETED RENOVATIONS

Comfort:

Cost:

Efficiency:



Total Cost $28,180

Renovations	Cost Per Unit	Units	Total
Insulate Attic Floor • *Attic floor insulation will reduce the heated area of the house, which will lower heating expenses* • *It will also help keep heat out of the home in the summer*	$11,180	1	$11,180
Heat Pumps on Sun Facing Side and Basement ** • *Strategically placing the heat pumps will keep the hotter bedrooms and the basement cooler and more comfortable* • *Residents with small children or respiratory issues should be prioritized to receive these rooms*	$2,300	6	$13,800
Replace Critical Windows *** • *Three windows are either broken or not sealed properly* • *Replacing all windows would be extremely expensive so we focus on only the critical windows*	$800	3	$2,400
Replace Critical Doors *** • *A door is not sealed properly, letting air escape* • *Replacing the door will keep heat in the home in the winter and out in the summer*	$800	1	$800

* See Appendix Q for more information

** Heat pump cost includes the cost for the units as well as an estimated labor cost

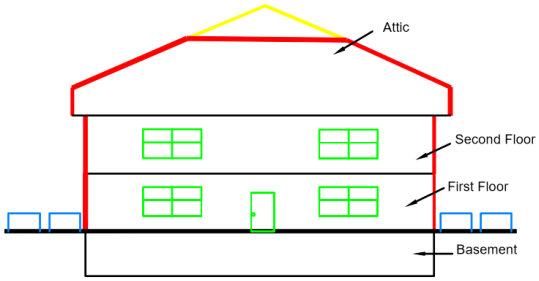
*** See appendix H for more information on which windows and doors are in bad shape

BOTTOMLESS WALLET

Comfort:

Cost: $ $ $ $ $

Efficiency:



Total Cost $146,820+

Renovations	Cost Per Unit	Units	Total
Insulate Attic Roof **** • *Allows for the option of renovating the attic still* • Prevents heat from rising up and out of the house	$15,970	1	$15,970
Insulate Exterior Building walls *** • *Insulates the buildings envelope keeping heat out in the summers and in the winters*	$18,150	1	$18,150
Solar Panels • *Will greatly decrease energy costs and help with rebates from National Grid*	$35,000	1	$35,000
Heat Pumps in Every Room ** • *Cool individual rooms instead of the entire house* • *Each room can also be set to different temperatures depending on comfort and needs of the residents*	$2,300	15	$34,500
Replace All Windows • *Three windows are either broken, or not sealed properly* • *Replacing all windows would improve the insulation of the house and improve the heat retention of all windows*	$800	52	$41,600
Replace Necessary Doors • *The two doors are not sealed completely* • *Replacing the doors will keep heat in the home in the winter, and out in the summer*	$800	2	$1,600

* See Appendix R for more information

** Heat pump cost includes the cost for the units as well as an estimated labor cost

*** Need to make sure the exterior walls are properly vented before installing insulation. Without proper venting or a moisture shield, a moisture/mold problem can happen because the insulation will absorb the moisture

**** This will also incur additional costs to avoid moisture and mold problems: ventilating the attic, replacing the roof, and installing temporary insulation covers over the windows. Further costs to make the attic livable include creating another exit like a fire escape, replacing all windows and possibly replacing the floor.

A LA CARTE

This set of options is a set of low-cost, simple solutions that can be incorporated into any other solution. These solutions are both comfort and energy efficiency improvements.

Modify Thermostats

- Program thermostats to reduce temperature when house is inactive
- Modify thermostat zones to maximize efficiency

Cost per Unit: $0

Blackout Curtains

- Insulate windows and minimize radiant heat in summer

Cost per Unit: $11.00

Reflective Blinds

- Reflects sunlight let in through windows to help reduce the room temperature

Cost per Unit: $22.50

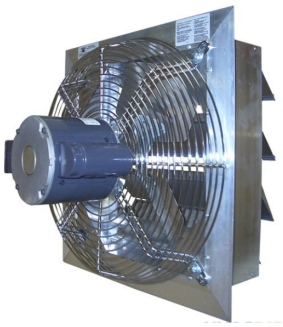
Door Grille

- Buy in conjunction with exhaust fan for ventilation.
- To be attached to attic door to allow for ventilation of hot air in the summer

Cost per Unit: $80.00

Exhaust Fan

- Vents air from the lower floors, up through the stairwell, into the attic, and out of the home



Cost per Unit: $500.00

House Plants

- Can be used to help lower humidity and improve air quality

Cost per Unit: $30.00

* See Appendix S for more information

NEXT STEPS

Our final recommendation is to implement the status quo package. We also recommend the door grille, exhaust fan, and blackout curtains from the A La Carte section. The following is a list of steps we believe Friendly House should follow to implement these solutions.

1. Energy audit through Mass Save to verify the group's work and talk about rebates and funding (see Appendix V).

2. Apply for grants and look into other funding sources as shown in Appendix V.

3. Start by implementing lower cost solutions from the A La Carte menu.

- Getting the exhaust fan and door grille combination will help keep air circulating the house in the summer, especially when residents are cooking in the house later in the day
- Getting blackout curtains especially on the sun facing side of the building will help keep the heat from the sun out of the house

4. Insulation installed in the floorboards of the attic.

- Keep the temperature more consistent in the house.
- Reduce the energy bills of the house

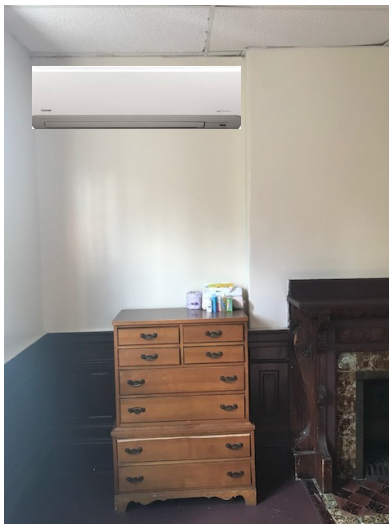
5. Install the mini-split heat pumps in the 13 bedrooms, office, and playroom

- Improve thermal comfort
- Humidity reduction
- More control over room to room temperature

6. Replace the three critical windows and one door as shown in Appendix H.

- Replacing the windows that are cracked and not closing properly
- Making sure all other windows are closed on top and bottom

Adding in an exhaust fan and door grille to the attic



Adding heat pumps in the residents room

Spray foam insulation in the attic floor boards

WPI

Worcester Community Project Center

Friendly House, Inc.

Neighborhood Center