Analyzing Energy Losses in the Pingen Household Using Thermal Images

EGR 250

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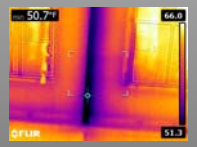
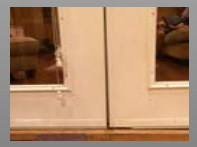
Objective

The purpose of this project was to analyze the thermal energy loss in a standard home. We used a thermal imaging camera to identify problem areas where the largest energy losses were apparent. By using the concepts and equations associated with heat transfer, we were able to quantify the problem areas, calculate the money lost through these problem spots, and predict the savings associated with our suggestions for improvement.





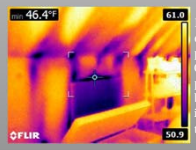
Above is an example of how the FLIR camera works. The crack in the middle of the doors is much colder than the other parts of the door, shown by the deep purple color. This alerts us to a potential issue. Because there is such a great temperature difference, we can assume that heat from the house is escaping through this area. Our goal in this project was to take areas like this and present possible solutions in order to save energy and money.

Principles of Heat Transfer

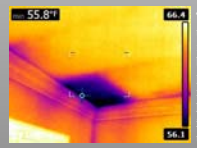
Mechanisms of Heat Transfer

- Conduction: Conduction occurs through a material due to the contact between adjacent energetic particles
- Radiation: Radiation occurs through the emission of electromagnetic waves
- Convection: Convection is the transfer of thermal energy via fluid flow; it is the combination of mass flow and conduction

Problem Areas

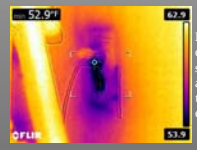


Here is the attic entrance in the playroom. Currently, it is a piece of particle board with no insulation on the back.



This is a picture taken in the master bedroom. The problem is resulting from a lack of insulation. in the attic above.

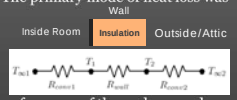
Windows are a large source of heat loss. Double-pane windows reduce these losses.



Non-insulated electrical sockets also allow some heat to be lost to the environment.

Analysis

The thermal images showed temperature differences which the group compared, identifying the ten most drastically different spots. Four of these areas posed the largest problems for energy loss in the house and occurred in various places, mostly in the floor of the attic. We hypothesized that lack of insulation, caused the majority of these temperature differences. The primary mode of heat loss was conduction through the walls. However, considering the thermal conduction network shown in the figure, the heat loss Q through the wall is equivalent to the convection between the inside air and the wall. We determined the approximate surface area of these places and performed a numerical analysis on them by utilizing the equation for convection heat transfer:



$$Q = hA(T_{surface} - T_{air,out}) \quad (W)$$

In order to analyze such a wide variety of situations, we had to make a few assumptions. Since the coefficient of convective heat transfer, h, varies with air velocity, we had to choose an approximate value. We learned from the book *Fundamentals of Thermal-Fluid Sciences* that the value of h for air can vary from 2 to 25. Also, we found a formula on *engineeringtoolbox.com* ,which led to a value of h=10.45 for air with zero velocity. Thus, we decided to calculate the energy loss for each area using h=2, 10.45, and 25, giving us a lower, middle, and upper limit. This allowed us to better approximate the overall energy loss and possible savings from eliminating the problem areas.

Using the energy values we calculated and the Jackson Energy Authority kilowatt-hour cost, we determined the approximate amount of energy lost per year. Next, we calculated the money lost yearly due to these problem spots. Finally, we offered solutions to these problems and estimated the return on investment for our solutions.

Energy and Money Losses for Varying h Values

h=2					
Location	Area of Space (m^2)	Q_loss (Good) (W)	Q_loss (Bad) (W)	Energy Lost	Money Lost Per Year
Playroom	0.724	7.24	15.363	8.123	$3.89
J&J's Room	0.1703	0.6812	2.687	2.0058	$0.96
Master Bed	0.14258	0.776	3.057	2.281	$1.09
Master Bath	0.1316	0.453	2.164	1.711	$0.82
				Total:	$6.77

h=10.45					
Location	Area of Space (m^2)	Q_loss (Good) (W)	Q_loss (Bad) (W)	Energy Lost	Money Lost Per Year
Playroom	0.724	37.83	80.27	42.44	$20.34
J&J's Room	0.1703	3.56	14.04	10.48	$5.02
Master Bed	0.14258	4.053	15.972	11.919	$5.71
Master Bath	0.1316	2.365	11.304	8.939	$4.28
				Total:	$35.35

h=25					
Location	Area of Space (m^2)	Q_loss (Good) (W)	Q_loss (Bad) (W)	Energy Lost	Money Lost Per Year
Playroom	0.724	90.5	192.041	101.541	$48.65
J&J's Room	0.1703	8.515	33.592	25.077	$12.02
Master Bed	0.14258	9.695	38.211	28.516	$13.66
Master Bath	0.1316	5.659	27.044	21.385	$10.25
				Total:	$84.58

List of Improvements

Attic:

Owens Corning EcoTouch 9-1/2 in. x 15 in. x 25 ft. R-30 Unfaced Continuous Roll Fiberglas Insulation (Home Depot)

$17.79 / each

Windows and Doors:

OSI 10 fl.-oz. CLEAR No.000 QUAD Advanced Formula Window Door and Siding Sealant

$5.55 / each

Doors:

Frost King E/O 1-1/4 in. x 10 ft. Black High Density Rubber Foam Weather Stripping Tape

$7.67 / each

Savings and Return on Investment

	h= 2	h=10.45	h=25
Total Savings per year:	$6.77	$35.35	$84.58
Return on Investment:	2.5 Years	6 months	2.5 months

Conclusion

After analyzing the Pingen's house, we determined that insulating the four major problem spots would save an average of $35.35 per year. The return on investment for this amount is approximately six months. Additionally, weather stripping can be added to the doors, and weather sealant to cracks around the window sills . This will further improve the energy efficiency of the home. These areas are difficult to quantify and thus, have been left out of our analysis.

The four spots we analyzed only represented a small fraction of the total energy losses of the home. In order to more accurately analyze the energy losses of the home, a more thorough study must be conducted.

Special Thanks To:

Dr. Pingen and family

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