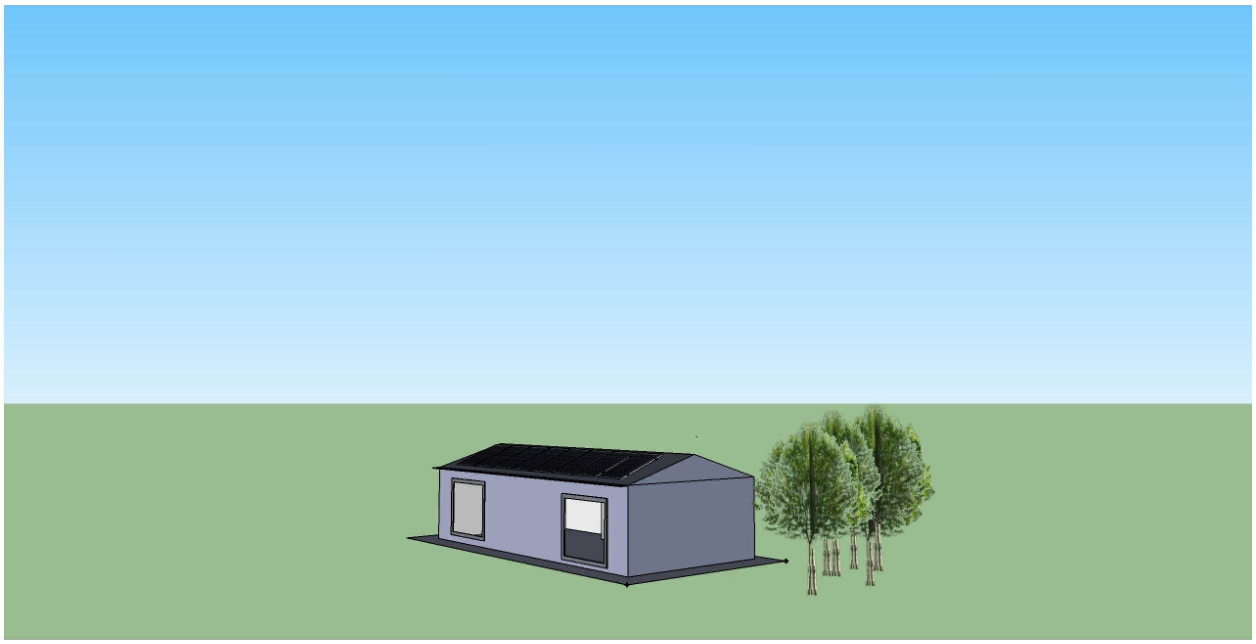
Zero Energy Home Project Report



Engineering Design 100

Section 14

Written by International Engineers

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Abstract: -

Zero Energy Homes are very crucial because they produce energy that is beneficial for the environment and cost effective for the owners of the house. These types of homes generate equivalent amounts of input and output energy leading to a self-sustaining house with zero net energy. For this project, we were asked to utilize and apply the engineering design processes we learned in class in order to build a zero energy home that meats a certain customer needs analysis. Working in teams of three, we each researched and familiarized ourselves with the topic of Zero Energy Homes (ZEH). We used the information we acquired by doing some research to design, within a 5 week period, a ZEH model that exploits several passive solar design strategies for facilitating the most heat retention with the slightest possible heat loss.

Introduction: -

Self-sustaining energy is the key to building a better future. One of the biggest problems towering over and gripping our nation today is the profuse and heavy consumption of resources that are not only ridiculously expensive but also extremely harmful to the environment. To prevent the inevitable demise of our planet, many concerned individuals have adopted eco-friendly polices integrating them into their everyday lives. Although such activities as recycling paper, growing organic food, and minimizing use of water and electricity have over the years proved to be beneficial, none have provided a significant solution to this modern day problem the way Zero Energy Homes have. Unlike typical households that consume vigorous amount of energy, Zero Energy Homes (ZEH) produce the same amount of energy they consume resulting in zero net energy consumption. By capitalizing on the use of natural eco-friendly resources and passive solar techniques, Zero Energy Homes can provide the most comfortable, satisfying lifestyle with the least expenses and damage to the environment.

Clearly Defined Problem: -

The task given for this assignment is to construct an aesthetically pleasing Zero Energy Home model for a family of four that can absorb and retain the most heat with the smallest possible electrical appliance use as well as minimal heat loss. To build such a model, we utilized online resources and looked up passive solar heating strategies, and proceeded with that knowledge to construct several prototype designs, and eventually picking the one that we believed could best achieve our desired goal.

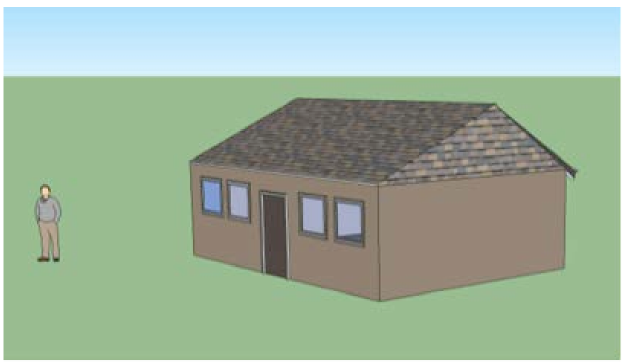
Materials: -

The materials we used for building the model were as follows

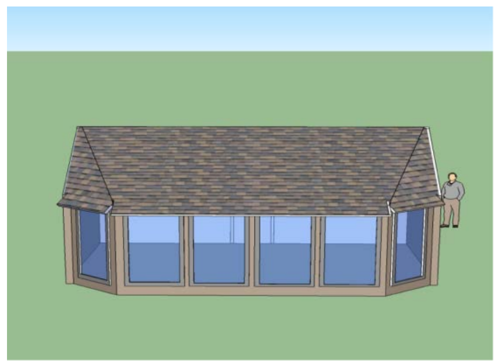
- Duct tape
- 1 "30cm" Ruler
- 1 Styrofoam poster
- Utility knife (cutter)
- Aluminum foil
- Rubber sheet (to act as absorber)

Models Designed: -

***Sketch up initial designs**



House 1

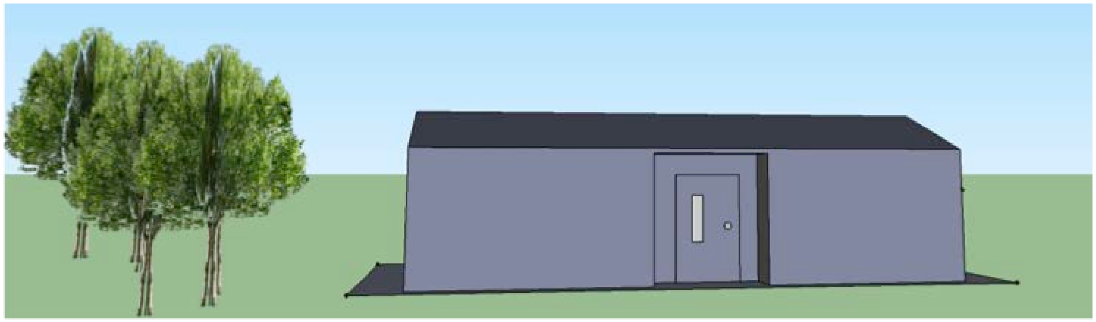


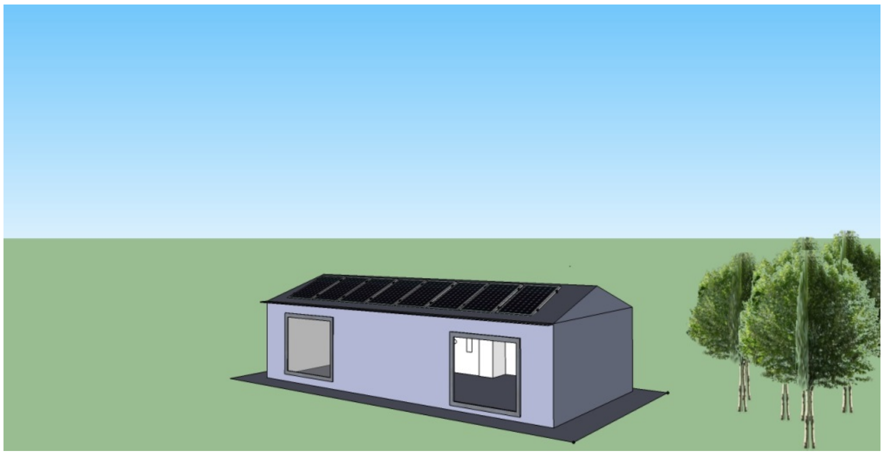
House 1

House 2

***Final sketch up design**

- Relying on our concept selection results and online resources, we were able to enhance the design for house 3 and created a final design based on that model. The final design capitalizes on Solar panels and windows for passive solar heating.





Concept Generation: -

House 1 was a home with north side facing windows and area for solar panels. The home also had a design for aluminum insulation within the home and a rubber floor to act as an absorber of the passive heat. House 2 was similar in its design of insulation and flooring but varied in shape and window placement. The home has a south-facing wall that had three sides that was designed to allow maximum sun exposure during all months of the year; the home would also be more aerodynamic with a more curved wall compared to a simple box structure. The south-facing wall was also filled with window space for passive heating, and allowed area on the roof for solar panels. The third house was a combination of the first and second home. The south facing wall was had large windows that would allow a large amount of sunlight into the home. The roof was designed with area for solar panels and optimal sun exposure. The homes shape was a simple box. The insulation and flooring remained the same.

Concept Selection: -

		House 1		**House 2**		**House 3**	
Criteria	Weight	Rating	Weighted Score (WS)	Rating	WS	Rating	WS
Passive Solar	30%	1	0.3	3	0.9	2	0.6
Active Solar	40%	1	0.4	3	1.2	3	1.2
Energy Saving	20%	3	0.6	1	0.2	4	0.8
Appearance	10%	3	0.3	2	0.2	2	0.2
Total:	**100%**		**1.6**		**2.5**		**2.8**

The final concept, house 3, scored the highest on the concept selection matrix. This home applied characteristics of the first two homes to create a design that would be ideal for the experiment. House 3 saved a large amount of energy compared to the other homes through the use of passive and active solar technologies. This home was also able to have better insulation than house 2 which aided in its energy savings. With research through the ZEH research assignment, many houses warned of having too many windows that would allow for less insulation. This was a major factor in choosing house 3. Because house 2 had a large amount of windows, the risk of losing heat in the experiment existed. With a goal being a positive net change in the temperature of the home, house 3 became the best design.

Design/ Energy Analysis: -

The home has an open floor plan to allow for the heat to move throughout the home and to provide ventilation. The south-facing wall is lined with windows, and the south of the house is also very open so a large amount of passive solar heat can be gained. To avoid the home from being too warm in the summer, the south-facing roof provides an overhang so that the home will not become overheated due to excess sun exposure through passive heating. The entire south-facing roof was left free for the placement of the solar panels for the home.

The homes sustainability could be increased through the addition of a vegetable garden to produce food, as well as a large amount of trees to provide protection from wind. Through ZEH research, some homes collected rainwater in barrels to be used to water the garden. This feature would provide a water source that would be no cost.

When building a zero energy home, appliances like a washer are very essential. While size and appearance may be viable in narrowing down results to find the perfect choice, both initial and operating costs are seem to be high in importance. A less expensive model might be the optimal solution, however, sometimes selecting a less expensive one with a short payback time is not the best economic investment. With research through the washer assignment we chose energy efficient Kenmore 417.4110. This washer was a bit more expensive than the LG model, causing a longer payback time, the quality is high. The payback was shorter for the Kenmore than for the whirlpool.

Other appliances were investigated and researched in the same manor. The type of oven for cooking food showed large concern between choosing an electric stove or an induction stove. Although more expensive initially, the induction stove proved a wiser purchase because of the little cost of operation and long usage time. The induction stove cooks much faster allowing for less energy needed to cook the food and thus an even lower energy cost to operate.

Another wise appliance would be energy efficient showerheads. These energy efficient heads use less water and save in both water pump costs and the cost to heat water that is used in a shower. Ultimately, they lead to less water usage in a shower that is the same length of time. Lastly, energy efficient dishwashers were researched. Many different energy efficient dishwashers are on the market, yet a great option is the dishwashers that use booster heaters. These save the amount of water needed to clean the same amount of dishes. They can be more expensive to purchase initially but pay for themselves in energy savings in less than one year. The use of energy efficient appliances greatly reduces the amount of energy needed in the home and allows for it to be zero energy.

Some of the appliances include in our home are induction oven, stove, refrigerator/freezer, microwave, television, cable/DVR, living room/kitchen/bathroom/bedroom lights, washing machine, and more. The energy cost for such appliances was calculated through an online energy calculation. That value was then used to determine the array size of the PV system needed to make the home zero energy. This is the formula used to calculate the amount of solar panels our home needed.

Calculations

Array Size (kW) = (annual kWh usage)/ (365 days/year)/ (solar hours/day)/ (0.75 derate factor)

8.50 kW = (9096 kWh) / (365 days/year) / (3.91 /day) / (0.75 derate factor)

It takes 4-5 solar panels per 1kW, our home would then need about 35 solar panels in order to provide enough electricity.

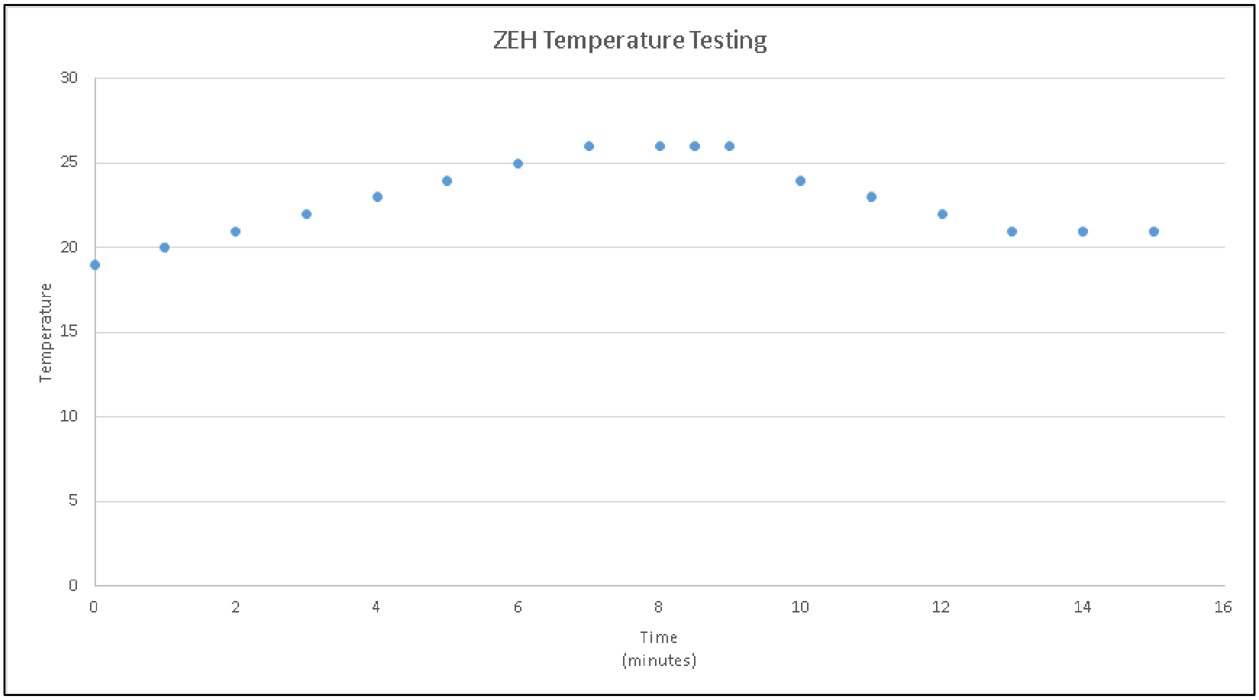
Temperature Test Results: -

The procedure used to test the efficiency of our model was as follows:

- From 0-8 minutes the house was exposed to the lamp
- From 8.5- 15 the house was placed in front of a fan with ice simulating the night time
- Data was recorded throughout the entire process

Time (day)	Temperature
0	19
1	20
2	21
3	22
4	23
5	24
6	25
7	26

8	26
8.5	26
9	26
10	24
11	23
12	22
13	21
14	21
15	21

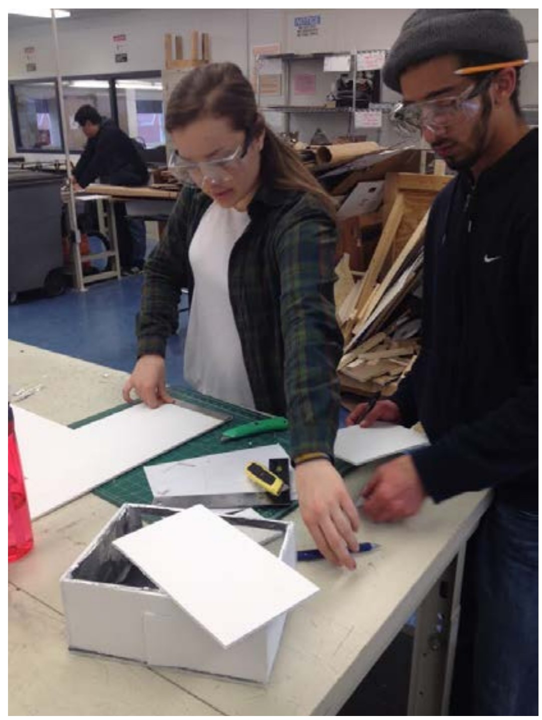


The temperature of the house was tested with a probe. The south side of the house was exposed to a light bulb for eight minutes simulating how the sun would be absorbed to warm the house. The house was then removed and exposed to a fan with a bucket of ice in front of it for the remaining time. The fan simulated the wind throughout the night. The temperature was monitored and then recorded.

Our house gained the most energy of any of the homes. Although our house did not retain the most heat, it still kept a higher temperature than the initial starting temperature, which all the other houses did as well. Our house had a large black material on the south-facing roof, along with large windows to let in light. This was very beneficial in allowing the heat to be absorbed into the rubber that was in the floor. The only downfall that our home had was that perhaps it was not as well insulated as other groups' homes. One team had applied a large amount of tape around their home that provided a lot of insulation. The window space on our home was very well thought out. Some teams had more windows than we did which allowed for heat to be absorbed but it also caused a lot of loss with the wind.

<u>Pictures: -</u>

**The following pictures depict the actual building of the ZEH model after the final sketch up design was constructed. We would like to thank the Hammond faculty for allowing us to use the room.*



Conclusion: -

All in all, the ZEH design our team built was a tremendous success. We were told that our model did in fact win the competition, as our design was able to retain heat the best. Regardless of this accomplishment, we still benefited from the contributions of the models and presentations made by the other groups in this class. We learned from other groups' models a significant amount of knowledge about building a ZEH. Furthermore, although our model did pretty well during the testing process, there were some features that could have been added to improve its performance during the test. It is undeniable that we learned how to improve the quality of maintaining heat from the other models. Having big windows without well-insulated walls was the main cause of losing some of the heat in our model. Actually, we learned that in order to retain an even higher amount of heat, we should have the walls very insulated, so that they do not emit the heat easily. The best model in retaining heat while doing the experiment was the model that had thick, insulated walls. Considering we had the best model; our house must've been the closest to having the best interior insulation. Indeed, if we had the chance to improve our model, we would definitely enhance the quality of the insulation in our house by trying to use a variety of materials for insulation so that we would make the walls retain heat easier and minimize heat emission and loss.

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