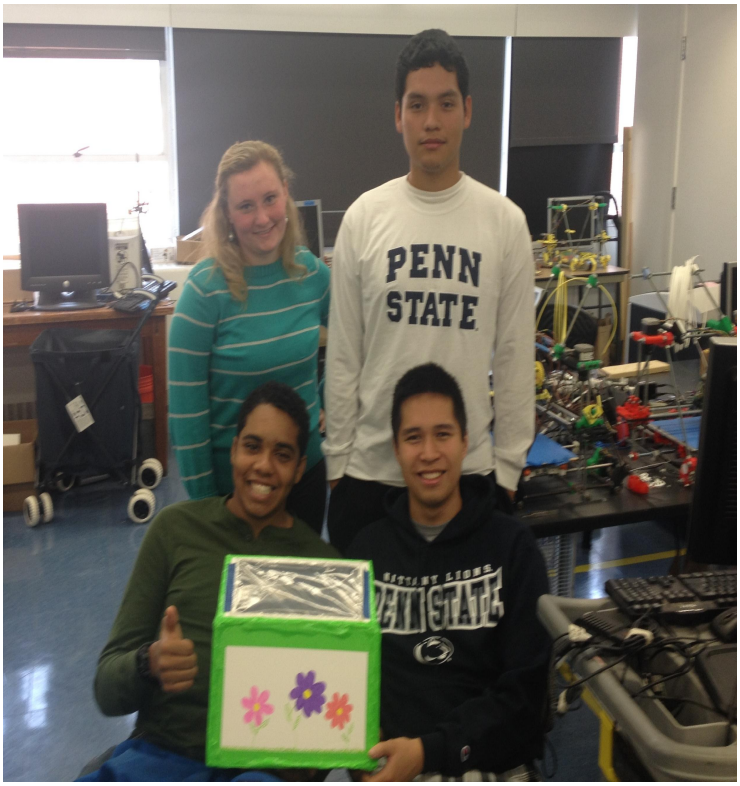
Zero Energy Home Project I

EDSGN 100: Section 014

Team #8: Bob the Builders

Professor: Dr. Smita Bharti

Friday, October 25, 2013



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Abstract

Zero Energy Homes are the homes of the future. A zero energy home is a house that uses natural renewable resources and is built on green building principles. Using what we learned in class, we created a scale model, a three-dimensional computer model, and a floor layout for our zero energy home design. As a group we used the Eight-Step Engineering process to design our home efficiently and effectively. Overall we wanted to design a house that stays away from using fossil fuels and that it is environmental friendly.

Introduction

Our team, Bob the Builders, consisted of four people were able to produce our final product of zero energy home. The important skill we learned in class that helped us achieve our goal was the engineering design process. We identified the problem, we researched ideas and concepts for our zero energy home, and we were able to create a model through the design process. We agree that our zero energy home meets the requirements of what a zero energy home should be and that it suits the needs for a family of four.

Problem

The design challenge for this project was to design and build a Zero Energy Home using passive solar heating to maintain a comfortable living temperature. Following the design constraints given, the house was to suit a family of four in the local areas of Pennsylvania. The model would then be tested on its ability to

maintain heat by placing it under a lamp for eight minutes and then in front of a fan for seven minutes. The lamp would represent the sunlight during the day, while the fan would represent the wind chill during the night.

Research

The question is what is a zero energy home? As a group we researched about zero energy homes and this is what we found.

Zero Energy Home:

- A home that produces same amount of energy as it uses.
- It uses natural resources such as solar, wind, geothermal, and hydro to power the home
- Passive solar is incorporated into the design of the home
- Efficient appliances are selected
- Effective heating and cooling a home

After we knew a general idea of what a zero energy home is we started to brainstorm ideas of what our zero energy home. We researched features and concepts that we want to incorporate in our design of a zero energy home.

Solar Panels

- produces electricity from collecting sunlight
- can be placed on roofs facing south to maximize capture of sunlight
- production of electricity can be used immediately, stored, or sent to a grid

Passive Solar Heating

- solar thermal gain from sunlight entering the structures windows
- no need of nonrenewable resources to heat up a home
- can control the amount of solar thermal gain by installing retractable window shades

Insulation

- Higher R-value of insulation provides a tight-seal home
    - lowers the amount of heat escaping through walls which allows the home to keep warm for a longer period of time
- spray foam is the ideal insulation choice for a zero energy home
    - superior air-sealing properties, fills around pipes and wires in walls

Recycling/Reusing water

- installing recycling system will reduce the usage of municipal water
- gray water from showers, sinks, or washers can be reused to irrigate a garden or for flushing toilets
- these systems filter and disinfect gray water so that it can be reused

Advantages of a One-story vs Two-story home

- Easier and cheaper to heat and cool a one-story home
    - circulation of hot or cool air is more fluid between all the rooms
- Safer in some ways
    - evacuation of family members is quicker in case of fire
    - no risk of falling down stairs

- There is little to no wasted space
    - one-story houses uses all the available space for living areas

Concept Generation

As a group we had to narrow down the criteria of our project. We pulled together all of the possible options for the shape, size, main energy source, appliances and the appeal of our zero energy home. Together we narrowed down the list until we unanimously agreed upon on of the standards and the conditions that our home we have to uphold. On the rubric, we were told that the house was supposed to retain heat during the icy wind coming from a fan in order to receive a higher mark. That being the case, we collectively decided to make the structure of the home a normal rectangle and about 1500 sq/feet just as any family of four home would. This being a zero energy project located in the Pennsylvania, it was only sensible that we pick solar panels as our main source of energy besides the passive heating from the sun. In order to keep the streak of doing things environmentally friendly, we decided to choose “Energy Star” as our primary choice of appliances. As for the appeal of our home, we went with the 1 story house because this will be able to keep the warmth from the sun inside the house as long as possible to combat those dreadful winters here in Pennsylvania.

Concept Selection

Shape	Size	Enegry Source	Appliances	Appeal
Square	1000 sq/feet	Solar Panels	Energy Star	1 Story
Rectangle	1500 sq/feet	Wind Turbines	Basic	2 Stories
Circle	2000 sq/feet	Geothermal		
Parallelogram	2000+ sq/feet	Hydroelectric		

We chose the shape to be a rectangle because we thought that it would be the easiest and cheapest to build with. The rectangle was chosen over the square because we wanted to reduce the amount of surface area that was exposed to the wind. The circle would be good at diverting the wind, however, it would be too hard to build and would leave more gaps where the cold air could potentially seep in. the parallelogram is very similar to the rectangle, aside from the fact that it can also divert wind like the circle. In the end, we decided that the difference between the parallelogram were very insignificant and the rectangle shape was just much easier to build.

Over our research, we have compared many houses and in the end, we concluded that 2000 square feet is about the best for heat conservation as overall efficiency.

The Solar Panels were chosen because the others were very improbably in our case. Solar Panels are able to produce energy by only taking up a portion of the roof. The wind turbines would require larger fields and many of them in order for this method to be effective. Geothermal is not very possible because there

aren't any volcanos in the Pennsylvania area that we can harness the energy from. Hydroelectric energy would constrain us to only near the water. We decided to use Solar Panels because they are the the most versatile and efficient.

The Energy Star appliances were chosen so that we could reduce the amount of electricity that we would use in order so that we hopefully achieve our goal of having a "zero energy" home.

The one story building would result in better temperature control and circulation because of the open space up top, as well as needing to only heat up one story rather than two. What tends to happen with two story houses is that the second story would become much hotter than the first due to heat rising. With a one story house, the unwanted heat will not be a factor.

Design and Energy Analysis

A very important aspect of the overall design of our house is to not only efficiently maintain heat, but to also make sure we use energy efficient appliances in order to reduce the amount of energy that we use.

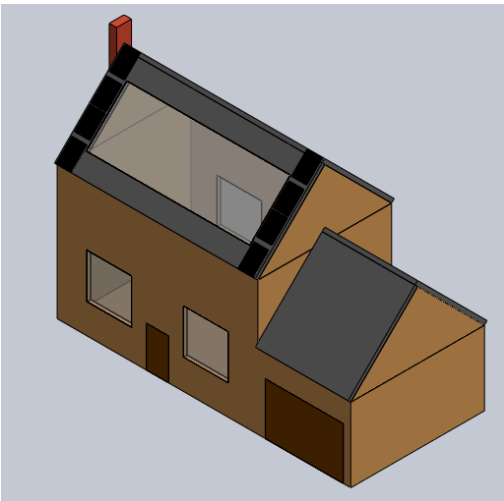
For lighting, we plan to use LED lights, they will use approximately 6-8 Watts (Fluorescent lights use about 13-15 Watts). They also last an average of 50,000 hours as opposed to 8,000 hours of the fluorescent light bulbs.

We also decided to use a low-flow shower head in order to conserve the amount of water that we use. Normal shower heads will use about 2.5 gallons per minute, however, low-flow shower heads will typically use below 2.0 gallons per minute. If the average amount of shower time is about 10 minutes each day, every

day, then savings could be about 1825 gallons ($7.30 if the average cost of water is $4/kgal.

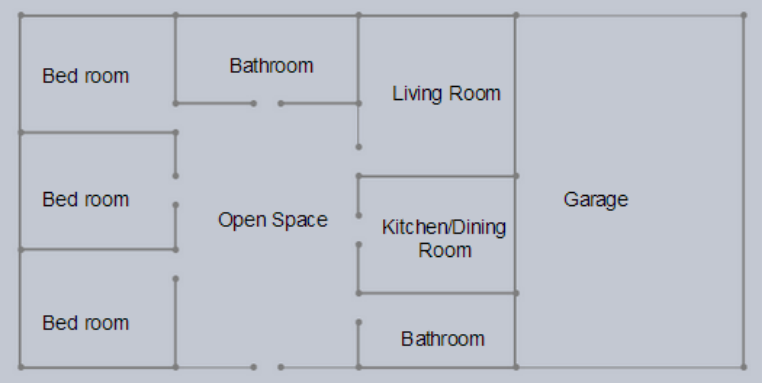
For our appliances, we chose only those with a 'Energy Star' approved sticker on them. Energy Star is a program backed by the Environmental Protection Agency. They help select appliances that have low energy which results in less annual costs as well helping protect the environment.

3D Model



Solidworks model

Scaled/Real Life Model



In Depth Model Description

During our Concept Selection phase, we chose to build our house in a rectangular shape with about 2000 square feet of space, as well as only having a one story building. The rectangular shape would be cheap and easy to build, as well as have an even temperature distribution. We researched some houses and found that the most energy efficient houses were roughly around 2000 square feet. The open space in the middle will help with circulating the heat around the whole house. The garage is meant to block the wind coming in on the east side so that the main part of the body would not become as cold. We also included a wood fire-place in order to provide even more heating.

The dimensions of the actual house would be about 36x54 feet, however, the scale model is about 8x12 inches. The house contains three bedrooms, two bathrooms, a kitchen/dining room, a living room, and a garage.

The house contains one large window for passive heating. This is another advantage of the one story house, the sun can shine directly into the whole house and not just the top floor. There will also be solar panels laid out around the whole window in order to gather energy to use on the appliances.

On the scaled model, we had the outside walls be the foam core board, we then layered rubber over that, and then aluminum foil to reflect the sunlight and keep it in the house. The Floor contained the foam core board and black fabric in order to absorb heat.

Conclusion

Bob the Builders worked together for the first half of the semester planning, researching, and designing our Zero Energy Home. Given our goal, we worked many hours outside of class to produce our energy efficient model. As a group we decided to not only focus on the goal itself, but what we would want our own energy efficient house to look like. All in all, we were successful in the building of our model and the testing of the heat maintained. We look forward to working together in the upcoming Engineering Design projects.

Works Cited

"Compare: LED Lights vs CFL vs Incandescent Lighting Chart." *Compare: LED Lights vs CFL vs Incandescent Lighting Chart*. N.p., n.d. Web. 24 Oct. 2013. <http://www.designrecycleinc.com/led comp chart.html>.

"EPA WaterSense | Water Efficient Showerheads | Low Flow Showerheads." *EPA*. Environmental Protection Agency, n.d. Web. 24 Oct. 2013. <http://www.epa.gov/WaterSense/products/showerheads.html>.

"Green Home | Green Architect | Modern Home Design | Modern Architect | Zero Energy Homes." *Green Home | Green Architect | Modern Home Design | Modern Architect | Zero Energy Homes*. N.p., n.d. Web. 24 Oct. 2013. <http://www.zeroenergy.com/index.html>.

"Have You Made the Switch?" *Home : ENERGY STAR*. N.p., n.d. Web. 24 Oct. 2013.

<http://www.energystar.gov/>.

"More Home Blog Building Quality and Value On Your Lot." *The Advantages of a One-Story Home over a Two-Story Home*. N.p., n.d. Web. 24 Oct. 2013. <http://www.palmharbor.com/morehome/the-advantages-of-a-one-story-home-over-a-two-story-home/>.

"Residential System | Water Recycling Systems." *Water Recycling Systems*. N.p., n.d. Web. 25 Oct. 2013. <http://reusegraywater.com/residential-system/>.

"Zero Energy Home." *Zero Energy Home*. N.p., n.d. Web. 24 Oct. 2013. <http://www.energy4you.net/zerohome.htm>.