Zero Energy Home

EDSGN 100
Section 4
Team 2
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Zero Energy Lions

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Executive Summary

The world has a need for zero energy homes. With fossil fuels becoming less abundant, alternative energy sources are being incorporated into modern architecture. The Nittany family contracted the Zero Energy Lions to develop and build a sustainable home for them. This four person family is searching for an aesthetically pleasing, efficient home, and within a budget of $140,000. It will be placed in Philadelphia, Pennsylvania where the family wants the house. Our objective is to meet all the needs of the family, as well as incorporate the best technology in minimal energy usage. Some specifications of our house is that it will have two bedrooms, one bathroom without a bath, a kitchen, and family room. It will have 4 inch walls on the inside and 6 inch outer walls. The roof is 12 inches thick and angled at 20 degrees on the south facing side for the solar panels.

While designing our project we researched various types of zero energy homes across the nation. We specifically researched houses in the northeast region like Pennsylvania, New York, Connecticut and Massachusetts. We investigated zero energy home patents to make sure that we did not steal anyone else's ideas. Some patents include specific placement of solar panels and self sufficient cooling. To further our knowledge on zero energy homes, we also researched consumer surveys to be sure that our house fulfills all of our customer's needs and noted that consumers want their homes to be environmentally conscious, as well as aesthetically appealing.

When designing a new style of home, many things can go wrong. Some risks of designing are that we can develop a house that is not sturdy or
strong enough for the weather that will be present in the winter time or during storms in Philadelphia, where our house will located. Another risk is that our house, even though we are making it become zero energy, may be susceptible to consuming some energy. We also risk not pleasing our customer with the look of our house because our main focus is making it zero energy, rather than the appearance. To avoid this, we can show our customers our floor plan to make sure they like the way it looks and make sure to them that it may not be exactly what they want. We can also hire some structural engineers to make sure our house does not collapse and is strong. Our house for the Nittany family will be completed on October 16, 2015.

**Mission**

Our mission is to design a home for the Nittany family of four. The house will be energy efficient, safe for the environment, as well as aesthetically appealing in Philadelphia, Pennsylvania.
Abstract

The dangers of the earth’s dying climate are becoming a more and more pressing issue every year. As the leading energy consumer, it is America’s job to head in the effort to conserve energy. To do this, we must first start with buildings. We can first start by cutting down the energy used in houses and business complexes. Our company, Zero Energy Lions, is taking the initiative of building zero energy homes to help conserve energy and save the environment. For this house, we worked with our consumers to develop a house that meets their needs that is also environmentally friendly.

Introduction

Because of the current environmental concerns, individuals are becoming environmentally friendly and trying to use the least amount of energy as possible. Furthermore, families want houses that are comfortable as well as ecologically responsible. One of these families, the Nittany family, contacted the Zero Energy Lions for help with this task of building an environmentally friendly home. The Zero Energy Lions did this by using solar power, passive solar energy, as well as heat absorbing materials like slate on the outside. We were able to build a beautiful, zero energy home for the Nittany family with under $140,000.
The Nittany family came to the Zero Energy Lions in search for a sustainable home for their four person family. They want their house to be affordable, elegant, as well as environmentally friendly. The Nittany family further requested that their home be located in Pennsylvania. To appease these requests, the Zero Energy Lions designed a home that is under $140,000, spaciously laid out, as well as environmentally conscious.

## Customer Needs Analysis

<table>
<thead>
<tr>
<th>Customer Needs</th>
<th>Needs Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>I want an affordable house</td>
<td>The cost of the house is under $140,000</td>
</tr>
<tr>
<td>I want an environmentally friendly home</td>
<td>The house’s main source of energy will be solar from solar panels and passive solar energy.</td>
</tr>
<tr>
<td>I want an aesthetically pleasing house</td>
<td>The house will look like a fashionable normal house</td>
</tr>
<tr>
<td>I want to be able to fit my four person family</td>
<td>The house will be spacious enough for the entire family</td>
</tr>
<tr>
<td>I want to live in Pennsylvania</td>
<td>The house will be built in Philadelphia, Pennsylvania</td>
</tr>
</tbody>
</table>
Location

For our building location we have chosen Philadelphia, Pennsylvania. Our clients requested to live in Pennsylvania and we chose the city of Philadelphia because of the city’s growing environmental efforts and green society. Philadelphia is one of America’s largest cities and it is trying to become a more environmental friendly community. In 2008 Mayor Nutter established the Philadelphia Office of Sustainability with the main goal of making Philadelphia the greenest city in America. Although there is no definitive way of determining the greenest city in the United States, Philadelphia is on the right track. The Greenworks Philadelphia plan established in 2009 created a variety of tax breaks and incentives for builders and homeowners to build homes and buildings that are energy efficient.
Philadelphia, Pennsylvania

Sun Patterns in Philadelphia

We looked at the sun patterns in Philadelphia to help decide how to best utilize solar energy. Philadelphia has a decent amount of sun exposure with 15:02 hours of sunlight on the longest day in June and 9:20 hours on the shortest day in December.

Average Temperature in Philadelphia

The temperature in Philadelphia typically ranges from from 24°F to 87°F, but can occasionally go below 12°F or above 94°F. Knowing this, we developed a home that could comfortably withstand the temperature range in Philadelphia.
**Matrix Chart**

Matrix charts are comparative rating systems for consensus building amongst multi-functional teams of engineers and problem solvers to develop designs to meet the basic needs of a problem. We formed our needs matrix table from the list of customer needs we were presented with. Thus, the four basic needs for our home were implemented; we included, Eco-friendliness, affordability, Sustainability, and energy efficiency.

Our matrix is shown below:

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Specific Floor choice</th>
<th>R Value Insulation</th>
<th>House Size</th>
<th>Window s</th>
<th>Roof Angle</th>
<th>Outside Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco-Friendly</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Affordable</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Sustainable</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Energy Efficient</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sum of +</strong></td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Sum of 0</strong></td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Sum of -</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Net Score</strong></td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
Benchmarking

Benchmarking is the process of documenting existing designs in order to evaluate what has already been tested. With this information engineers can then proceed with an educated viewpoint in order to create the best design for the problem at hand. For our research, we detailed 4 energy dependant homes across the northern United States. We documented specifications that are crucial to the maximization of energy efficiency, such as the insulation R-value, the size of the photovoltaic system, and types of heating systems. From this data we were able to gain a better understanding of the most efficient heat sources, PV system sizes, compared to the square footage of the home, and the most efficient house type.

Our research chart is pictured below:
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Denver, Colorado</td>
<td>Maynard, Massachusetts</td>
<td>Princeton, Massachusetts</td>
<td>Russellville, Alabama</td>
</tr>
<tr>
<td><strong>House Size</strong></td>
<td>1,280 sqft</td>
<td>1,250 sqft</td>
<td>2,500 sqft</td>
<td>1,232 sqft</td>
</tr>
<tr>
<td><strong># of Floors</strong></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong># of Occupants</strong></td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong># of Bedrooms</strong></td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Main Heating Fuel</strong></td>
<td>Electricity and natural gas</td>
<td>Electricity</td>
<td>Electricity</td>
<td>Natural</td>
</tr>
<tr>
<td><strong>Size of Photovoltaic Systems</strong></td>
<td>4kW</td>
<td>6.15 kW</td>
<td>14.4 kW</td>
<td>7 kW</td>
</tr>
<tr>
<td><strong>Solar Water Heater</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>R- Value of Wall Insulation</strong></td>
<td>R40</td>
<td>R42</td>
<td>R62</td>
<td>R13</td>
</tr>
<tr>
<td><strong>R- Value of Ceiling Insulation</strong></td>
<td>R60</td>
<td>R63</td>
<td>R63</td>
<td>R54.6</td>
</tr>
<tr>
<td><strong>Ventilation air recovery</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Predicted annual energy use</strong></td>
<td>13,030 kWh</td>
<td>(-8 HERS)</td>
<td>(-4 HERS)</td>
<td>Save 4,658 kWh</td>
</tr>
</tbody>
</table>
Research

Solar Panels

About 90% of the world’s solar panels today are based on the use of silicon, and due to that fact the panels can take on many different forms, but the purity of the silicon may not always be the same. The more aligned the silicon molecules are, the better the panel will be at converting solar energy into electricity. A few examples of solar panels include monocrystalline and polycrystalline solar cells. Monocrystalline cells are made of silicon ingots, which are cylindrical and optimize performance, giving them the highest efficiency rate. These types of cells are also space efficient, and live the longest lives, yet of course they are most expensive. Polycrystalline cells are made by melting silicon and then molding into thin squares. These cells are simpler and cost less, but are also less efficient in both energy production and space consumption. We feel that polycrystalline cells would fit better in our design, and provide the necessary energy to support our family.

Windows

Windows are a very important part of a passive solar design, which relies heavily on the sun’s ability to heat the home. Passive solar design strategies vary by building location and regional climate, but the basic
window guidelines remain the same—select, orient, and size glass to maximize solar heat gain in winter and minimize it in summer. Double paned windows with a gas fill allow adequate insulation for any energy efficient home. However there is also triple paned windows, with two gas pockets that are more effective, but significantly heavier, therefore we chose the double paned.

**ZEH Energy Sources:**

**Solar:** Energy converted from the sun, through silicon panels, the most commonly used

**Wind:** Mechanical & Electrical energy harvested from the wind usually through wind turbines

**Geothermal:** Energy harnessed from the earth

**Electricity Grid:** The energy acquired from power suppliers’ power plants, and then transmitted through wires to the consumer. This is the energy we are trying to avoid.
Sketches
Solidworks
Final Design

Our approach to this project was to design a simple home, that gave the residents everything they requested. The rather small square footage was a must to keep the energy intake low, but also makes the home cozy and inviting for the family. The south side of the home houses a floor to ceiling window that allows for a passive solar design to heat the majority of the home, as the large stone slab on the floor absorbs and emits the heat from the sunlight. On top of that, the solar panels on the roof provide the energy needed for the house to sustain itself. Geothermal systems are also employed to heat/cool water depending on the season.
Conclusion

Throughout the world, energy is in high demand. The United States is a leader in energy consumption. Because of this, the United States needs to be a leader in changing the way individuals waste energy. The main use of energy in America is from residential property. Therefore, America must begin changing the way its citizens use energy in homes and houses. The Zero Energy Lions knew this and took action to develop a zero energy home that is affordable, spacious, and elegant. Together, the Zero Energy Lions were able to successfully design and model a beautiful Zero Energy Home for the Nittany family of four for $130,775 in Philadelphia, Pennsylvania.
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