Zero Energy House
EDSGN 100 Section 6
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Second Floor
First Floor
Our design team created a design for a zero energy house for a four person family. To accomplish this we used several passive solar features to reduce energy use. Then to account for the energy we did use we equipped the house with active solar features such as a PV system and a solar water heater. In addition to conserving electricity, we also tried to conserve water with various water recycling features.

The goal of this project was to design a house for four people to live in that was also a zero energy house. A zero energy house is a house that in a full year makes as much energy as it uses. To accomplish this the obvious answer is to use active solar features such as PV (photovoltaic) Systems. However, by using passive solar principals we lowered the energy they would use and therefor the energy they needed to make. The house was to be made in Pennsylvania so we decided to build it in Philadelphia. We started with a needs analysis and then did some research on passive solar features. We brainstormed some potential designs and then combined them for our final design. We then built a scale model of the house and tested it.

To come up with our needs analysis we thought of what we would need and want if we were the four person family planning to build this house. We figured they would want three bedrooms, two bathrooms, a kitchen, dining room, family room, and a laundry room. They would also require appliances such as a washer, dryer, oven, dish washer, refrigerator, and microwave. In addition to the needs, they would also want some luxuries such as a television, gaming system for the kids, computer, telephones, etc.

We visited the Morningstar home, a zero energy house on campus, to find out more information on what a zero energy house looked like. There we learned several passive solar principals such as how to use water as a thermal mass. We also learned how to make the most out of your windows by using shading in the summer and letting in sunshine during the winter. In addition, the tour guide also said that windows on any side besides the south actually loses heat. She also introduced SIP Panels for insulation which are supposed to better insulation than traditional insulation. Finally, we were also able to see the active solar principals that the house used which were a PV System and a solar water heater.

Morningstar Home
We also searched the internet to find information on the position of the sun for Philadelphia. We took into consideration the azimuth angle and elevation angle. This information would give us the angles we need to figure out the tilt of our solar panels and size of our overhang.

To begin the process we each designed our own house. Then we traded designs and noted things we liked and disliked about each design. Then we took the traits we liked about each design and tried to combine it all into one house. Our final design met all of the requirements of our four person family and used several passive solar principals.

There are various roof designs that we could use on our house. We decided to go with the shed roof for two reasons: it gave us the most area to put solar panels and was simpler to make for the model than our second choice the saltbox roof.
From our experience at the Morningstar house we decided to only put windows on the south side of the house. This should give us the maximum gain and minimum loss as long as we used proper shading. To do the shading we used an overhang. To calculate the size of the overhang we decided to make it shade as much of the window as possible in the summer and the least amount of shade in the winter. To figure this out we first found the length of the overhang that would cover the entire window. Then using this length we calculated how much would be shaded during the winter to see if we had sunlight on most of the window. We used the information we found about the elevation angles during the winter and summer months.

The last passive feature we used was a thermal mass. To do this we decided to use wooden floors that would heat up in the sun and tubs of water underneath them. The heat from the wood should transfer to the water and then it would slowly be released during the night. The tubs would only be where the sun would hit in the winter so that we would not have access water that would hinder our efforts.

Some other things that would decrease our energy use is good insulation. From our visit to the Morningstar house we learned about SIP panels. After a little research we found that they greatly increase the R value (how good of an insulator it is). So we decided to use eight inch SIP panels for all the walls and the roof.
To complete the thermal envelope we would use triple-pane windows with Argon gas, Zenon gas, or a combination of the two. We found that these had the highest R value and would be even better if we used a double low-e glazing with high Solar Heat Gain Coefficient on it.

We used an energy calculator to estimate how much energy our family of four would use. We found that our family would use about 7,447 kWh a year. To make this energy we looked at
several different solar panels and compared their efficiency and cost per watt. We found that the X21-335 solar panels were the second most efficient but almost half the cost per watt of the most efficient. We then used this information to figure out how many panels we would need and found that we would require twenty three panels. In addition to the solar panels we would also use a solar water heater like the Morningstar house used. This would significantly cut back our water heating costs.

Another thing we wanted to do was conserve water usage. To do this we would use a water recycling system we found during some research. Also, we would send the dirty water from the shower and sink to the toilet and use it to flush instead of using clean water.

Our scale model was supposed to be around 70 square inches. We wanted our actual house to be 30’x50’x20’ because this gave us more area for windows than a square house. So our model ended up being 10.5”x6.5”x4.32”. The model was made out of foam board to
represent the foam in the SIP panels that would be our thermal envelope. For the windows we used saran wrap and layered it to represent the triple-pane windows. To make the roof fit more tightly we made a lip on the top and bottom so that when the roof sat on top it they interlocked. To make our thermal mass we used black rubber in front of the windows. This seemed to work quite well as our house heated up the most and kept the most out of all the groups. One thing we liked about another design was a skylight window that allowed direct sunlight in during the day time. However, we think it probably caused a lot of loss during the winter.

We feel our design was a success because in the experiment it gained a lot of heat. This showed that our base ideas were working. When these things are put into an actual house they would work even better. Our model was by no means air tight like the actual house would be. In addition, the windows in the actual house would probably be better insulators than the thin layers of saran wrap. Another thing to consider is that in the experiment we had a fan with ice in front of it to represent the night time. However, we felt that the wind was not proportional to the house and would represent a tornado or blizzard rather than a normal night breeze. The experiment however did not test for the ability to stay cool in the summer either. We do feel that our overhang will make our model keep pretty cool in the summer though. In addition, our solar panels are very efficient and we have plenty of room to on the roof for them because of the style of roof we chose. Overall our house performed well in our experiment and should perform well in real conditions.
### Appendix

**PV Systems**

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Price</th>
<th>Area (m²)</th>
<th>Rated Power (W)</th>
<th>Cost Per Watt</th>
<th>Efficiency</th>
<th>5000 W Area</th>
<th># panels</th>
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<td>X21-335</td>
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<td>1.63</td>
<td>335</td>
<td>$5.62</td>
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1.5 x 15 panels = 7500W
23 panels x $1,882 per panel = $43,286

**Calculations for the overhang:**

![Effect of different orientations](image1.png)

![Effect of tilt to horizontal](image2.png)
First,

\[ x = \frac{6}{\tan 68^\circ} = 2.42 \text{ ft} \]

Then,

\[ y = 2.42 \tan 22^\circ = .98 \text{ ft} \]

So the overhang should be 2.42 ft to completely shade during the summer and let all the sunlight in during the winter.
3D Model
Works Cited


References

Energy Calculator: Search for “ZEH calculator” and it’s the XLS with something about Spring Creek Homestead in the title. It should be like the second one.


MorningStar Home: http://sustainability.psu.edu/morningstar-solar-home

3D Model: Visit my website to see the full model http://www.personal.psu.edu/dlt5230/