Zero Energy Home Title

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Section 016
Team #3
Submitted to: Wallace Catanach
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Tong Zhu Hellen Sarmiento Mike Roszkowski Bryan Woodside
Emails: tyz5064@psu.edu, hqs5185@psu.edu, myr5401@psu.edu, bsw5173@psu.edu

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Executive Summary

In today's economy people are looking for ways to save money. One of the biggest things people spend their money on is utilities, one of the most expensive being electricity. We set out to design a home that would have a net zero energy consumption. This will eliminate any electricity bill, and therefore save the owner that money. In order to do this we developed a house using the 8-step engineering process. The finished design will have room for a family of four, be environmentally friendly, and is going to be designed for the Philadelphia area.

Introduction

A four-member team was given the task of developing a Zero Energy House, using the engineering design process that was taught in class. As a team we identified the problem, brainstormed solutions, chose the best solutions, and designed a home based off of our conclusions. The problem is that the average American household consumers too much energy and ends up costing the average household owner a lot of money in energy bills. We determined could be solved by using energy producing devices such as solar panels and wind turbines in order to produce energy and lower the dependence on outside energy. Customer needs were noted and taken into consideration when the house was being designed. Research was done on different types of energy producing technology, as well as devices that could be used to reduce the loss of energy in a house. Once the research was completed we eliminated the products that were inferior or too costly for our budget. Once the benchmarking process was over multiple house designs were made and the best was selected. A model of the house was then designed and presented to the John Doe agency for approval.

Mission Statement

Our mission is to design and build an eco-friendly house that has a net-energy consumption of zero, while still being aesthetically pleasing and affordable.

Customer Needs Analysis

After surveying 20 people from all age groups these were some of the most common responses we heard in regards to Zero Energy Homes. The initial goal of the project is to make a home that requires zero outside energy. The second goal of the project was to meet customer needs and to make the house aesthetically appeasing as well. The needs of the customers were then analyzed and accounted for in the design of the house.

We choose Richmond, Virginia as the location of our zero energy home. Due to its relatively mild winters, and good yearlong sunlight we thought it would be an ideal location for our house.

The data from the survey was then collected and was prepared into needs statements.

Customer Statement	Needs Statement
My electricity bill is too high.	The house will produce its own energy.
I want enough room for my family to live	The house will be comfortable for a family of four.
I need my house to be comfortable in the summer and winter.	The house will be heated and cooled.
I want my house to be eco-friendly	No fossil fuels will be used to produce energy.
My house needs to have a lot of natural light	Windows will installed in order to maximize sunlight
I want a spacious house	The house will have a lot of open areas
I want to use energy efficient things	The house will be equipped with energy efficient appliances and windows.
I want the house to be affordable	The house will cost less than $200,00
I want to use solar energy	The house will utilize solar panels.
I wan to use less water	The house will be designed to consume less water.
I wan the house to be pretty	The house will have an attractive design.
I want my house to be fixable with everyday tools	The house will be low maintenance.
I don't want to not have power	The house will be attached to the grid for backup power
I want my house to have a low impact on the environment	House will have a low impact on the environment.
I want my house to last	The house will last a long time.

Needs statement	Importance(1-5)
The house will produce its own energy	5
The house will be comfortable for a family of four	4
The house will be heated and cooled	5
The house use no fossil fuels will be used to produce energy	5
The house's windows will installed in order to maximize sunlight	4
The house will have a lot of open areas	3
The house will be equipped with energy efficient appliances and windows	5
The house will cost less than $200,000	3
The house will utilize solar panels	4
The house will be designed to consume less water	4
The house will have an attractive design	3
The house will be able to be fixed using everyday tools	3
The house will be attached to the grid for backup power	5
The house will have a low impact on the environment	3
The house will last a long time	5

-Needs and Metrics Chart

	Metrics	Solar Panels	Number of Bedrooms	Insulated walls	Energy efficient heating and Cooling	Energy efficient appliances and windows	Recycled Materials	Affordable housing area	Total Cost	Number of windows	Design of the House
#	Needs Statements										
1	The House will produce its own energy	X									
2	The house will be comfortable for a family of four		X								X
3	The house will be heated and cooled			X	X					X	
4	No fossil fuels will be used to provided energy for the house	X									
5	Windows will maximize sunlight	X								X	X
6	The house will have open areas		X								X
7	The house will be equipped with energy efficient appliances and windows					X					
8	The house will be affordable						X	X	X		
9	The house will utilize Solar panels	X									
10	The house will be designed to use less water					X					X
11	The house will have an attractive design										X
12	The house will be low maintenance										X
13	The house will be attached to the grid for backup power										X
14	The house will have a low environmental impact	X			X	X	X				X
15	The house will last a long time						X				X

External Research

Many things go into making a home Zero Energy Home, there are many things that a home can utilize in order to maximize the efficiency of a home. There are some of the most important ones we found.

Insulation: Insulation is essential thing that every house needs to get in order to keep the temperature inside the house from escaping. Insulation keeps a house warm in the winter and cool in the summer. The mist important thing when

considering insulation is the R-value. The higher the R-value the better the insulation is at keeping the temp. of a room the way it is. Insulation usually used in the walls and celling of a house but can also be used in the floors, in order to maximize its effectiveness.

Renewable Energy Sources:

-Solar Energy- Solar energy is the process of capturing, converting and distributing the energy from the suns rays. There are two different types of solar panels: passive and active. Active Solar panels use photovoltaic panels and solar thermal collectors, in order to collect and distribute the suns energy. Passive solar is the process of orientating a building so that the suns rays can enter a building and the naturally circulating air heats the house. Solar energy is good way to produce energy since, once the panels are bought and installed, besides maintenance there is no further cost. However it also has its faults such as not being able to produce at night or when it is cloudy out.

-Wind Energy- Wind energy is the process of using wind to spin a turbine which produces energy. It is more reliable than solar panel, and just as coast effective. The main problem with wind turbines is that they are very large and are an unpleasant sight. This makes them harder for a person to implement by themselves and harder to utilize.

-Hydroelectricity- The process of using water to turn a turbine which then generates electricity. This is also an effective way to create clean energy. The main problem with hydroelectricity is that an water source large enough to spin a turbine is need in order to spin the turbine and produce electricity. Larger hydroelectricity can have environmental effects as well such heating up large areas of water created by dams. The smaller hydro-electrical systems don't have the same effect on the environment, but are usually cheap and low cost once installed.

Energy Efficient Appliances: Energy efficient appliances are used in many modern house. They use less energy than older models and many times preform better too. These appliances save money by: lowering utility bills and last longer than many non-energy efficient appliances. Energy efficient appliances include: refrigerators, freezers, dishwashers, and clothes washers.

Energy Efficient Windows: Energy efficient windows work in a similar way to energy efficient appliances they work better than older models, and save the owner money by being more energy efficient. They work by preventing the heat from leaving the inside when it is cold out and prevent s the heat from coming in, in the summer

House of quality:

Key:

Symbol	Correlation
X	Strong
C	Weak
V	Negative

	Characteristics	Small amount of energy needed	Large amount of daily Sunlight	Total Cost	Total Area	Eco-Friendly	Modern Commodities
Customer Needs							
The house will produce its own energy	C				C		X
The house will be comfortable for a family of four		C		X		C	
The house will be heated and cooled		X			V	C	
No fossil fuels will be used to provided energy for the house	C	C	C		X		C
Windows will maximize sunlight		X					
The house will have open areas				X		C	
The house will be equipped with energy efficient appliances and windows	X	C	C		X	X	C
The house will be affordable			X				
The house will utilize Solar panels	C	X			X		X
The house will be designed to use less water	C		C		C	C	C
The house will have an attractive design			X	C		X	
The house will be low maintenance				C		C	C
The house will be attached to the grid for backup power	C						X
The house will have a low environmental impact	C				X		C
The house will last a long time			X		C		

Benchmarking: When comparing the products to use on the house we used only the best in terms of solar panels and energy efficient products. We used the best products we could find in order to design the best house possible. As far as materials for the house went we made sure to use quality products while still taking the budget into account.

We did research on Zero energy Homes in similar areas:

Home #1

Location (city, state)	Richmond, Virginia		
House size (floor area in square feet)	3,600 square foot		
Number of floors	2		
URL of web site where info is found	http://www.bainwaring.com/stone		
Number of occupants	4		
Number of bedrooms	3		
Type of heating system	heat pump		
Main heating fuel	electricity		
Size of photovoltaic system	20kw		
Solar water heater	No		
R-value of wall insulation	25		
R-value of ceiling insulation	50		
Ventilation air heat recovery	Yes		
Predicted or measured annual energy use	7300 kWh		

Home #2

Location (city, state)	Seattle, WA	
House size (floor area in square feet)	1915 square foot	
Number of floors	2	
URL of web site where info is found	http://www.gree	
Number of occupants	4	
Number of bedrooms	3	
Type of heating system	heat pump	
Main heating fuel	electricity	
Size of photovoltaic system	6 kw	
Solar water heater	no	
R-value of wall insulation	26	
R-value of ceiling insulation	42	
Ventilation air heat recovery	Yes	
Predicted or measured annual energy use	6,064 kWh	

Product Dissection: We analyzed the different types of products used in Zero Energy Homes through out the U.S. We found that the most common way for a Zero Energy Home to produce electricity is by generating it through Solar panels. We also compared different types of materials used to build the different types of house in the Virginia area. We also noted that Energy Efficient appliances were used in almost all zero energy homes.

World Market: With many people in today's world looking for an affordable way to find a house that pays for itself. A zero energy home is a great way to do just that. Over time the house will pay for itself, and still be a comfortable way to live life. This in addition to the fact that a zero energy home is extremely eco-friendly and produces zero CO2 emissions.

Concept Generation

After completing our research we narrowed the list of many products that we could use on our house down to a select few.

-Energy Production: Solar panels, wind turbines, geothermal, hydroelectric, and nuclear.
-Size: 1500-2000sq. ft.
Heating: Passive solar, geothermal, or oil burning.
Appliances: Energy efficient only
Windows: Energy efficient only
Lighting: energy efficient light bulbs, lots of windows, sunroofs.
Climate Control: Insulation and Insulated windows
Water Heating: Solar water heater

		concept 1		concept 2	
Customer Needs	Weight%	rating	weighted score	rating	weighted score
The house will produce its own energy	15%	5	0.75	4	0.6
The house will be comfortable for a family of four	10%	4	0.4	3	0.3
The house will be heated and cooled	10%	5	0.5	4	0.4
The house use no fossil fuels will be used to produce energy	5%	5	0.25	4	0.2
The house's windows will installed in order to maximize sunlight	5%	3	0.15	5	0.25
The house will have a lot of open areas	5%	4	0.2	3	0.15
The house will be equipped with energy efficient appliances and windows	5%	4	0.2	4	0.2
The house will cost less than $200,00	5%	3	0.15	5	0.25
The house will utilize solar panels	5%	4	0.2	4	0.2
The house will be designed to consume less water	5%	3	0.15	5	0.25
The house will have an attractive design	5%	3	0.15	4	0.2
The house will be able to be fixed using everyday tools	5%	3	0.15	4	0.2
The house will be attached to the grid for backup power	5%	4	0.2	4	0.2
The house will have a low impact on the environment	5%	3	0.15	4	0.2
The house will last a long time	10%	5	0.5	5	0.5
Total score			1.25		1.1

Concept Selection

After researching which components to put into the house we decided to put the following in the house.

Energy Source: Photovoltaic and Geothermal Pump

For our house we decided to use 4.21 kW photovoltaic system. This would provide enough information to power the house, and since we are not using this to heat, cool or heat the water it should be more than enough energy to power the house. The photovoltaic system is also the most practical for the area that we choose. The pump is practical for the cold winters and warm summers, and is cheaper in the end, then using the solar power, which would require us to get a larger system. The tax credits from the Gov. also make it cheaper.

Size: 1,000 square feet

The size may seem small but it makes the house much more efficient in the sense that it is easier to cool and easier to heat. The size is small but with two bedrooms the house would have enough room for a family of four.

Water Heater: Solar Water Heater

By installing a solar water heater o our home we eliminate the need to heat water-using energy from the photovoltaic system. Since there's already solar panels on the house it only make sense to heat the water using a solar water heater.

Heating and Cooling: Geothermal Heat Pump

By installing a geothermal heat pump we can eliminate the need to heat and cool the house using the photovoltaic system, which would require more energy than the house would produce. A heat pump is a more environmentally friendly way of heating and cooling a house, compared to heating the house with an oil burning furnace, and an air conditioning unit that is run off of electricity.

Insulation: Recycled newspaper with blown cellulose

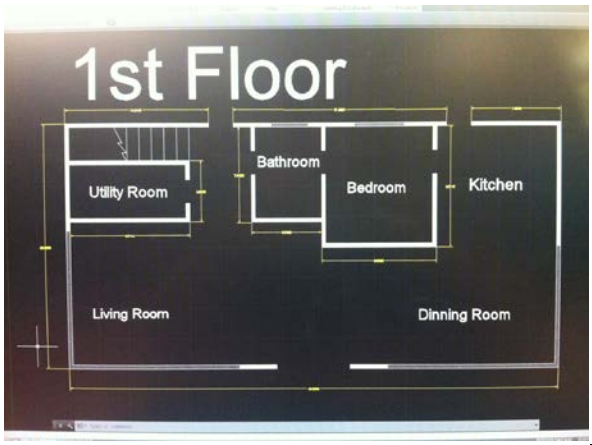
This type of insulation is designed particularly to prevent heat loss in the winter and heat gain in the summer. The insulation has a higher R-value than standard fiberglass insulation.

Appliances/Windows: Energy efficient Appliances/Windows

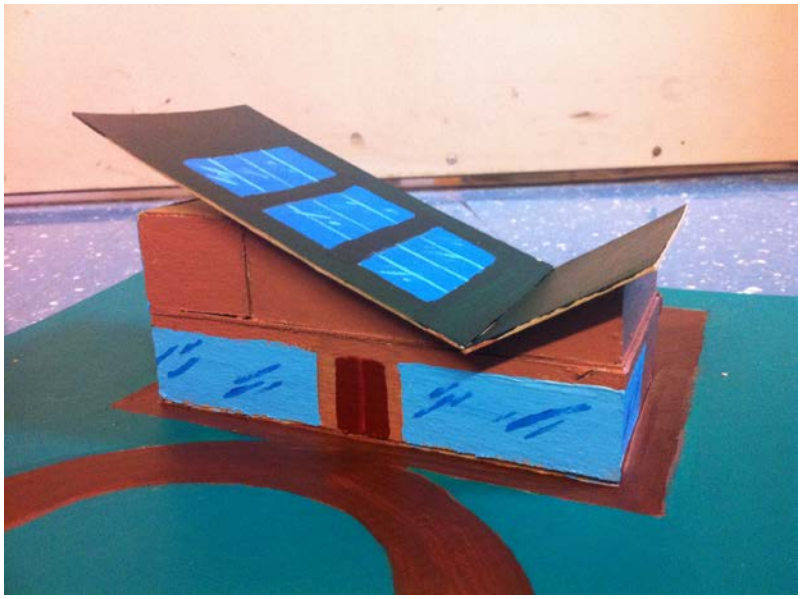
By using energy efficient appliances and windows we save a lot of money every year as compared to using older less efficient models. Energy efficient windows will help to reduce the amount heat lost in the winter and keep the heat out in the summer. By using Energy efficient appliances we reduce the amount of power we need to power the house.

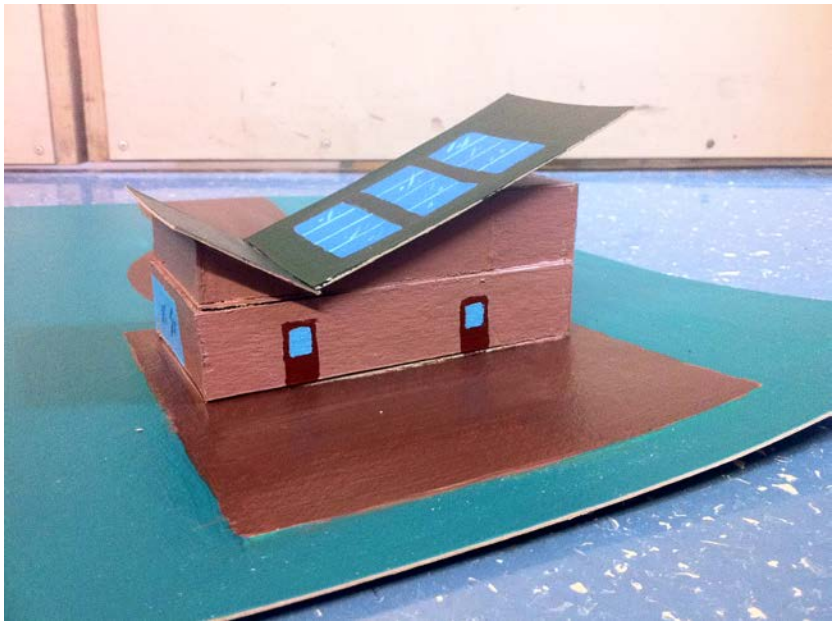
Embodiment Design

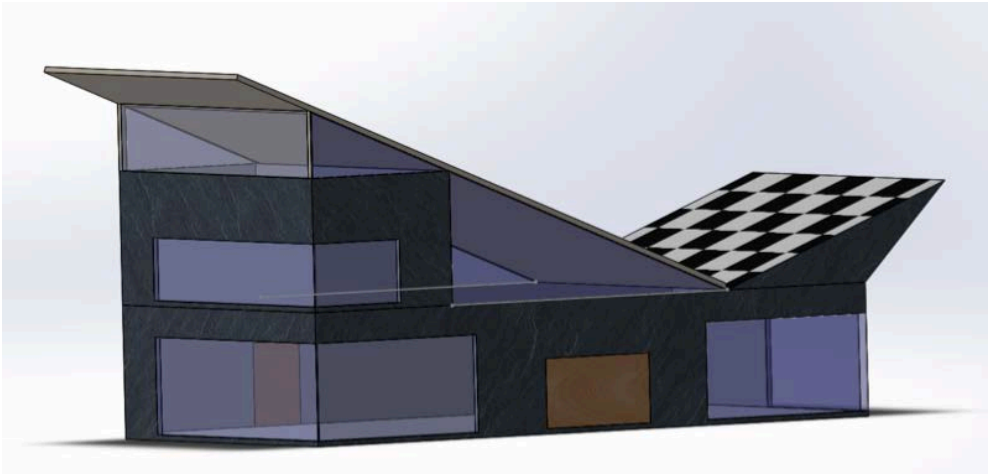
Our Zero Energy Home is composed of a first and second floor. In the first floor we can find a bedroom, bathroom, living room, dinning room, kitchen, a utility room, and stairs leading to the second floor. On the second floor we have another bedroom with two closets. It's 1,000 square feet of net zero living space. The roofs are v-shaped, one side is 14ft by 24ft and the longer side is 38ft by 24ft. The roof is equipped with nine solar panels. The roof is also strategically positioned at an angle of 41 degrees to maximize the solar energy. The house has a total of 413 square feet of wall space dedicated to windows, for the purpose minimizing electricity

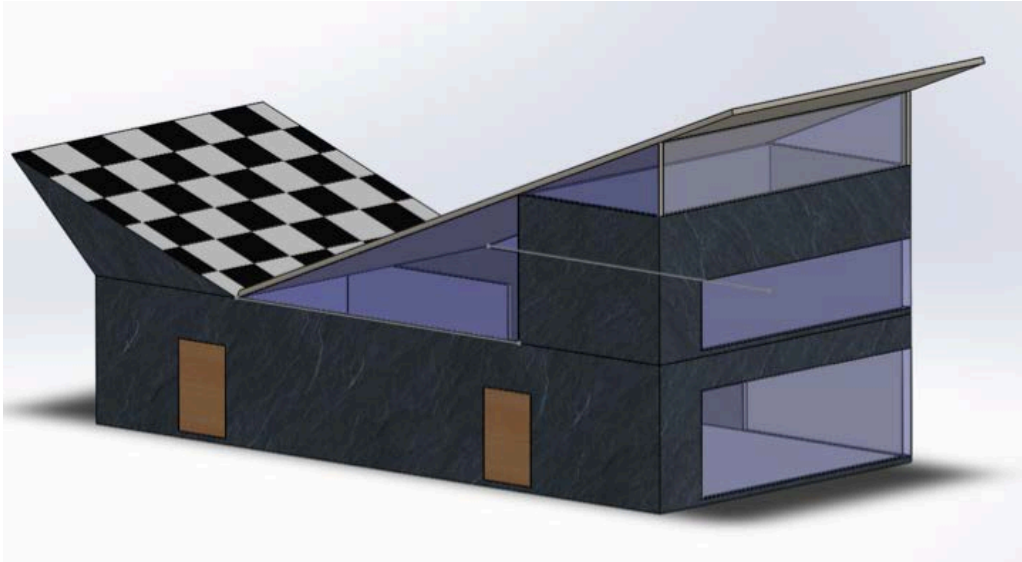

1st Floor
Utility Room
Bathroom
Bedroom
Kitchen
Living Room
Dinning Room

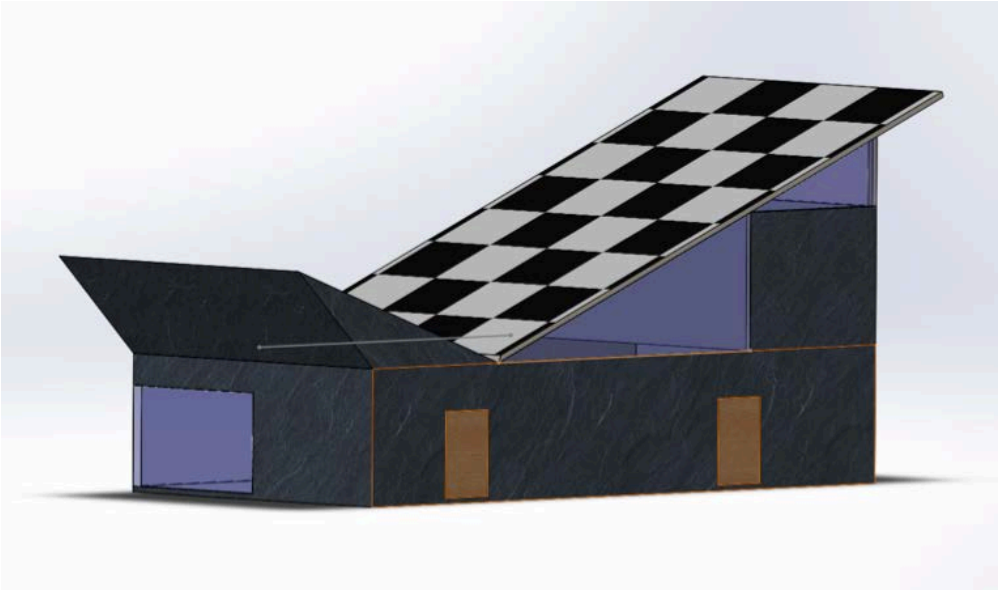
2nd Floor
Closet
Bedroom
Closet

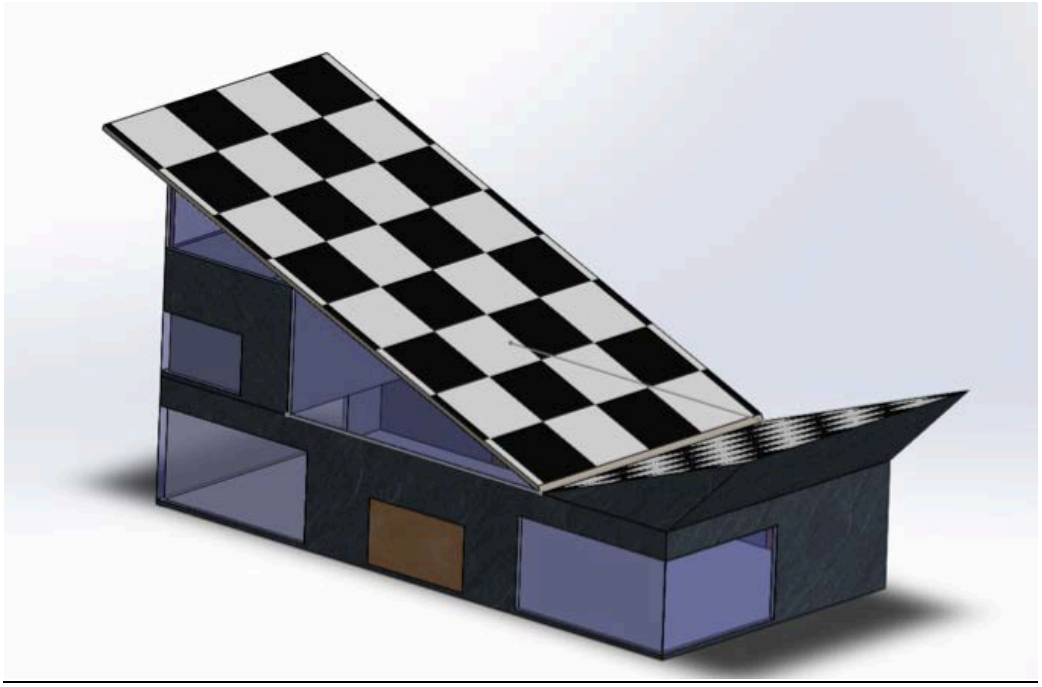












Energy Calculator

General Info

Location	Philadelphia
Electricity cost ($/kwh)	0.1
House type	2 story
Conditioned floor area (sq.ft.)	1,000
Number of bedrooms	2

Envelope Details

Wall construction	Double 2x4 with 10" foam
Ceiling Insulation	R40
Window type	Triple low-e
Upper floor ceiling area (sq.ft.)	200
North wall area (gross) (sq.ft.)	320
East wall area (sq.ft.)	160
South wall area (sq.ft.)	320
West wall area (sq.ft.)	160
North window area (sq.ft.)	80
East window area (sq.ft.)	160
South window area (sq.ft.)	80

West window area (sq.ft.)	160
Air tightness	Tight with heat recovery

Appliances

Refrigerator	Energy Star
Clothes Washer	Energy Star
Dishwasher	Energy Star
Small Appliance Input	

Extras

Garage	a. None
Hot Tub	a. None
Pool	a. None

Heating & Cooling

Type of heating & cooling system	Electric geothermal heat pump

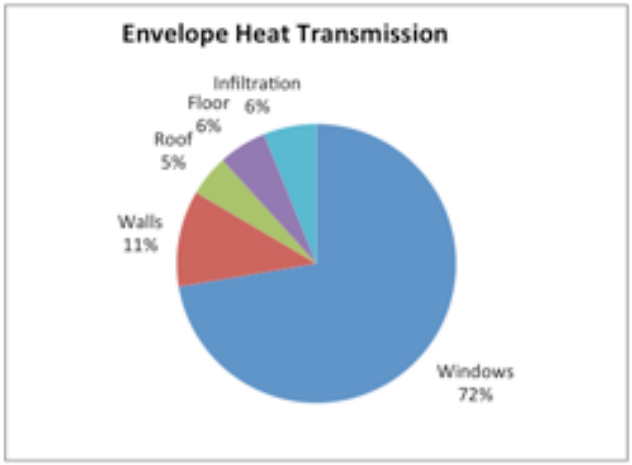
Solar Technologies

Size of PV system (kw)	4.21
Solar water heater	Yes

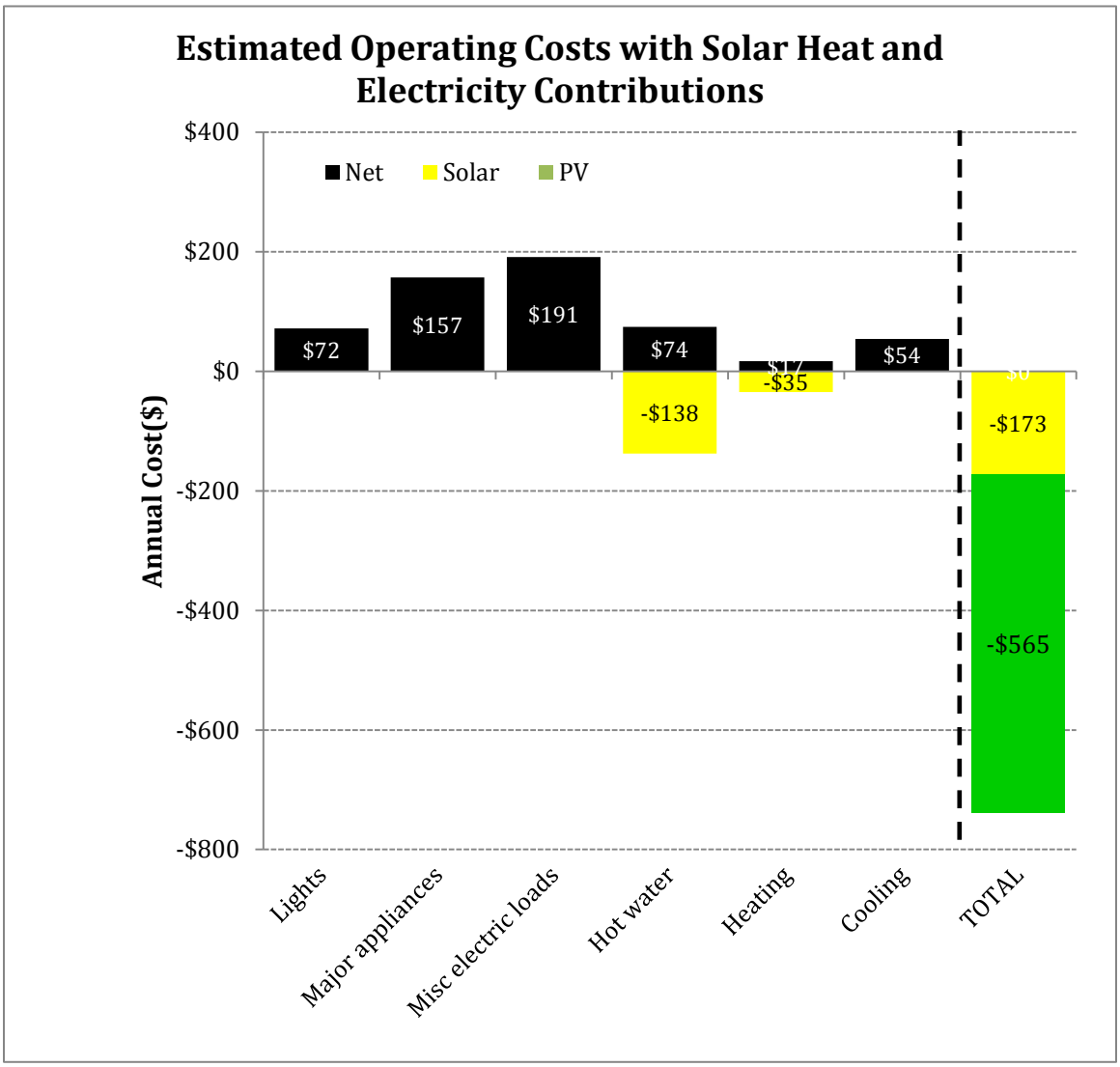
Behavior

Water conservation	A lot
Uses clothesline	A lot
Thermostat setback	Some
Heat thermostat setting (F)	70
Cool thermostat setting (F)	76

Results



Base House Cost	**$130,223**
PV Cost	**$21,047**
Upgrade Costs	**$21,664**
Total House Cost	**$172,934**



Specifications	
Zero Energy Home Item/s:	**Prices:**
Ground Fault Circuit Interrupter	$30.00
Doorbell	$50.00
First TV	$1,500.00
Power Speakers	$150.00

Microwave	$150.00
Extra Refrigerator	$600.00
Toaster	$50.00
Blender	$50.00
Can Opener	$20.00
Espresso Machine	$180.00
Home Security System	$50.00 per month
Laptop PC (Plugged In)	$700.00
Printer (Inkjet)	$150.00
DSL/Cable Modem	$80.00
Curling Iron	$40.00
Electric Shaver	$70.00
Vacuum Cleaner (Upright)	$200.00
Cell Phone Charger	$20.00
Battery Charger	$30.00
Surge Protector/Power Strip	$20.00
Timer (Irrigation)	$50.00
Iron	$40.00
Well Pump	$300.00
Large Water Tank	$800.00
Total Price	$6,120.00

Customer Spending	
Total House Cost	$172,934.00
Total Upgrade Cost	$21,664.12
Total Small Appliance Cost	$5,330.00
Total Customer Spending Price	$199,928.12

Conclusion

Through this process we were able to design a Aero Energy Home using the 8-step engineering process. By using this process we were better able to understand the process that the average engineer goes through in order to design a product. The hours spent researching and designing. We also were able to discovery different things about our team members, our strengths, weaknesses, and habits good or bad. We successfully went through the whole engineering process from surveying people to find consumer needs to finding the final products that we would actually go on the house in concept selections. After this we were able to finally develop a model in solid works and after that we were able to build a real life model. The process that engineers go through is a long but necessary one in order to make the best product possible for the consumers.

Works Cited

GreenFiber Turns Recycled Paper into Insulation | Earth911.com." Earth911.com | More Ideas, Less Waste . http://earth911.com/news/2012/12/03/greenfiber-recycled-paper-insulation/ (accessed October 17, 2013).

&, Paul Fisette. "UMass Amherst: Building and Construction Technology Â» Cellulose Insulation â€“ A Smart Choice." UMass Amherst: Building and Construction Technology. http://bct.eco.umass.edu/publications/by-title/cellulose-insulation-a-smart-choice/ (accessed October 17, 2013).

"An Introduction to Solar Energy." Home :: Northeastern University. http://www.ccs.neu.edu/home/feneric/solar.html (accessed October 17, 2013).

Crumbaker, K., and P. McCarty. "Introduction to Domestic Solar Hot Water Systems." Colorado State University Extension. http://www.ext.colostate.edu/pubs/consumer/10627.html (accessed October 17, 2013).

"Energy Smart Insulation :: Insulation Types and Comparison." Energy Smart Insulation :: Energy Smart Home Insulation Contractor Attic Walls Basement. http://energysmartohio.com/plan-your-job/insulation-types (accessed October 17, 2013).

"Geothermal Heat Pump Basics." Geothermal Heat Pump Basics. www.nrel.gov/learning/re_geo_heat_pumps.html (accessed October 17, 2013).

Hippo, Flying. " Introduction to Geothermal Heat Pump Systems - Iowa Energy Center." Iowa Energy Center. http://www.iowaenergycenter.org/grant-and-research-library/introduction-to-geothermal-heat-pump-systems/ (accessed October 17, 2013).

"Installing Recycled Paper Insulation." Green Homes - Simple Ways to Make Your Home More Efficient, Healthier. http://www.greenhomesconsultant.com/recycled-paper-insulation.html (accessed October 17, 2013).

Media, Demand. "Introduction to Solar Panels | Home Guides | SF Gate." Home Guides | SF Gate. http://homeguides.sfgate.com/introduction-solar-panels-79606.html (accessed October 17, 2013).

"Quick intro to geothermal heat pumps | Earth's Heat." Earth's Heat. http://earthsheat.blogspot.com/2013/01/quick-intro-to-geothermal-heat-pumps.html (accessed October 17, 2013).

Sitzmann, Bernd. "Solar water heater with thermosyphon circulation." Solar water heater with thermosyphon circulation. leebell.net/packratworkshop/pdf/solar_water_heating.pdf (accessed October 17, 2013).

"Solar Panel Comparison - June 2013 - Energy Informative." Solar Panels and Home Energy Efficiency - Energy Informative. http://energyinformative.org/solar-panel-comparison/ (accessed October 17, 2013).

Trimarchi, Maria. "HowStuffWorks "Introduction to Spray-on Solar Panels"." HowStuffWorks "Science".

http://science.howstuffworks.com/environmental/green-tech/sustainable/spray-on-solar-panel.htm (accessed October 17, 2013).

"Types of Insulation | Department of Energy." Department of Energy. http://energy.gov/energysaver/articles/types-insulation (accessed October 17, 2013).

"Welcome to Tascon Industries." Welcome to Tascon Industries. http://www.tasconindustries.com/Insulation%20Comparison.html (accessed October 17, 2013).

"comparing residential water heaters for energy use economics and emissions." comparing residential water heaters for energy use economics and emissions. www.buildwithpropane.com/pdf/Water-Heating-3E-Analysis.pdf (accessed October 17, 2013).