Zero Energy Home

EDSGN 100
Section 06
KJET Inc.
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Introduction

We were assigned with a project of creating a Zero Energy Home. Through a design process, we were able to do so. We produced a scale model of our home made out of foam board and other materials. To simulate an actual home during the summer and winter, we had to put our home through a series of tests. First, we had to put our home in front of a heat lamp to see how much heat it would absorb. Then, we put our home next to a fan to see how much heat it would retain. Through this process, we learned about passive and active solar features and how it can affect a home. Although, our house did not retain as much heat as we would have liked, we learned how to improve it if we were to actually build a real size model.

Our Goal: The goal for this project is to create a zero energy home model that is able to create more or the same amount of energy than that it uses annually, in other words a self-sustainable house. Our house model had to have features of a passive solar design that can capture the greatest amount of heat when light from a light bulb was shining on it and retain heat when wind was blown through the east facing side of the house. Another aspect we had to consider was how cost effective is our house. By calculating how much energy the house uses and how much energy the house collects we can determine whether the house truly uses zero energy.

Clearly Defined Problem

In our world, we are far from sustainability. Sustainability is meeting the needs of our world now without ruining the resources people will need for the future. Even though, this is a problem for our world, we can start with one person, one home to start saving our earth. By creating a zero energy home, people use renewable energy sources, such as solar or wind power, to run their home. Thus, reducing the greenhouse gases into the environment. If we want to save our earth for future generations, we need to begin using more renewable resources and building zero energy homes to keep our earth clean.

External Research

Before we began designing our Zero Energy Home, we researched other homes to get an idea of how to design our house and what to include in the model.

Location (city, state)	Truro, Maine
House size (floor area in square feet)	6200 square feet
Number of floors	2 floor
URL of web site where info is found	http://www4.uwm.edu/shwec/zeronetenergy/residentialProjects.cfm?id=5- http://www.zeroenergy.com/p_truro.html
Number of occupants	-
Number of bedrooms	7 bedrooms and 8 bathrooms
Type of heating system (forced air, hydronic, radiant floor, heat pump, etc.	the house mainly uses passive heat design · Heat pump
Main heating fuel (electricity, natural gas, wood, oil, etc.)	Geothermal heating and cooling
Size of photovoltaic system (kilowatts)	11.7 KW
Solar water heater (yes or no)	Yes
R-value of wall insulation	-
R-value of ceiling insulation	Rr-12
Ventilation air heat recovery (yes or no)	yes
Predicted or measured annual energy use	The house uses almost near zero energy annually.
Any other pertinent info	Can be separated into two parts

Location (city, state)	Shelburne, Massachusetts
House size (floor area in square feet)	2400 square feet
Number of floors	2 floors
URL of web site where info is found	http://www.greenbuildingadvisor.com/homes/net-zero-home-massachusetts
Number of occupants	
Number of bedrooms	3
Type of heating system (forced air, hydronic, radiant floor, heat pump, etc.	2 Fujitsu 12RLS2 ductless minisplit heat pumps; electric resistance heating panels
Main heating fuel (electricity, natural gas, wood, oil, etc.)	
Size of photovoltaic system (kilowatts)	7.65 kW
Solar water heater (yes or no)	yes
R-value of wall insulation	46
R-value of ceiling insulation	56
Ventilation air heat recovery (yes or no)	yes

Predicted or measured annual energy use	6.6 MMBTU

The house is built in 2014 by an international architecture office, which is called Snøhetta. The building is the pilot project on a family house out of the ordinary. It provides both the living and energy needs of a family.

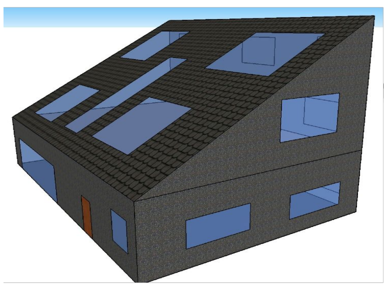
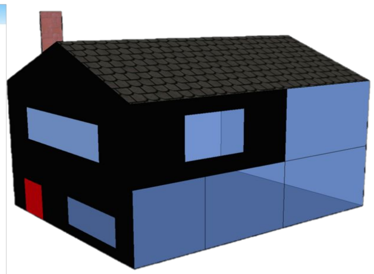
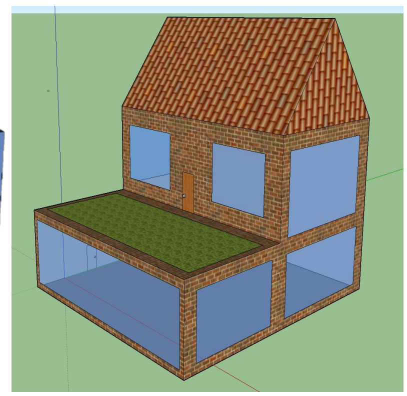
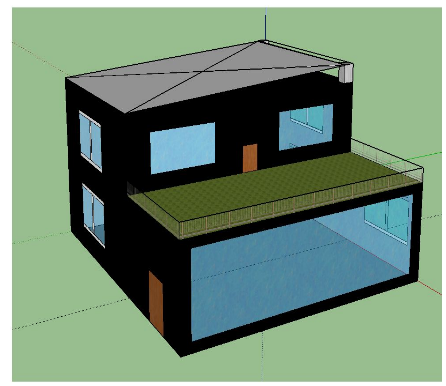
Location (city, state)	Larvik, Norway
House size (floor area in square feet)	200 m^2
Number of floors	2
URL of web site where info is found	http://snohetta.com/project/188-zeb-pilot-house
Number of occupants	A family
Number of bedrooms	3
Type of heating system (forced air, hydronic, radiant floor, heat pump, etc.	Radiator on each floor to heat the whole house and the boiler which can heat the water
Main heating fuel (electricity, natural gas, wood, oil, etc.)	Electricity which is produced by solar-thermal panels
Size of photovoltaic system (kilowatts)	150 m^2-19200Kw/hr-year
Solar water heater (yes or no)	Yes
R-value of wall insulation	N/A
R-value of ceiling insulation	N/A

Ventilation air heat recovery (yes or no)	Yes
Predicted or measured annual energy use	7272Kw/hr
Other heat protect	Thermal mass, auto-light &air system
Degree of the roof	19

Location (city, state)	Charlotte, Vermont
House size (floor area in square feet)	2800 SF
Number of floors	2
URL of web site where info is found	https://www.wbdg.org/references/cs_ch.php
Number of occupants	n/a
Number of bedrooms	n/a
Type of heating system (forced air, hydronic, radiant floor, heat pump, etc.	Ground Source Heat Pump, southern-facing windows,
Main heating fuel (electricity, natural gas, wood, oil, etc.)	Electricity
Size of photovoltaic system (kilowatts)	6,622 kWh
Solar water heater (yes or no)	No
R-value of wall insulation	40

R-value of ceiling insulation	56
Ventilation air heat recovery (yes or no)	yes
Predicted or measured annual energy use	5,999kWh

Concept Generation

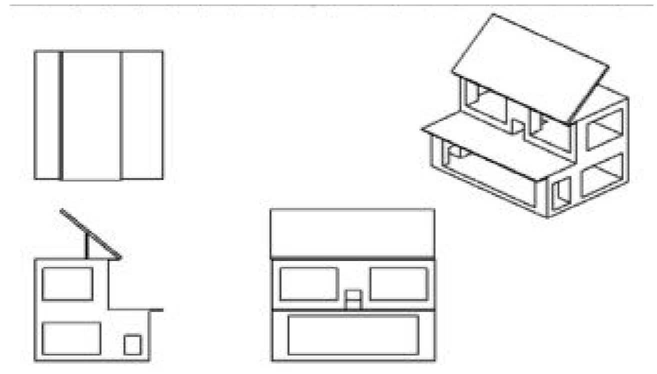
To decide on the design of our house, we each drew up our own idea of what we thought our ideal Zero Energy Home would look like. The person who designed each home, from left to right, goes Teodora, Emma, Kyle, then, Sam. We all created a home with lots of windows for maximum solar gain. We also each added a tilted roof facing south, so we could place solar panels on the roof to achieve as much solar energy as possible. Kyle’s and Sam’s homes were the most similar, both built with a block style. They also each had an idea to put a garden on the roof to have the dirt absorb heat to warm the house and to grow their own organic vegetables.

Concept Selection

Criteria	Weight	Rating Emma	weight	Rating Sam	Weight	Rating Dora	Weight	Rating Kyle	Weight
layout	10%	2	0.2	4	0.4	4	0.4	4	0.4
windows	40%	5	2	5	2	5	2	5	2
insulation	20%	3	0.6	4	0.8	3	0.6	4	0.8
Resistivity to wind	20%	4	0.8	3	0.6	3	0.6	4	0.8
practicality	10%	4	0.4	3	0.3	4	0.4	4	0.4
total	100%	18	4	19	4.1	19	4	21	4.4

To select which our to built, we came up with a list of criteria we all thought is needed for a Zero Energy Home. Then, we weighted each one based off importance. Then, looked at each house and rated each criteria from 1 to 5. Kyle's home got the highest score, then Sam came in second. Therefore, we decided to combine both of their ideas to get our Zero Energy Home.

Design



The house is faced to the south and its length is ten inches, width is seven inches, and height is eight inches. There are seven windows and the three are faced to the south in order to absorb the heat. To avoid overheating, we put an overhang on the first and second story to block sunlight. The house is a modern design, which is not like the general house, which shape looks like a triangle. We decided to make it rectangle because there will be more space and we can make good use of it. For example, on the second floor, there is a flat roof, where we will have a garden, which we can use to grow organic vegetables to supply ourselves, instead of buying from the supermarket. However, if we were to actually build the house, we will need to make a drainage system or the ceiling will be damage because the rain will not be able to run off it. Therefore, we thought about the problem and we decided to add a pipe along the side of wall and collect the excess rainwater, which we can reuse.

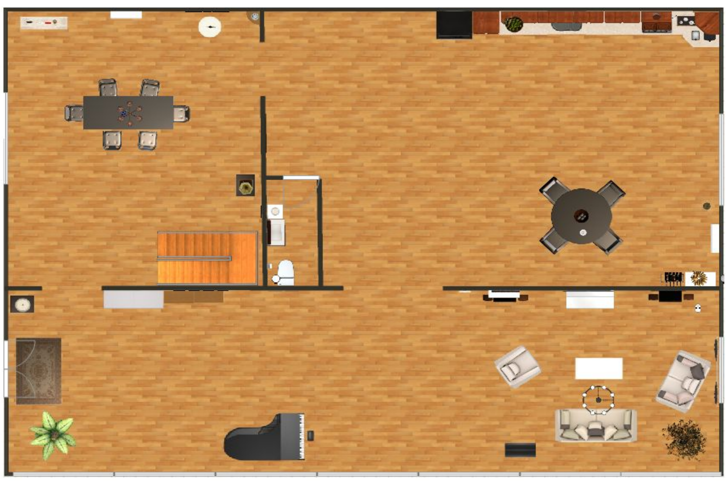
To determine the length we need for our overhang, we use the formula below. As we know that the sunlight shines through the window area should be 10% of floor area, so we measure out floor area and use the formula below to calculate the final result.

1st floor:
Total floor area: 7*10=70 (in^2)
Window area we need: 70*0.1=7 (in^2)
X= overhang, y= window length, sun light angle: 68°
Window weight=8 the sunlight length need: 7/8=0.875
Ytan12°=0.875

xcot12°=y
Therefore, x=0.875 (in)

2nd floor:
Floor area: 4.5*10=45
Window area we need: 45*0.1=4.5
4.5/7=0.642
Ytan12°=0.642
xcot12°=y
Therefore, x=0.642 (in)

First Floor Layout



When we designed the layout, we considered two important things. One was how to make people feel comfortable living inside and the other is how to make the design improve our zero energy house at the same time. Therefore, first, we decided to make the wall a dark wood style, which can absorb the sunlight radiation and also, the style makes people feel peace and warm. Second, we want the living room is big and bright, so we made it close to the window. Third, the stairs need to be close to the entrance in case of an emergency situation. Fourth, the kitchen should be away from the entrance because in Chinese culture, it is not good for people's health and wealth, and it is also polite when people visit your home, they see a beautiful living room, instead of the owner cooking. Last, we made each room have an open door which allows the air to move freely throughout the home.

Second Floor Layout

The second floor is a typical style. The house is for a general family, so we made two bedrooms. One is for parents and the other can be the children.

Energy Analysis

Solar Panel Information

Model Number

ND-250QCS

Price

$290.00

Area and Cost per Watt

1.63 m^2 and $1.16

Efficiency

15.34%

Cost of Installation of Solar Panels

Calculated from: http://www.cpi.coop/my-account/online-usage-calculator/
http://sroeco.com/solar/calculate-solar-cost/what_size_solar_system_do_i_need/

Total Cost Estimate	$34,323.24
Usage	1257 KWH
Bill per Month	$101.82
Solar PV System Size	14.09 kW
Total Area	1127.2 m^2
Number of Solar Panels	56-70
Cost per Watt	$3.48
Solar Cost Estimate	$49,033.20
30% Cost Estimate	$14,709.96

Washer Selection

The four washers that were chosen for the assignment are as follows: Asko W6324, Bosch WAE20060UC, Maytag MHW7000X, and the Electrolux EWFLS70. The annual cost for each washer are, respectively, $59, $76, $98, and $102. The first cost for the washers are, respectively, $1130, $990, $840, and $600. The Electrolux has the cheapest first cost, but it also has the highest annual cost. After comparing all the machines to the Electrolux for payback time, it was found that it would take 15 years for the Bosch washer to make up that money, 60 years for the Maytag to make back the money, and 12 years for the Asko to make back the money. The Asko washer should last long enough to make back all the money by not buying the Electrolux, so buying the Asko W6324 would be the best investment.

Conclusion

When the house underwent experimentation, it went from 23°C to 28°C during the daytime, and then decreases in temperature from 28°C to 22°C. The house received a net gain of -1°C throughout the testing. Some ways this could have been improved would be to add better insulation to the house. The house had several openings that heat was able to escape through. Had those openings been closed off, the house would have lost much less temperature during the night time cycle. Another way to improve the house would have been to add more windows at a 45° angle, so that more sunlight could have heated the house. This way, the house would have increased in temperature by a higher amount during the daytime. We also found that it would have been better had we not put the door to enter the house or any windows on the east side of the house. The wind was blowing from the east and therefore was able to enter the house through the door and windows, decreasing the temperature of the house at a faster rate.

Much of the design components, such as solar panels and the garden, of the house could not be implemented in the model version of the house. Had these components been implemented, the house would have performed better. The solar panels could have been used to create energy that could heat the house, and the garden could have retained more of the heat during the night time. Through some improvements, and the addition of these components, our house could be capable of accommodating a four-person family and also sustaining itself through both passive solar and active solar implementations.