# Zero Energy Home Design Project

Engineering Design and Graphics 100

Section 20

Team 8

Submitted to: Professor Bevin Etienne

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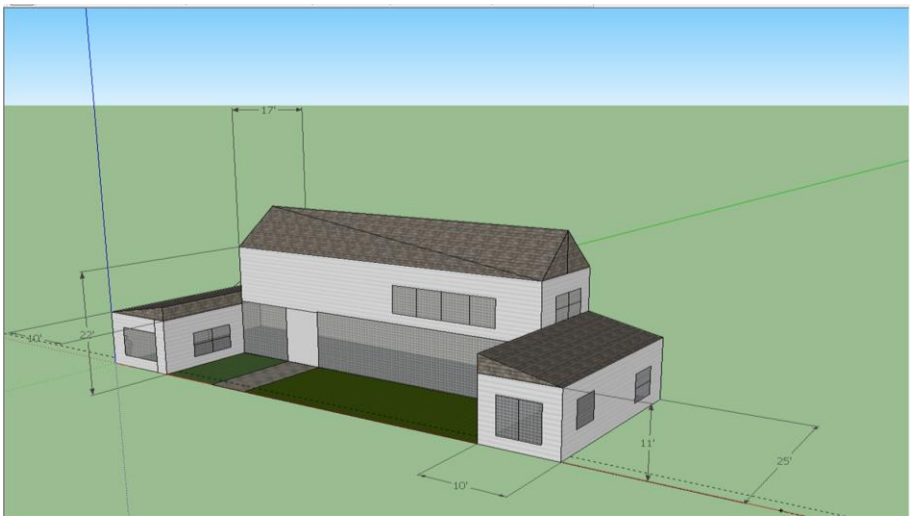
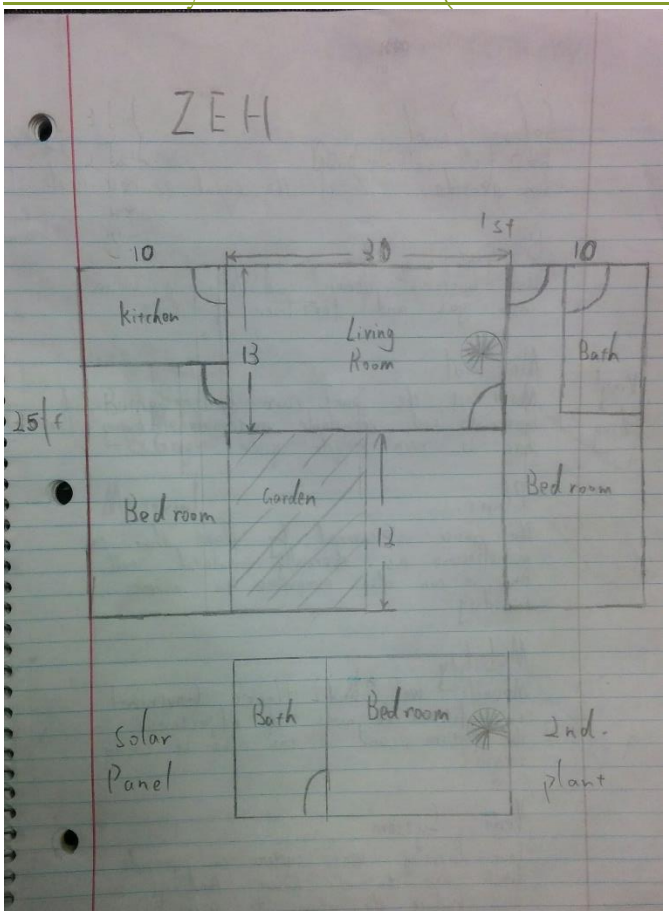
Prototype of our zero energy home on SketchUp:




Internal Layout of Home: (Total 1620 sq feet)



## Abstract
Nowadays the amount of contamination is making us look for better ways to produce energy. The main problem is maintaining our way of living when changing the ways we use to produce energy. With our zero energy home we would like to implement systems that can help us save energy by producing more energy than what we use. Our main purpose when making our project is to make a house that makes life easier for the customer while making significant savings on energy by using systems that does not affect our environment.

## Introduction
Our society is in a point where contamination is really affecting our way of living. For this purpose we should start finding ways to protect our environment by changing the way we live. An excellent way to start protecting the environment is changing the environment you live in. What we did is that we designed a self-sustainable house where you can maintain your way of living while protecting the environment. This is a perfect idea as you can start implementing renewable energy sources that are good for the environment while you also save financially. Whit this project we would like to prove that there are a lot of affordable ways you can start saving energy in your house while not changing your standards of living.

## Mission Statement
The goal of our team is to make a zero energy home that meets the needs of the customer. We aim to make a home where the customer can save high amounts of energy while maintaining his standards of living and protecting the environment. With this project we would like to get the interest of individuals that want to find better ways to produce energy for their houses, making a solid market base.

## Customer Needs Analysis
By doing some research we found out that the customer's criteria were having an affordable home, save energy, low maintenance costs and certifications. They also want to maintain their standard way of living, so we tried to focus on implementing systems that did not need much maintenance or affected the way the customer lives. The customer wants to have a home in Philadelphia, for 4 persons and with a budget of $200,000.

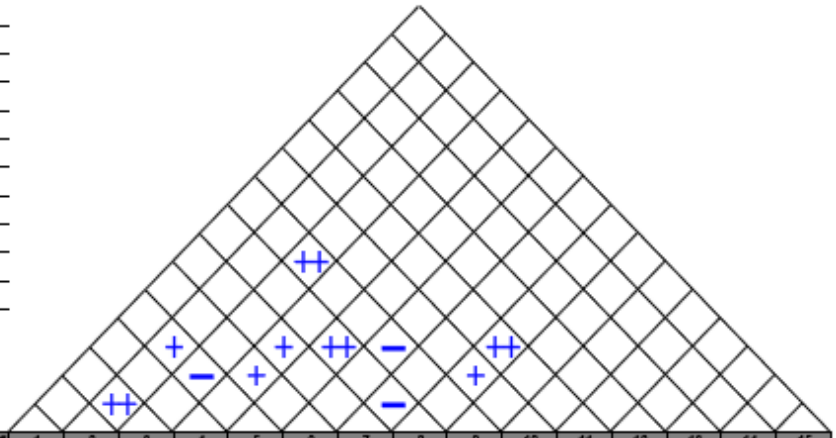
We plan on implementing solar energy systems, geothermal heating systems and design strategies to make a home that is better for the customer. These systems, when used the right way, are affordable, they save energy and have low maintenance costs. When focusing on the design of the house the costumer wants it to look good, so we will focus on having big windows, a sunroom and a design that helps save energy.

The customer also wants to have an efficient lighting system and some appliances, so we did some research to find efficient lightbulbs and efficient appliances with low costs to help the customer save energy and money.

Our main goal is to satisfy the customer by implementing systems that are affordable, save energy and does not affect the aesthetic part of the house.

## House of Quality

Title:
Author:
Date:
Notes:



| Row # | Max Relationship Value in Row | Relative Weight | Weight / Importance | Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Quality Characteristics (a.k.a. "Functional Requirements" or "Hows") | 1 Low budget | 2 solar panels | 3 geothermal energy | 4 energy star appliances | 5 large square footage | 6 two stories | 7 cost per square foot | 8 efficient light bulbs | 9 sun light | 10 sunny area | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Direction of Improvement: Minimize (▼), Maximize (▲), or Target (X) | X | X | X | ▲ | ▲ | X | ▼ | ▲ | ▲ | X | | | | | |
| 1 | 9 | 14.3 | 5.0 | Located in Pennsylvania | | | | | | | | | | Θ | | | | | |
| 2 | 9 | 14.3 | 5.0 | Under $200,000 | Θ | | | | | | Θ | | | | | | | | |
| 3 | 9 | 14.3 | 5.0 | Zero energy home | | Θ | ▲ | Θ | | | | Θ | Θ | | | | | | |
| 4 | 3 | 11.4 | 4.0 | Family of four | | | | | O | O | | | | | | | | | |
| 5 | 3 | 11.4 | 4.0 | Comfortable living space | | | | | O | | | | | | | | | | |
| 6 | 9 | 8.6 | 3.0 | Low maintinance | | | | Θ | | | | | | | | | | | |
| 7 | 9 | 11.4 | 4.0 | Efficient systems | | | | Θ | | | | Θ | Θ | | | | | | |
| 8 | | 5.7 | 2.0 | Good looking exterior | | | | | | | | | | | | | | | |
| 9 | 9 | 8.6 | 3.0 | Reduce energy | | Θ | | Θ | ▲ | O | | Θ | Θ | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | |
| | | | | Target or Limit Value | Under budget | produce a net energy | too costly | reduce energy | hard to heat and cool | more efficientlo heat and cool | lowest as possible | reduce energy | save on power | to power panels | | | | | |
| | | | | Difficulty (0=Easy to Accomplish, 10=Extremely Difficult) | 2 | 3 | 10 | 1 | 7 | 5 | 4 | 1 | 1 | 3 | | | | | |
| | | | | Max Relationship Value in Column | 9 | 9 | 1 | 9 | 3 | 3 | 9 | 9 | 9 | 9 | | | | | |
| | | | | Weight / Importance | 128.6 | 205.7 | 14.3 | 385.7 | 77.1 | 60.0 | 128.6 | 308.6 | 308.6 | 128.6 | | | | | |
| | | | | Relative Weight | 7.4 | 11.8 | 0.8 | 22.1 | 4.4 | 3.4 | 7.4 | 17.7 | 17.7 | 7.4 | | | | | |

## External Research

Our zero energy home will be able to save high amounts of energy by the use of sunlight as lightning for the house, heating and cooling. The sun can be used for this purpose by the use of geothermal heating and cooling systems or simply by positioning the windows strategically.

In the months of April to October sunlight can be used more than in the months of November to March. Windows in the house will be located to the south so we can take advantage of the sunlight. Also skylights will be located in specific spots so we can use sunlight in different angles. As in the summer temperatures are higher, we have to use different shades for the windows, one that is light, that will be used in the day; and another that is isolated, that will be used in the night and winter months.

The most important system in our house for cooling and heating will be the geothermal. This system gets the energy absorbed from the sun by the ground to cool or heat the house. The heat absorbed by the ground is transported by a duct system with a pump as warm air. This heat will be transported to the house where it can be used to heat the house and water heating. For the cooling, the heat in the air of the house is absorbed by the ducts and transported to the ground or used for water heating. This system is ideal to control the house's temperature, but it also has a high cost as it consumes between 1000 and 2000 kWh per year.

Another alternative for heating used in the house is the use of a sunroom. Insulated sunrooms primary function is heating as they have vents that can be controlled so you can regulate the amount of heat air that enters the house. An important thing when making a sunroom is its glazing. For our sunroom we have decided that it will have a vertical glazing as it has more heat gain at night when the angle of the sun is low, and it is the moment when we most need the heat. Also it is the less expensive and best insulated for the winter.

To generate the energy for the house we decided to lay on solar panels as they are the most efficient and ecological way to get energy. For our house we will use solar panels that can be adjusted during the seasons so we can take more advantage from the sunlight. Our solar panels will be tilted to the south as our ZEH will be in the northern hemisphere. This solar panels will be used to power our geothermal system and lightning system which will have LED lights to maximize efficiency and have less energy consumption.

## Patents

Geothermal systems patent was published on March 8, 1983 and given to James Downing, Jr. Another patent of this kind of system was given to Joseph Matula on October 16, 2013. His system had two circuits that used fluids and a pump. The last patent was given to Larry Simpson on November 4, 2014.

The patent for the sunroom with the specifications we are using was given to Dale Schneider on February 24 of 2000.

## Benchmarking

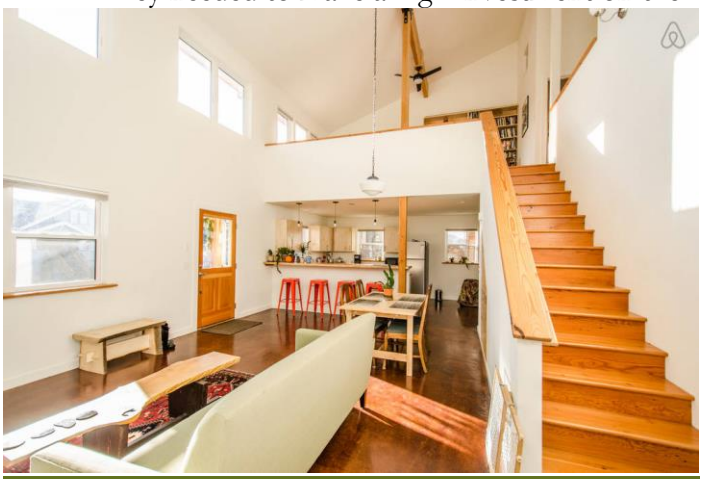
For our research we looked for famous ZEH located in places with climates that are similar to the ones in Philadelphia. Some of the ZEH we looked at are:

## InVision Zero Home in Midland, Michigan

- This zero energy home has a really simple design that makes it affordable. It was made to prove that you could make a zero energy home with lower costs.
- Has a geothermal heat pump for heating and an air exchanger.
- This house was designed so you do not need to generate a lot of energy. It was made focusing on the house's insulation and air sealing.
- It is a solar powered ZEH.
- They used a lower capital to make it, compared to the capital used in other ZEH.

## Zero Energy Ballard Home in Seattle, Washington

- It produces more energy that what it consumes.
- It uses solar energy with a line of solar panels in the roof.
- Many recycled materials were used on the construction of this home.
- It has two power lines so during the summer they feed power back into the grid.
- They needed to make a high investment on the house as they nearly spent $400,000.



## Zero Energy Vermont House

- The original purpose of this project was to make a house that has a low environmental impact while maintaining a high level of design and detail.
- It uses a geothermal heat pump, high efficiency lightning and appliances.
- It is a super insulated passive solar house as it allows southern lights to enter the house.
- It uses a 10 KW wind turbine to generate energy.
- It has a net zero energy use.

Some things we found useful about this houses where it's heating systems, insulation systems and energy generation. We decided that a geothermal heat pump would be ideal for our home. Also we decided to use solar panels as we realized it is the most efficient way to generate energy. Other things we implemented in the house by using this examples were high efficiency lights and appliances, use of sunlight and air sealing.

## Concept Generation

Our mission is to develop a zero energy home. The home must be located in Pennsylvania. And the home can also generate energy that equal or more than the annul energy cost of it. For creating a zero energy home, a lot of choices were considered before make the final decision. We must find a plan that is enforceable. That is, the materials to generate the energy must be cheap and accessible and the energy that generated must be clean. We must also create a home that is aesthetically pleasing, since most people choose homes on their appearances. The zero energy house system will generate the energy in the future so that the cost of equipment will pay back. But the cost of the equipment must be worth the function it has (clean energy, low cost to obtain and operate). For the sustainability, we will use the energy that will consume less material from natural. The lists below are the possibilities about the house's design.

The first decision was about energy.

- Solar
- Water
- Bioenergy
- Gas
- Wind
- Nuclear

- Wood
- Chemical energy

The second decision for our house was location.

- Most sunny place (Harrisburg & Philadelphia)
- Farmland
- Hilltop

The final and the most important decision was finance.

- Using solar panel
- Make a great vent system
- Make a garden and using the resource to provide house need
- Make a digesters and recycle waste
- Most of part to build our house was recyclable

## Concept Selection

Power selection

The list above is the concept select about our power selection. The decision we use is decided about the Net total. Therefore, the decision about our house's power is Solar. The bioenergy is still good but it will take a large place and cost a lot of money. We concluded through Homer that solar energy would produce enough energy to allow our house to become a net zero energy home.

| Evaluations criteria | Solar | Water | Bioenergy | Natural gas | Wind | Nuclear | Wood | Chemical energy |
|---|---|---|---|---|---|---|---|---|
| Energy efficient | + | - | + | + | + | + | 0 | 0 |
| Energy production capabilities | + | + | + | + | + | 0 | + | 0 |
| Cost | 0 | - | 0 | 0 | 0 | 0 | 0 | 0 |
| Ease of installation | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| Practical in most situations | + | 0 | - | - | - | - | - | 0 |
| Sum +'s | 3 | 1 | 3 | 2 | 2 | 1 | 1 | 0 |
| Sum 0's | 2 | 2 | 1 | 2 | 2 | 4 | 3 | 6 |
| Sum -'s | 0 | 2 | 1 | 1 | 1 | 1 | 1 | 0 |
| Net total | 3 | -1 | 2 | 1 | 1 | 0 | 1 | 0 |
| Continue? | yes | no | no | no | no | no | no | no |

In regards to our location selection, we decided to select in the sunny place like outside of Philadelphia. It has the most sun light on average throughout Pennsylvania. Solar is the most important energy in our house and the solar panels are cheap in comparison to other methods such as biogas. Also, the energy efficiency with the solar panel is higher than others.

Finance

| Evaluations criteria | Using solar panel | Make a great vent system | Make a garden | Make a digester | Using recyclable material |
|---|---|---|---|---|---|
| Convenience | + | - | - | - | - |
| Easy to repair | + | - | + | - | + |
| Cost | + | + | + | - | + |
| Recycle | + | + | + | + | + |
| Sum +'s | 4 | 2 | 3 | 1 | 3 |
| Sum 0's | 0 | 0 | 0 | 0 | 0 |
| Sum -'s | 0 | 2 | 1 | 3 | 1 |
| Net total | 4 | 0 | 2 | -2 | 2 |
| Continue? | yes | yes | no | no | yes |

The list above is about our important financial decision. We chose the all idea except a digester. The reason for that is digester will cost a lot of money and the biogas energy efficiency is lower than Solar.

## Design Description

According to the plan, we will build our zero energy home in Philadelphia, PA. It is a two stories house and can provide a family (four person) to live in. The first floor will have one kitchen, two bedrooms, a living room and a bathroom, having a total square footage of 1160. The second floor will only contain one bedroom and one bathroom and it has a total square footage of 460. There are many windows on the side south of the house to allow light to enter. We will have many windows on the south side of our home to allow the most amount of light in as possible. Since this would make the house hotter in the summer, we have blinds that reflect the sun's rays back out so the house can still stay cool in the summer. On top of the roof, we will have 390 square feet solar panel and 500 square feet plant because in this way we can insulate the house from outside and large partly use the solar power. This system will be a 4 kilowatt system so we can generate the power necessary to have this home be zero energy.

The material of the outer wall will be vinyl siding, it can provide necessary insulation and the cost is cheap. We will be using Energy Star appliances (washer, refrigerator, stove, oven, microwave) since they are the most efficient appliances available and allow the family to use the least amount of energy possible. LED lights throughout the home will furthermore help with this since they use the least amount of energy compared to CFL and incandescence light bulbs. For the solar panels, we will use energy star because solar panels in this brand can provide more energy translation compare

to other brands. What's more, the movable walls inside the house will increase the space that use, it can be easily moved and locked, fit the future needs of adjustment.

The energy generated by the house will be 5,042 kWh, compared to the total energy purchased, 3,211 kWh, for one year. And the cost of the house is $189,000, which includes everything mentioned in the design description.

## Conclusion

The final product ended up a success as it fit the needs of consumer, as it was an energy generating and comfortable house located in Philadelphia, while still maintaining the cost of budget. We spent a total of $189,457 on our design, so there is room for problems along the way. We focused on the full use of solar power because it will benefit the environment a lot, we don't need to consume anything to get the material of generating, and the power we get comes from outside of the system. Although the house considered to be net zero energy, it actually produces more energy than needed. We produced about 5,042 kWh per year and only calculated the use of 3,211 kWh. This gives the family much energy to sell back and room if they use more energy than calculated. The family can then sell back this energy and make money.

We would have to give instructions to the family so they know how they are supposed to use the power in their home. This family may have a habit of using a lot of electricity in their previous house, but this home will not be a zero energy home if they continue to do that. Simple things such as shutting off the lights once they leave a room and setting the house to a cooler temperature during the day when no one is home, will keep the house running as a zero energy home. As long as they do not use an excessive amount of power, they will have no problem selling back power to the electricity company. All in all, the model will be an example of zero energy house and might applied in the future usage of ZEH.

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