

Zero Energy Home
EDSGN 100, Section 20
Professor Etienne

Courtney Elsasser, Kelly Kowalski, Stephen Lonati, Johnna Morales

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Abstract:

Over the course of time, humans have always been very dependent on natural resources. This has become more prevalent over the past century, with new inventions using these natural resources, such as cars using gasoline. These resources have dwindled over time and will eventually die out if we keep using them at the same pace we have used them in the past. One of the many precautions put into place to be more eco-friendly is the zero energy home. This home is a house that produces all the energy required to run it through technologies such as solar panels, geothermal energy, wind energy, and more.

Introduction:

Since being assigned this project in the beginning of the semester, our group has been busy researching zero energy homes. We have discovered what the best layout for a zero energy home is, what alternative energy works well in certain areas, what new environmentally friendly appliances for the home have been invented, and so much more. We have explored every step of what goes into a project.

Mission Statement:

Our mission statement is to create a zero energy home in Pennsylvania that is suited for a family of four, and costs under \$200,000 to build.

[illegible]

Figure 1: House of Quality outlining customer needs, engineering metrics, and importance.

The house of quality is a very important part of the design process. This visual allows one to be able to clearly picture what the customer desires to be in their home. For this zero energy home, the customer needs it to be less than \$200,000, fit a family of four, have two bathrooms, and most importantly be zero energy. The house of quality also allows one to see if all of the customer specifications are being met. It ranks the importance of these specifications so it is easy to tell which ones are most important to implement in the design. Another important part of the house of quality is the section that compares your house/product to others on the

market. This shows how your product lines up against the competition. Overall, the house of quality is a very important and useful tool that can be used during the design process.

Conceptualization:

Before designing the house, the group first brainstormed methods of energy production. The main three methods we decided to focus researching on were the solar panels, the radiant flooring, and using geothermal energy for heating and cooling. The details of the design for the zero-energy home started coming together after finding an in-depth article about a zero-energy home in Washington State¹. This home had used argon gas windows, and radiant flooring to heat their entire house. However, with the radiant flooring the family had no air conditioning and while, that may work in cooler states; in Pennsylvania the summer-time weather is just too hot to save energy by not installing an air conditioner. This information was the deciding factor in how the house was going to be heated and cooled. After the deduction we would receive from both the state and federal government was applied, installing the geothermal system will cost \$18,000.

Through this house and others like it, we were able to determine what layout would be the best for our house. Many net zero energy houses were no more than one floor tall, and many lacked basements as well. With this in mind, we decided on a simple one floor house to help cut down on construction costs as well².

One zero-energy home website mentioned that building the entire roof on an angle would be the best way to optimize energy taken in from the sun, and we decide to take advantage of this when designing the roof.

The interior of the house we've designed was based on the blueprints of another net zero-energy home. It was a simple floorplan, with only four outside walls, a box shape to reduce outside surface area. We changed very little of the floorplan, except for the attached garage which we eliminated completely as many websites agreed that garages were not energy efficient and significantly added to the number of kilowatt hours a year used in the house.

Renewable Energy:

After researching different methods of producing or saving energy to make our home a zero net energy home, we came to the conclusion that the best methods were to use solar panels and geothermal to heat, cool, and power our house. Although there were many other options for producing energy, such as wind turbines and hydroelectric, these options did not work because of our geographic constraints. Because our home had to be in Pennsylvania, where there are not many fast running rivers for hydroelectric power, and minimal wind speeds for wind turbines, we had to go with other options.

One thing that really stood out to us when researching methods of generating energy was Solar City. Solar City is a company that rents the roof space of a home to install solar panels with no cost to the homeowner. Not only do the solar panels come free of charge to the homeowner, but they also save the homeowner money in energy bills. If the solar panels produce more energy than the homeowner can consume, the additional energy is sold back to the grid, which can even give the homeowners a profit. We chose our location in Pennsylvania based on where Solar City was able to install solar panels on the house; therefore, we chose Broomall, Pennsylvania. Broomall is in southeast Pennsylvania.

Although the energy coming from the solar panels is a great amount, it is still not enough, so we turned to geothermal. For only \$18,000, after the government reimbursement on geothermal installation, our home has geothermal for its heating and cooling. This saves us about 2900 kWh per year on heating and cooling.

Design:

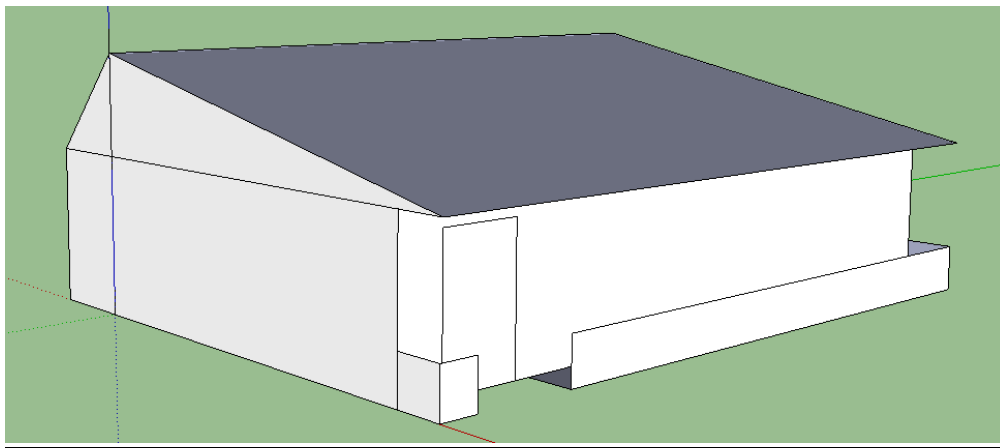


Image 1: Outside of Zero Energy Home, designed in SketchUp

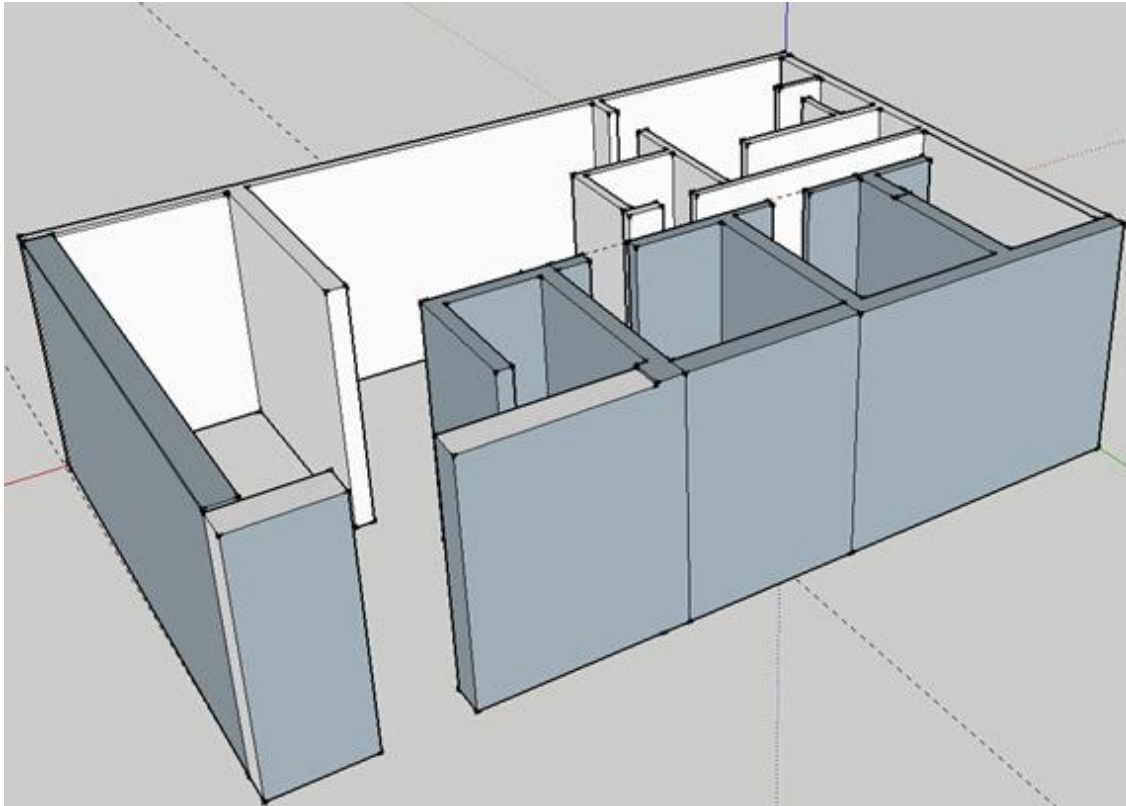
The house we designed is optimized for zero energy with one floor, with a roof that is slanted and angled towards the south in order to make the best out of the solar panels that we have on the roof. The house is 47 by 27 feet or 1300 total square feet.

For our insulation, we decided on using faced fiberglass batts. The additional face on this insulation will aid in moisture reduction within the home, lowering our heating bill. This insulation will be used both in the walls and underneath the flooring to make sure the house is not drafty and repels moisture³. In total, we would need about 2800 sq. feet for both the walls

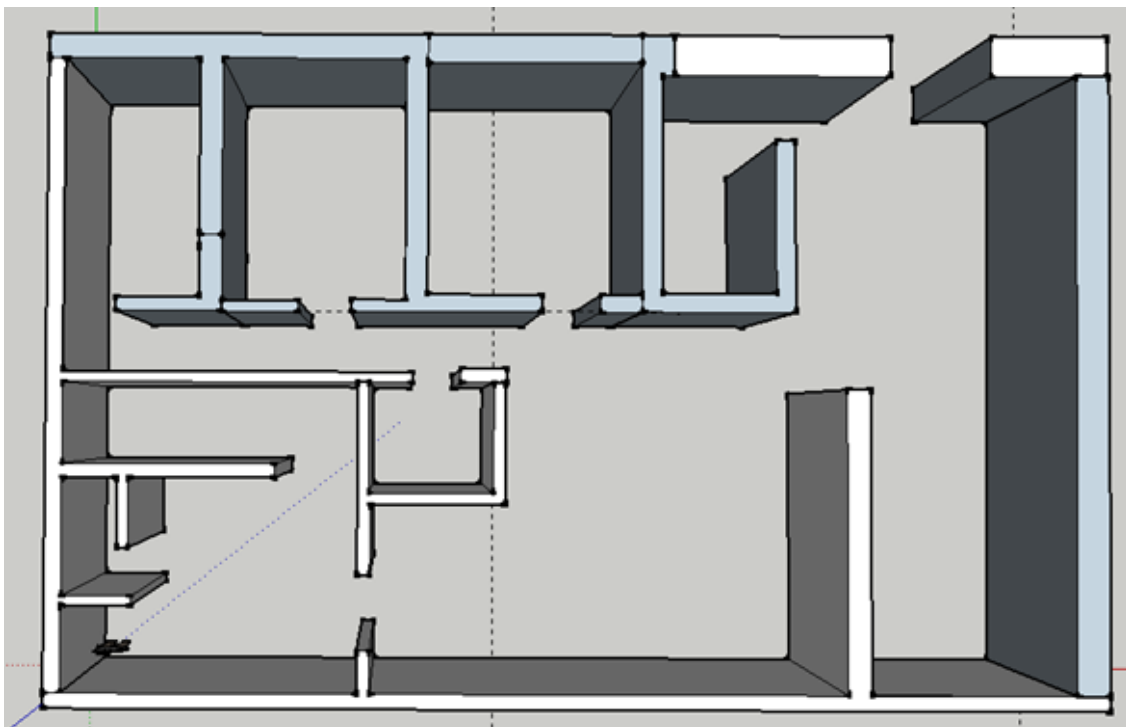
and the flooring, which will come up to less than \$2000⁴. For our windows, we decided to use the Jeld-Wen V4500 series single hung vinyl frame windows⁵. These windows come insulated with argon gas, which helps to keep the temperatures inside the home constant. We are planning to have about 16 windows in the entire house, so the cost for all of the windows is about \$2386.40. For the outside of the house, we will be using insulated vinyl siding⁶. Although this type of siding is pricier than regular siding, the investment will pay off in the long run, due to the durability of the siding, along with its role in aiding to help insulate the home even more. This type of siding costs about \$3-8 per sq. foot. The roof shingles we chose for our home are environmentally friendly and more durable than regular roofing⁷. Enviroshake singles for our whole roof would only cost about \$30,000, and would also benefit our home since it needs a sturdy roof in order to have the solar panels mounted onto them.

For around our house, we will be planting trees to help insulate the house even more. During the summer, the leaves of the trees will help to block the sunlight out of the home, while during the winter, the lack of leaves invites the sunlight into the home in order to help heat the home. These trees would help lower our heating and cooling costs, as well as provide pleasing scenery along with fresh fruit when the trees are in bloom. We will be planting seven trees in total around our house, two cherry trees and five oak trees, and this will cost approximately \$150. In addition to the trees for around our home, we will also be planting a garden in our yard. This will help to promote outdoor activity, and help to lower emissions in the air by not buying imported foods and not using the car to get groceries. For our garden, we will grow cucumbers, tomatoes, corn, strawberries, and raspberries. In total, the seeds and plants for our garden will cost about \$105.

Layout:



Images 2 and 3: Inside of Zero Energy Home designed in SketchUp



The inside of our house has three bedrooms, two and a half bathrooms, a vaulted living room, a study, a kitchen, and a mud room. The whole house is one floor. This is more energy efficient because heat and air only have to floor through one, simple floor.

All of our bathroom appliances are Delta brand. They have WaterSense certification, which promotes water conservation. This includes the two shower heads, three faucets, and three toilets.

Our kitchen is where most of the energy efficient appliances are. There is a self-cleaning oven. This oven's insulation is thicker than a regular over, keeping all of the heat in instead of releasing it to the surroundings. The refrigerator is extremely energy efficient; it uses ten percent less energy than the minimum federal efficiency standards. The microwave goes over the oven, to conserve the energy between the two. The kitchen does not come equipped with a dishwasher because they are very inefficient. Dishwasher use a lot of water between the wash and clean cycles and the excess is discarded instead of reused.

In the mudroom, there is an Energy Star washer and dryer combination. This appliance circulates warm energy in, which is converted to water and does not need to be vented. It only needs cold water so no extra energy is spent warming the water up.

The flooring of the whole house, except for the bedrooms and bathrooms, is bamboo flooring⁸. This flooring is around the same price as regular wood flooring, however it is better for the environment because bamboo trees grow at an astonishing rate of about three feet per day.

Energy Usage:

To discover how much energy we needed to produce per year to cover heating and cooling costs we used an online calculator which allowed you to put in the appliances in use and the wattage and then it calculated how much energy you would need to cover the costs. Every year, the home uses about 5500 kWh of energy per year⁹. This may sound like a lot, but by using geothermal alone, we were able to save about 2900 kWh of energy per year. The solar panels that are on the roof produce the rest of the energy plus more to make our energy production greater than our consumption. After installing a geothermal system, we would need a 4kw system to cover the rest of our energy needs. This system would be installed by Solar City at no cost to us.

Conclusion:

In conclusion, we were able to design our zero energy home in Broomall, Pennsylvania for under \$200,000. Our total cost for the home was \$194,416.30, which is about \$5000 under budget. Our energy consumption before taking into account the energy produced from solar panels and geothermal is 11,374 kwh per year; however, thanks to the solar panels and geothermal, we are able to produce that and more, making our net energy consumption zero.

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