Zero Energy Home Project

EDSGN 100: Section 16

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Team 5: Terrible Trio + 1

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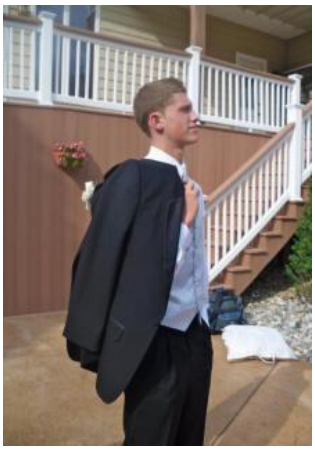

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Abstract

In a time where people are starting to become more aware of Earth's limited resources, many are starting to turn to *Zero Energy Homes*. The home's main goal is to have zero net energy consumption per year, which basically means to produce as much energy as it consumes. Our project ultimately provides what we believe to be the best possible design for a Zero Energy Home.

Mission Statement

Our team's mission is to design a zero energy home for a family of four in Philadelphia, Pennsylvania. Our main priority is to have the family live comfortably with all necessary amenities, while at the same time yielding an annual net charge of zero.

Introduction

This report provides all of the steps our team took to turn our research and brainstorming into a model creation of an ideal Zero Energy Home. All of our ideas and thoughts that have gone into the home design are clearly expressed, as well as our understanding and usage of the engineering design process.

Preliminary Research

Location (city, state)	Charlotte, Vermont
House size (floor area in square feet)	2800
Number of floors	2
URL of web site where info is found	http://www.wbdg.org/references/cs_ch.php
Number of occupants	Single Family
Number of bedrooms	N/A
Type of heating system (forced air, radiant floor, heat pump, etc.	Ground Source heat pump
Main heating fuel (electricity, natural gas, wood, oil, etc.)	Electricity
Size of photovoltaic system (kilowatts)	None - Used wind
Solar water heater (yes or no)	No (Geothermal)
R-value of wall insulation	40
R-value of ceiling insulation	40
Ventilation air heat recovery (yes or no)	Yes
Predicted or measured annual energy use	5,999 kWh
Any other pertinent info	

Location (city, state)	Lebanon, New Jersey
House size (floor area in square feet)	4,200
Number of floors	2
URL of web site where info is found	http://www.collegepublishing.us/jgb/samples/JGB_V5N2_b01_hoque.pdf
Number of occupants	Single Family
Number of bedrooms	4
Type of heating system (forced air, radiant floor, heat pump, etc.	Air & Solar Thermal

Main heating fuel (electricity, natural gas, wood, oil, etc.)	Electricity
Size of photovoltaic system (kilowatts)	9.8 kW
Solar water heater (yes or no)	Yes
R-value of wall insulation	40 °F-ft^2-hr/BTU
R-value of ceiling insulation	56 °F-ft^2-hr/BTU
Ventilation air heat recovery (yes or no)	No
Predicted or measured annual energy use	5, 999 kWh
Any other pertinent info	

Technologies

I. Insulating Concrete Form
   a. R-Values from R-16 to R-34
   b. Reduced Heating and cooling costs
   c. Minimal air infiltration
   d. Long-term durability
   e. No food source for insects
   f. 4 hour fire rating
   g. Uses 40% less concrete

Solar Water Heater: provides a significant amount of your household hot water needs for a large portion of the year. It costs between $1,500 and $3,500, while electric and gas heaters range from $150 to $450. Solar water heaters pay for themselves within four to eight years by saving money on natural/electric gas.

Geothermal Heating/Cooling System: geothermal pump is a central heating and/ or cooling system that pumps heat and/ or air to or from the ground.

Energy Star Appliances: appliances that save you money by using less electricity and water than other similar appliances. There is also a better appliance energy efficiency that comes from better quality and technology advanced materials.

Photovoltaic cells: uses solar cells to convert light to electricity. Consists of cells, electrical and mechanical connections, and means of regulating and modifying the electrical output of a home.

Rain Water Collective System: rainwater is collected in vessels at the edge of the roof. The water is collected in the gutters, and then drained into the collection vessel through downward pipes.

Needs –Metric Matrix

	Photovoltaic System	Large Arched Glass	3 bedrooms	Stainless Steel Appliances	Large Slate Surface Area Floor	1500 square feet	Solar Water Heating	Energy Star Appliances	Wind Energy	Wall Insulation	Open Living Space	Philadelphia
The ZEH provides enough energy for itself, an electric car, and excess	x				x		x	x	x	x		
The ZEH is solar and built in PA	x	x			x		x					x
The ZEH is for a family of four			x			x					x	
The ZEH is self-sustainable by the principles of green energy	x				x		x	x	x	x		
The ZEH is attractive to live in		x	x	x		x					x	x
The ZEH must function, but also be aesthetically pleasing	x	x	x	x	x	x	x	x	x	x	x	x

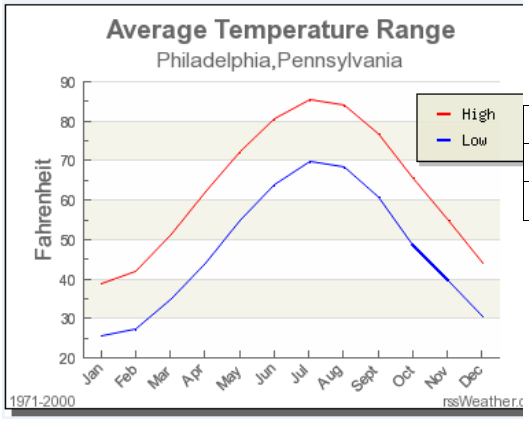
Need	Importance (0-5)
The ZEH provides enough energy.	5
The ZEH is solar and built in PA.	3
The ZEH is for a family of four.	3
The ZEH is self-sustainable.	4
The ZEH is attractive	2
The ZEH is aesthetically pleasing.	3

Concept Selection

Type Of Energy	Cost	Efficiency	Feasible	Final Design
Wind Power	X			No
Solar Power	X	X	X	Yes
Geothermal		X		No
Solar Water Heater	X	X	X	Yes
Ranch Style House	X	X	X	Yes
Multi-Level Home		X	X	No

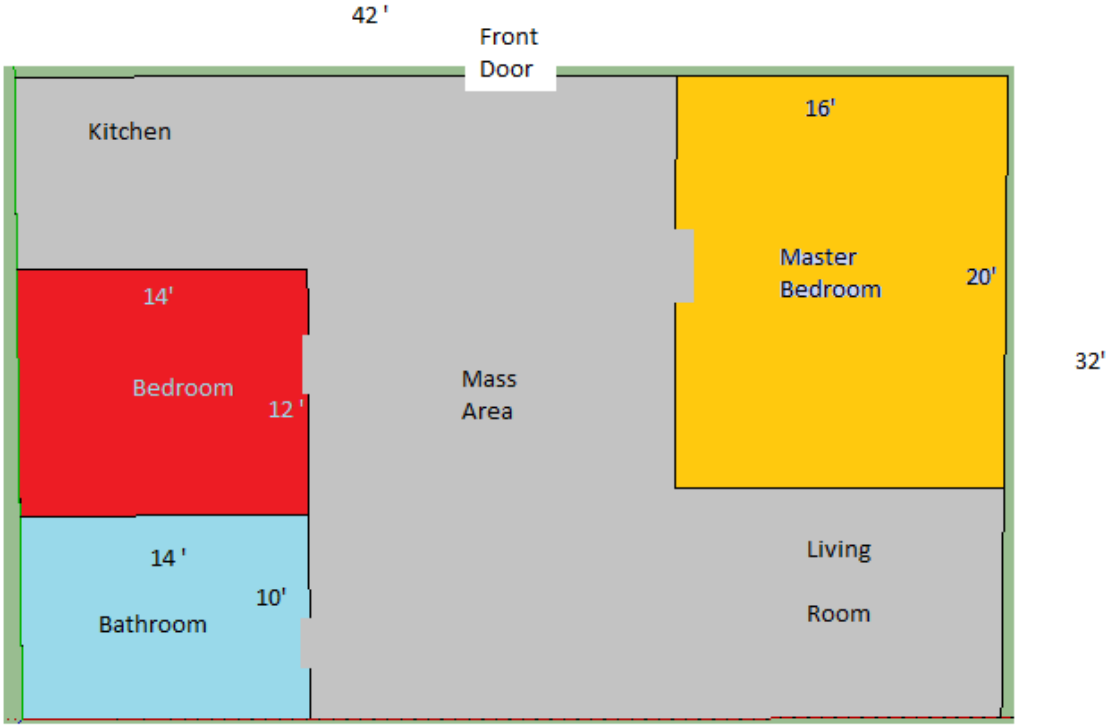
Concepts	
Interior	Hardwood floors in bedrooms, heat conductive slab everywhere else except the bathroom.
Interior Structure	Very open, two bedrooms
Interior Appliances	Stainless Steel Appliances
Exterior	Stone-faced
Structure	One story, arched roof
Landscape	Large yards with trees

Location

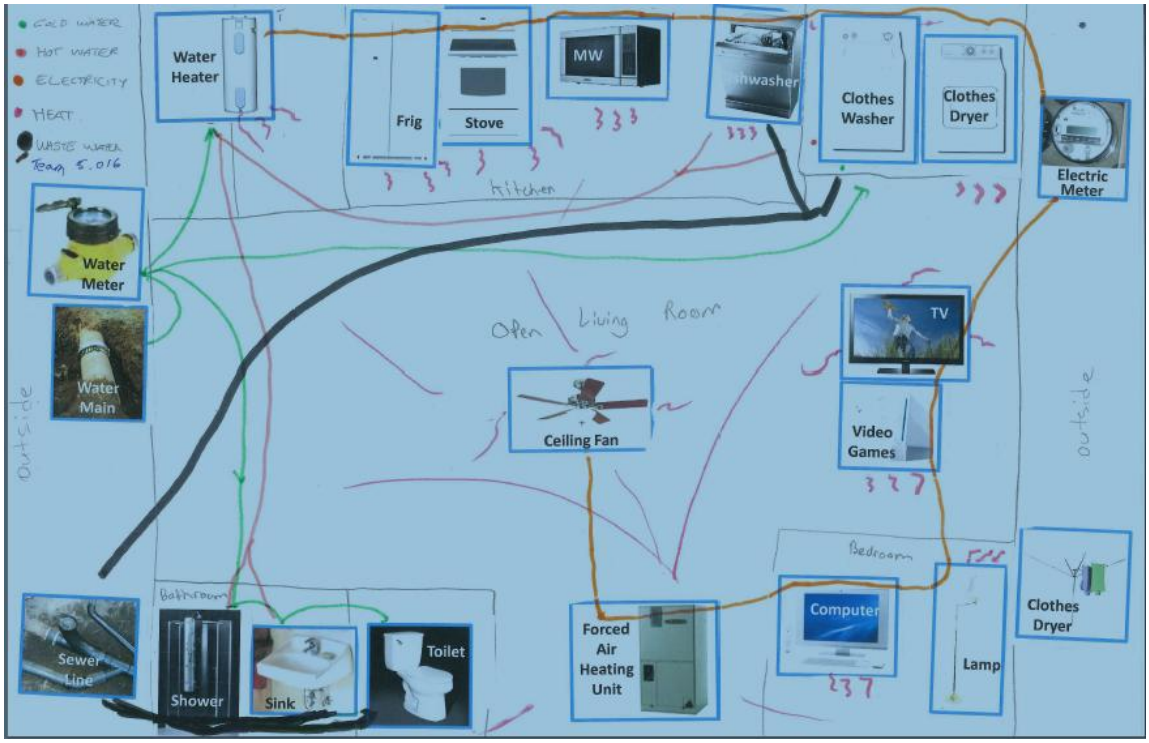


Philadelphia, Pennsylvania	
Average Rainfall per Year	42.05 inches
Average Sun Hours per Day	4.3 hours

Floor Plan



Energy Flow

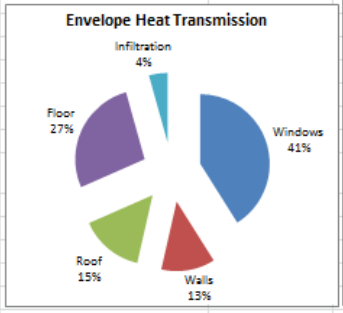


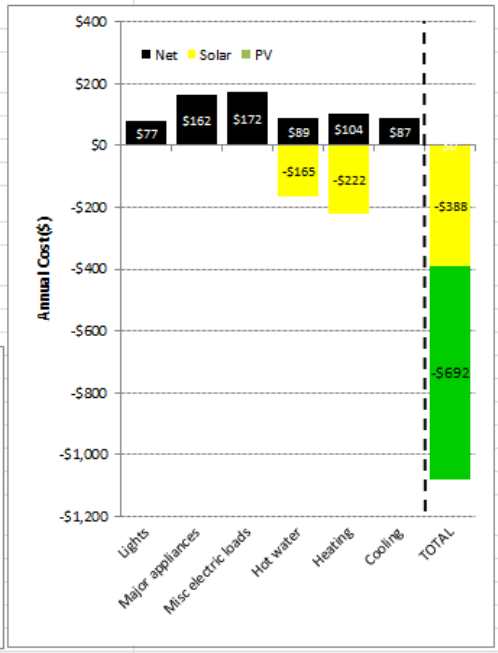
Photovoltaic System

Penn State Center for Sustainability — Zero Energy Home Calculator

General Info	
Location	Philadelphia
Electricity cost ($/kwh)	0.1
Conditioned floor area (sq.ft.)	1152
Number of bedrooms	3
Envelope Details	
Wall construction	Double 2x4 with 10" foam
Ceiling Insulation	R60
Window type	Super double low-e
Upper floor ceiling area (sq.ft.)	1593.5
North wall area (gross) (sq.ft.)	480
East wall area (sq.ft.)	320
South wall area (sq.ft.)	80
West wall area (sq.ft.)	320
North window area (sq.ft.)	0
East window area (sq.ft.)	0
South window area (sq.ft.)	320
West window area (sq.ft.)	0
Air tightness	Tight with heat recovery
Appliances	
Refrigerator	Best
Clothes Washer	Best
Dishwasher	Best
Amount of other appliances	A lot less

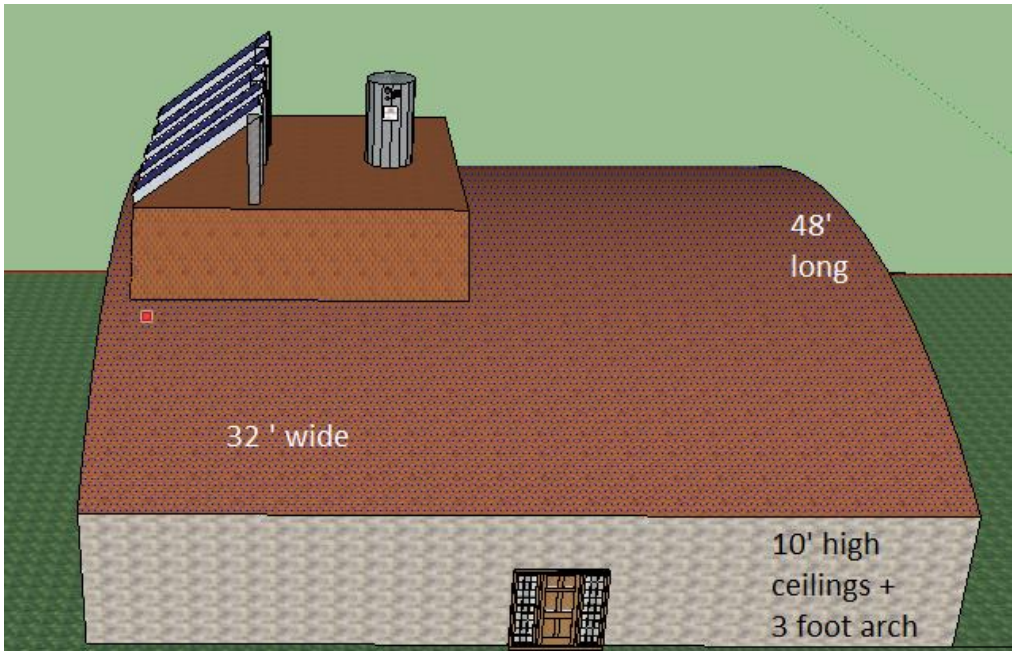
Heating & Cooling	
Type of heating & cooling system	Electric resistance
Solar Technologies	
Size of PV system (kw)	5.2
Solar water heater	Yes
Behavior	
Water conservation	A lot
Uses clothesline	A lot
Thermostat setback	A lot
Heat thermostat setting (F)	68
Cool thermostat setting (F)	76



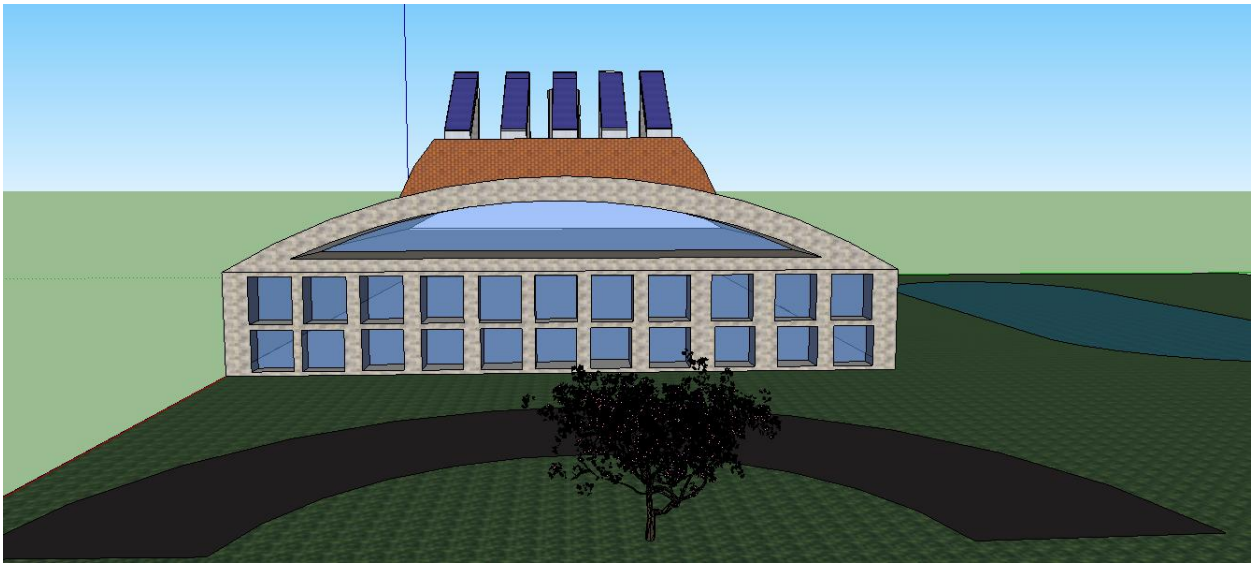


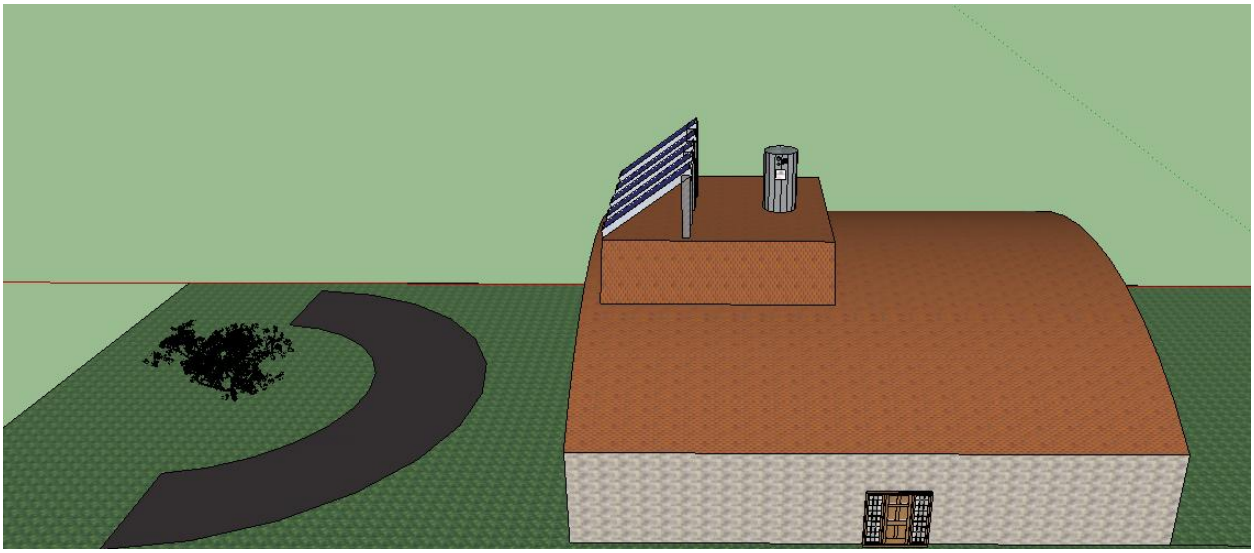
Manufacturer	Single Panel Cost	Model Number	Rated Power (W)	Area (m^2)	Cost /W	Efficiency	Total Panels Needed	Total Area (m^2)	Total Panel Cost
First Solar	$343	Fs-280	280	0.72	$1.23	11.10%	19	13.69	$6,517

Concept Dimensions



Final Concept





Final Description

When people think of a Net Zero Energy Home, chances are they do not envision the design presented by Team 5. The most unique aspect of the design lies within the curvature of the roof, a necessary feature to accommodate for the entire South-Wall being windows. This creates a very unique design that will provide a great view for occupants. Team 5's "barrack-like" structure allows for 1600 ft^2, allowing a full bathroom and a luxurious master bedroom, plus a normal bedroom for two children. The overall theme of the house can be summed up in one word: open. The only walls on the interior of the house are for the bedrooms and the bathroom. This was yet another reason that the arch design was needed to provide structure for the house without interfering with the open nature of the house. The interior of the bedrooms will have beautiful hardwood floors, the bathroom will have tile, and most importantly the rest of the floor will be covered in a conductive slab, which will allow the solar heat brought in by the windows to be spread across the house. The house will have the best insulation available, insulating concrete foam. Another important aspect in designing a Zero energy home is within the appliances within the house. This state-of-the-art house will only have appliances labeled "Energy-Star" and will house a solar water heater on the roof to decrease the amount of energy needed. The final aspect of the house will be the photovoltaic system, namely 19 solar panels facing the South that will bring in 5.2 kW of energy per year.

Conclusion

The initial thought of a Zero Energy Home can seem futuristic and unattainable, this project demonstrates that these types of homes already exist and with little sacrifice, anyone who believes in green technology can own a home that is self-sustainable. A second very important concept that is very clear throughout the project is the idea of conservation and how engineering will play a huge role in the future if the world as it is known as today is to continue. Society needs to make a big change towards its attitude of green energy, and as the video of "The Story of Stuff" showed, the entire culture needs to be changed, or there will be severe consequences. Finally, as with any project, one of the most important aspects has nothing to do with the topicality of the project: teamwork. The nature of the Zero Energy Project allows everyone to become involved and present ideas about a common goal.

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