Zero Energy Home

EDSGN 100 Section 001

Team 8

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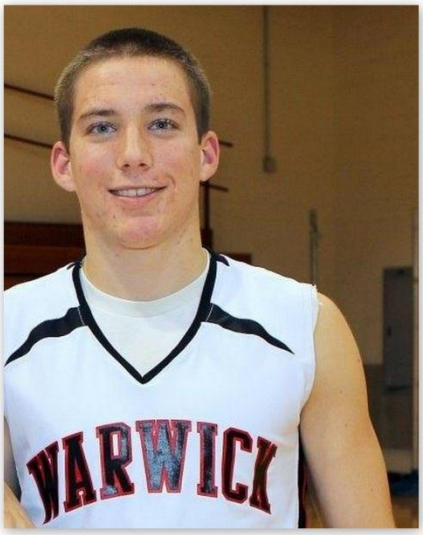

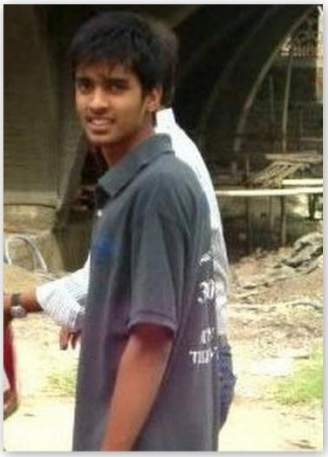

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Abstract

The focus of this development project was to design a zero energy home in the State College, Pennsylvania . External research on net zero homes, green technology practices, and cost estimates were done to develop a home which had a net zero energy use. Using the research we developed a two story home which is comfortable for a family. Our home's design has a slanted roof allowing for the most optimal space for solar panels. By doing this, our house created a net energy of zero and meets most of the needs of the consumers.

Introduction:

Zero energy homes are homes that have zero energy consumption and no carbon emissions. A zero-energy home is about as efficient as a house can get without giving up electricity altogether. It has all the comforts of a regular house -- it heats, cools, entertains, washes and dries. It just does it all more efficiently.

A ZEH is built from the ground up with energy efficiency in mind. It starts with the most basic design and construction elements, focusing on two major areas: reducing energy requirements for the systems that account for most of a home's energy use and increasing the home's built-in energy-generating capacity.

A ZEH incorporates:

- A solar-photovoltaic system for generating electricity
- A passive solar-thermal system for heating water

And it minimizes energy needs for:

- Space heating, space cooling and ventilation
- Water heating
- Lighting and appliances

The need for zero energy house

Zero Energy Homes are becoming more and more important as the resources are depleting. We are designing a home that will eliminate our dependence on those non-resources. And its low

carbon emission will help us reduce global warming which can be helpful for the entire world in a long run. Our goal is to build a home that produces more energy than it uses.

General Research

Zero-energy houses are houses with zero net energy consumption and zero carbon emissions annually. Traditional buildings consume about forty percent of the total fossil fuel energy in the US and Europe and are major contributors to the excess of gases that cause the greenhouse effect. Due to their ability to reduce carbon emissions and dependence on nonrenewable fossil fuels, zero energy houses are gaining popularity in countries throughout the world.

The energy for zero-energy houses are usually produced through energy-efficient technologies, such as solar and wind, while the construction of the house is focused on conserving energy and utilizing energy-efficient appliances. The zero-energy goal is becoming more realistic as alternate energy prices decrease, fossil fuel price increase and governments emphasize energy efficiency.

Zero-energy houses have become attainable not only through the developments made in alternative energy and construction technologies, but has also because of the significantly improved research in the field of energy efficiency, which collects precise energy performance data on traditional and experimental houses.

Global Marketplace

Zero-energy houses have gained popularity throughout the world in modern countries. Countries ranging from Malaysia to Iran have now put an increased importance on developing their zero-energy programs. In Canada, a program called the Net-Zero Home Coalition promotes zero-energy homes and standards. In 2006, England announced that by 2016 all new homes built will meet zero energy standards. Worldwide revenue from the zero-energy house market is projected to hit $690 billion by 2020 and then will nearly double by 2035. Clearly, zero-energy houses have been identified as a means to obtain a more sustainable world.

Customer Needs Analysis:

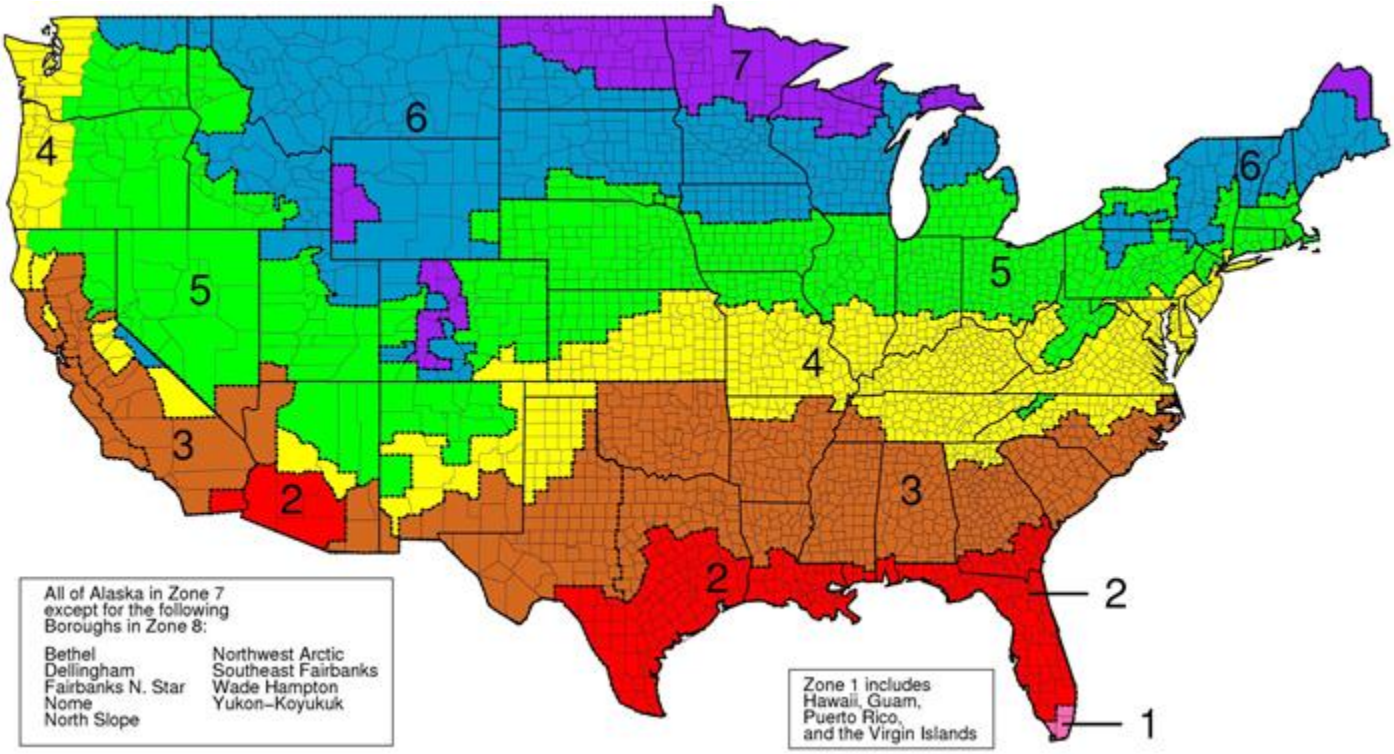
Based on a list of customer statements, we came up with a list of customer needs.

- It must be located in Pennsylvania.
- It should produce enough energy for a year and extra (Zero Energy).
- It should use Solar-power.
- It should house a family of four.
- It must Attractive looking.
- It should be Sustainable.
- Must have recycled and renewable resources used to make it.
- It shouldn't have byproducts.

<u>Background information</u>:

Location information:

Specified by the customer needs, we had to have the home located in Pennsylvania. We chose the location of State College, PA as a more specific location. The picture and chart below show the regions and their R-values.



Zone	Add Insulation to Attic		Floor
	Uninsulated Attic	Existing 3–4 Inches of Insulation	
1	R30 to R49	R25 to R30	R13

2	R30 to R60	R25 to R38	R13 to R19
3	R30 to R60	R25 to R38	R19 to R25
4	R38 to R60	R38	R25 to R30
5 to 8	R49 to R60	R38 to R49	R25 to R30

Wall Insulation: ***Whenever exterior siding is removed*** on an

Uninsulated **wood-frame wall:**

- Drill holes in the sheathing and blow insulation into the empty wall cavity before installing the new siding, and
- Zones 3–4: Add R5 insulative wall sheathing beneath the new siding
- Zones 5–8: Add R5 to R6 insulative wall sheathing beneath the new siding.

Insulated **wood-frame wall:**

- For Zones 4 to 8: Add R5 insulative sheathing before installing the new siding.

Based on this chart, a home located in State Colleg, PA should have relatively high insulation R-values. A home in this area should have an attic with r-values ranging from R49 to R60, wall R-values of R38 to R49, and flooring with R-values of R25 to R30. Knowing these values you can pick insulation.

External Research:

Existing Zero Energy Structures:

	Orleans, Massachusetts

Location (city, state)	
House size (floor area in square feet)	2000
Number of floors	1
URL of web site where info is found	http://zeroenergy.com/pmodlake.html
Number of occupants	4
Number of bedrooms	3
Type of heating system (forced air, hydronic, radiant floor, heat pump, etc.	Grid-tied Solar Electric System, Solar Hot Water System Plumbed, Radiant Floors, Hydro Air System, Energy Recovery Ventilator, Open & Closed Cell Spray Foam Insulation, Rigid Insulation, ENERGY STAR Certified HERS 39
Size of photovoltaic system (kilowatts)	2.5
Solar water heater (yes or no)	yes
R-value of wall insulation	50
R-value of ceiling insulation	60
Ventilation air heat recovery (yes or no)	yes
Predicted or measured annual energy use	

Any other pertinent info	Whole House Ventilation and Allergen Filtration System, Low or No VOC Materials/Sealants/Paints, Hard Floor Surfaces, Shoe Storage, Rainwater Management with Dry Wells, Motion Detection Ventilation in Bathrooms.

Location (city, state)	Turner Fall, Masssachussetts
House size (floor area in square feet)	1152
Number of	1

floors	
URL of web site where info is found	http://www.builditsolar.com/Projects/SolarHomes/MAZeroEnergy/MAZeroEnergy.htm
Number of occupants	2
Number of bedrooms	3
Type of heating system (forced air, hydronic, radiant floor, heat pump, etc.	passive solar heated and cooled; Fujitsu 9RLQ mini-split air source heat pump; sunmate hot air solar panel
Main heating fuel (electricity, natural gas, wood, oil, etc.)	solar, electricity
Size of photovoltaic system (kilowatts)	4.94
Solar water heater (yes or no)	yes

R-value of wall insulation	42
R-value of ceiling insulation	100
Ventilation air heat recovery (yes or no)	yes
Predicted or measured annual energy use	1949 kilowatts per year
Any other pertinent info	4892Kilowatts of energy produced per year

Location (city, state)	Hudson Valley, New York

House size (floor area in square feet)	
Number of floors	1
URL of web site where info is found	http://www.thenewyorkgreenadvocate.com/2010/01/fantasy-or-reality-zero-net-energy_30.html
Number of occupants	
Number of bedrooms	
Type of heating system (forced air, hydronic, radiant floor, heat pump, etc.	Fireplace, geothermal heating
Main heating fuel (electricity, natural gas, wood, oil, etc.)	Solar photovoltaic system for electricity
Size of photovoltaic system (kilowatts)	8.5
Solar water heater (yes or no)	yes
R-value of wall insulation	26
R-value of ceiling insulation	40
Ventilation air heat recovery (yes or no)	yes
Predicted or measured annual energy use	

Any other pertinent info	Only 3 small windows on the north side

Location	Charlotte, VT.
House size	2,970 square ft.
Number of floors	2 floors
URL	http://www.wbdg.org/references/cs_ch.php
Number of occupants	4 occupants
Number of bedrooms	4 bedrooms
Type of heating system	Forced air
Main heating fuel	Electricity
Size of photovoltaic system	7 kW
Solar water heater	Yes
R-value of wall insulation	40
R-value of ceiling insulation	56
Ventilation air heat recovery	Yes
Predicted or measured annual energy use	11998 kWh

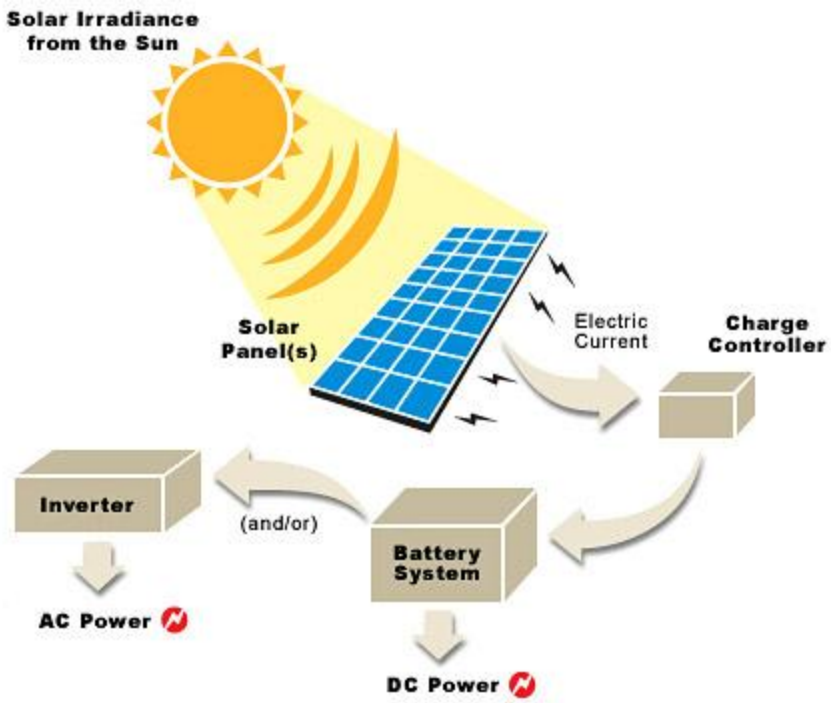
Existing Renewable energy sources:

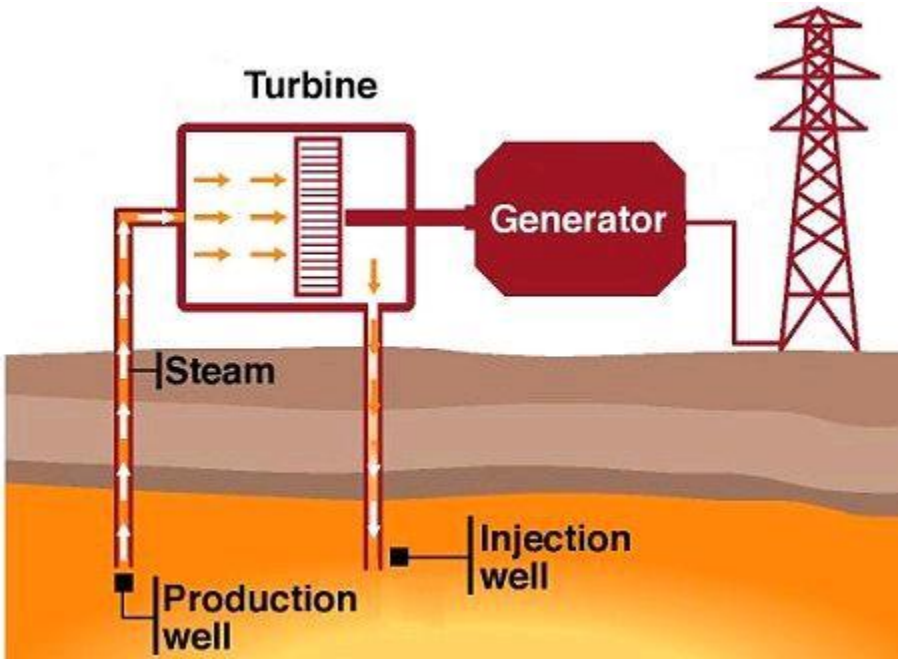
Solar Power: It is the use of the Sun's energy to provide heat, light, hot water, electricity for homes.

- It only supplies about 1% of the U.S. energy needs.
- Types of solar collectors
    - Passive solar building designs
    - Photovoltaic cells
    - Concentrating solar power systems focus sunlight with mirrors to create a high-intensity heat source
    - Flat-plate collectors

Costs:	
Equipment Costs	• **Solar panels:** About a third of the cost of a residential photovoltaic system comes from the cost of solar panels, which can cost around $4,500-$12,000. • **Power inverter:** The inverter, which converts DC to AC so you can connect to the grid, will cost $1,000-$3,000. • **Mounting hardware:** Depending on your home, you may need standoffs, rails, clips, etc., which cost around $800-$2,000. • **Wiring:** Wires and wiring boxes, disconnects, conduit, and other electrical components can total to around $1,000-$2,000.
Installation	• **System Installation:** Even before your system is up and running, you'll need to pay for the cost of installation, which ranges from $2,000-$4,000. • **Permits & Fees:** Local permitting and inspection fees can add over $2,500 to your solar costs. With other solar permitting fees, costs can total to around $3,000-$6,000.
incentives	• you're eligible to receive 30% off the total cost of your

	photovoltaic system from the federal government in the form of a Federal Solar Tax Credit
Advantages	• There is virtually no environmental impact.
Disadvantages	• There are concerns about the production of the collectors and the storage devices of the electricity • Can only collect electricity during the day when the sun is out • It is subject to other variables, like cloud cover and less hours of sunlight in the winter
Efficiency	• It get 11-15% efficiency out of the sunlight hitting a panel. • They are improving solar panels, there is a 40% efficient solar panels being produced now





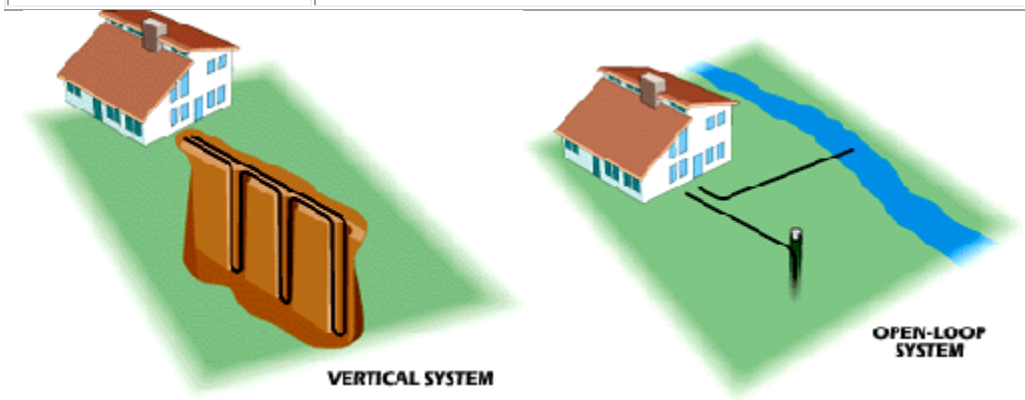
<u>Geothermal Power</u>: It uses the natural sources of heat inside the Earth to produce heat and electricity.

- Types of geothermal technologies
    - Direct-use systems: a well is drilled into a geothermal reservoir to provide a steady stream of hot water

- Use of deep reservoirs
- Geothermal heat pumps: are used for space heating and cooling as well as water heating, for residential and commercial applications.

- It barely meets less than 1% of the U.S. Power needs

Costs:	
Installation	$7,000
Advantages	• Produces few emissions • It is continuously available
Disadvantages	• The initial cost of design and installation can be costly yet this investment would be likely to pay off over the years of operation. • The area needed to lay the piping system can be quite large and this may not be suitable for small developments.
Efficiency	

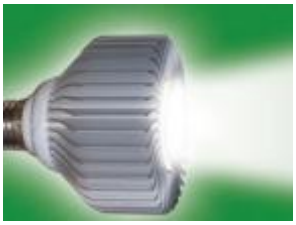


Insulation:

Research was done on different types of insulation. The best insulation option was spray foam. Spray foam is about a dollar a square foot, making it the cheapest cost option. Also, its insulation R-values for the amount used is incredibly affective. Refer to excel chart for comparisons to other insulations.

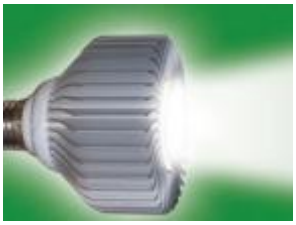
Types of lights we will use in our house: CFL, LED, or Incandescent?

http://www.designrecycleinc.com/led%20comp%20chart.html

Energy Efficiency & Energy Costs	 **Light Emitting Diodes (LEDs)**	**Incandescent Light Bulbs**	**Compact Fluorescents (CFLs)**
Life Span (average)	**50,000 hours**	**1,200 hours**	**8,000 hours**
Watts of electricity used (equivalent to 60 watt bulb). LEDs use less power (watts) per unit of light generated (lumens). LEDs help reduce greenhouse gas emissions from power plants and lower electric bills	**6 - 8 watts**	**60 watts**	**13-15 watts**
Kilo-watts of Electricity used (30 Incandescent Bulbs per year equivalent)	**329 KWh/yr.**	**3285 KWh/yr.**	**767 KWh/yr.**
Annual Operating Cost (30 Incandescent Bulbs per year equivalent)	**$32.85/year**	**$328.59/year**	**$76.65/year**

Environmental Impact	**Light Emitting Diodes (LEDs)**	**Incandescent Light Bulbs**	**Compact Fluorescents (CFLs)**
Contains the TOXIC Mercury	**No**	**No**	**Yes** - Mercury is very toxic to your health and the environment
RoHS Compliant	**Yes**	**Yes**	**No** - contains 1mg-5mg of Mercury and is a major risk to the environment
Carbon Dioxide Emissions (30 bulbs per year) Lower energy consumption decreases: CO2 emissions, sulfur oxide, and high-level nuclear waste.	**451 pounds/year**	**4500 pounds/year**	**1051 pounds/year**

Important Facts	**Light Emitting Diodes (LEDs)**	**Incandescent Light Bulbs**	**Compact Fluorescents (CFLs)**
Sensitivity to low temperatures	**None**	**Some**	**Yes - may not work under negative 10 degrees Fahrenheit or over 120 degrees Fahrenheit**
Sensitive to humidity	**No**	**Some**	**Yes**
On/off Cycling Switching a CFL on/off quickly, in a closet for instance, may decrease the lifespan of the bulb.	**No Effect**	**Some**	**Yes - can reduce lifespan drastically**
Turns on instantly	**Yes**	**Yes**	**No - takes time to warm up**
Durability	**Very Durable - LEDs can handle jarring and bumping**	**Not Very Durable - glass or filament can break easily**	**Not Very Durable - glass can break easily**
Heat Emitted	**3.4 btu's/hour**	**85 btu's/hour**	**30 btu's/hour**
Failure Modes	**Not typical**	**Some**	**Yes - may catch on fire, smoke, or omit an odor**

Light Output	 **Light Emitting Diodes (LEDs)**	**Incandescent Light Bulbs**	**Compact Fluorescents (CFLs)**
Lumens	**Watts**	**Watts**	**Watts**
450	**4-5**	**40**	**9-13**
800	**6-8**	**60**	**13-15**
1,100	**9-13**	**75**	**18-25**
1,600	**16-20**	**100**	**23-30**
2,600	**25-28**	**150**	**30-55**

Conclusion with lights: Light Emitting Diodes are going to be the type of light in our house. They are clearly the most efficient and environmentally friendly. They are far better for a house which is trying to achieve zero energy.

Cooktop type	Efficiency	Energy Factor	Annual est. costs, 1990$
Electric - baseline	1 to 4	0.74	$18
Electric - Halogen	5	0.75	$18
Electric - Induction	5	0.84	$16
Electric - Radiant	5	0.71	$19
Gas - baseline	1 to 2	0.16	$20
Gas - electronic ignition	3 to 4	0.40	$8
Gas - sealed burner	5	0.42	$7
Gas - Reflec surface	5	0.42	$7
Gas - Tstat burners	5	0.42	$7

http://www.induction-cooktop.com/icenergy.html

We are going to use an induction stove because it seems to be the most efficient.

Windows:

External research found that triple glazed windows would be the best option for the design of the zero energy house. When dealing with windows, the U-Factor is very important. What the U-Factor determines is the rate of heat loss. The lower the U-Factor of a window, the greater the window's resistance to heat flow and the better its insulating properties are. Through research it was discovered that high-performance double-pane windows can have U-Factors of 0.30 or lower, while some triple-pane windows can achieve U-Factors as low as 0.15. With regards to the U-Factor, the use of triple-pane windows will be the best method.

Scoring Stage

	Concepts								
		Solar Energy		Wind Power		Hydro power		Geothermal Power	
Selection Criteria	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Maintenance	15%	3	0.45	3	0.45	1	0.15	3	0.45
Cost of Insulation	20%	3	0.6	2	0.4	1	0.2	3	0.6
Durability	10%	3	0.3	3	0.3	4	0.4	3	0.3
Ease of Installation	10%	4	0.4	2	0.2	1	0.1	3	0.3
Cost per year	15%	3	0.45	3	0.45	1	0.15	3	0.45
Location Productivity	20%	4	0.8	2	0.4	1	0.2	3	0.6
Ease of Use	10%	4	0.4	3	0.3	1	0.1	3	0.3

	Total Score		3.4		2.5		1.3		3
	Rank		1		3		4		2
	Continue		Yes		No		No		No

The charts above state that solar power is the best option for powering your house it provides the most energy and the most ease of installation and maintenance. Geothermal is a good secondary alternative and is very good at heating your home that in conjunction with solar panels can be a powerful combination, putting out more energy per year, than an average family of four would use per year.

How we will achieve zero energy:

Our house is going to be a two-story modern style house. The house will have an open floor plan, and a portion where the top floor is open to the bottom. This combination of two stories and an area open to the top floor will allow for a greater surface area of windows to be present in our house. This will allow for more sunlight to enter the house and thus more passive solar energy. Two stories will also allow us to live more comfortably while still achieving a zero energy house. Our roof is going to be slanted towards the south side where it will be exposed to the most sun. It will be completely covered in solar panels, and also will have an overhang. The overhang will allow for more shade in the summer, and less shade in the winter. This is all based off of the angel of the sun. We will also have a garden in the front with lattice, which will have vines that grow in the summer and die in the winter. This will allow for shade in the summer, but no shade in the winter. Our garage will also have a slanted roof covered in solar panels facing the south side. This will allow for extra solar power energy. We will also use heat

recovery for showering to save energy. All of this combined with smart decisions such as using a clothesline and watching our use of water will help us to achieve a zero energy house.

KITCHEN

Electrically Powered Items	Quantity	Average monthly KWh	KWh/month	$/month
Refrigerator	1	182	182	14.34
Freezer	1	190	190	14.97
Dishwasher	1	60	60	4.73
Range / Oven	0	104		
Microwave	1	16	16	1.26
Hot Water Dispenser	1	49	49	3.86
Coffee Maker	1	19	19	1.50

DOMESTIC WELL PUMPS

Electrically Powered Items	Quantity	Average monthly KWh	KWh/month	$/month
Well Pump 1/2 HP	0	90		
Well Pump 3/4 HP	0	135		
Well Pump 1 HP	0	180		
Well Pump 1.5 HP	1	270	270	21.28
Well Pump 5 HP	0	900		

ENTERTAINMENT

Electrically Powered Items	Quantity	Average monthly KWh	KWh/month	$/month
Stereo	0	5		
TV 19"	1	18	18	1.42
TV 25"	0	26.6		
TV 35"	0	39.4		

LAUNDRY

Electrically Powered Items	loads/week	KWh/load	KWh/month	$/month
Dryer	2	3.12	25	1.97
Washing cold / cold	0	0.33		
Washing warm / cold	2	3.0	6	0.47
Washing hot / cold	0	5.0		
Washing warm / warm	0	6.0		
Washing hot / warm	0	7.0		

LIGHTING

Electrically Powered Items	Quantity	Average monthly KWh	KWh/month	$/month
Lighting # of Rooms	2	10	20	1.58
Outdoor Light 175 w	2	60	120	9.46
Outdoor Light 250 w	0	87		

MISC. EQUIPMENT

Electrically Powered Items	Quantity	Average monthly KWh	KWh/month	$/month
Hot Tub	1	600	600	47.38
Window Air Conditioner	1	134	134	10.59
Ceiling Fan	2	85	170	13.45
Electric Blanket	0	22		
24" Box Fan	0	30.6		
Computer	1	17.5	18	1.42
Water Bed Heater	0	175		
# of Water Heaters	1	220	220	17.42
Water Heater (# of People)	4	110	440	34.89

Estimated monthly household* usage: 2557 kWh;

Estimated monthly household* bill: $ 201.99

Heating usage not included in household totals

HEATING EQUIPMENT 4 HRS / DAY

Supplemental/alternate heat	Quantity	Units
Wood Stove	0	Cords per heating season
Pellet Stove	0	Bags per heating season
Propane Heater / Furnace	100	Gallons per heating season
Oil Furnace	0	Gallons per heating season

Estimate is based on a 6-month heating season

Electrically Powered Items	Quantity	Average monthly KWh	KWh/month	$/month
Furnace Fan	0	90		
Furn 15 KW ~ 1100 sq. ft.	0	1824		
Furn 20 KW ~ 2000 sq. ft.	0	2434		
Furn 25 KW ~ 3000 sq. ft.	0	3040		
Baseboard Lin. Feet	0	45.6		
Wall Heaters @ 2000 w	1	365	365	28.95
1500 w Portable	0	274		

Heat pump fan	0	90		
Heat pump 800-1100 sq. ft.	0	1094		
Heat pump 1100-2000 sq. ft.	1	1460	1460	116.04
Heat pump 2000-3000 sq. ft.	0	1824		

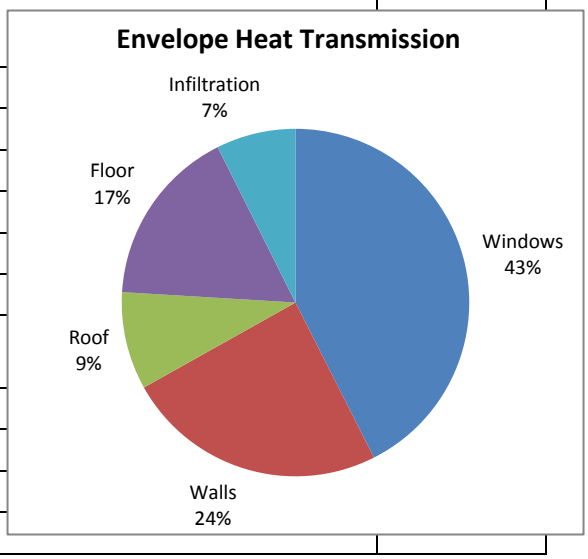
Estimated monthly heating usage: 1510 kWh

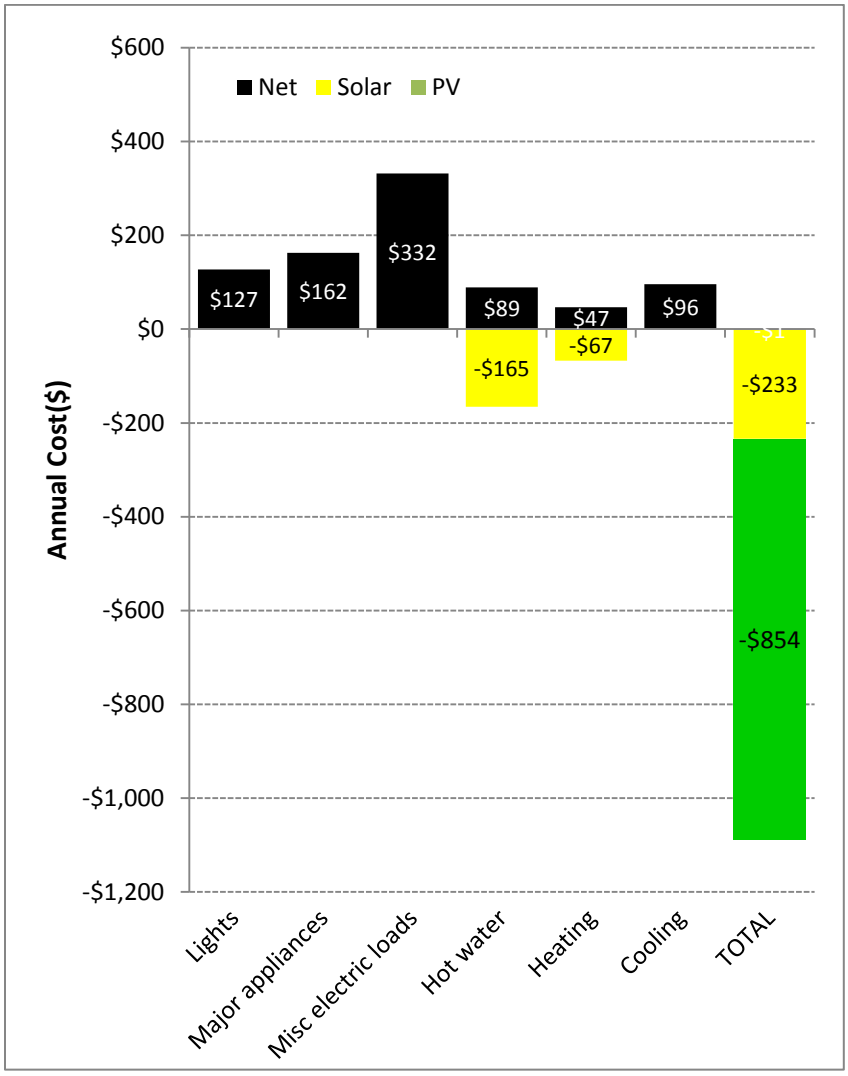
Estimated monthly heating bill: $ 120.02

ESTIMATED MONTHLY KWh USAGE 4067 Clear

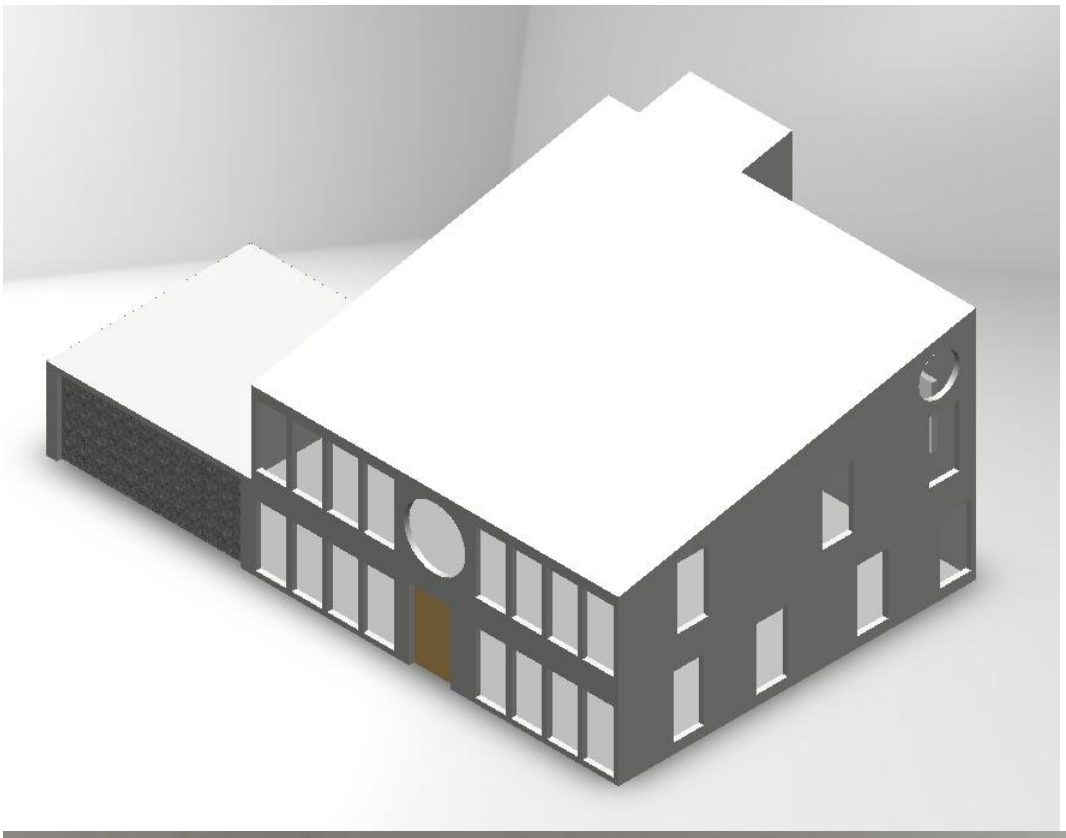
ESTIMATED MONTHLY BILL* $ 334.25

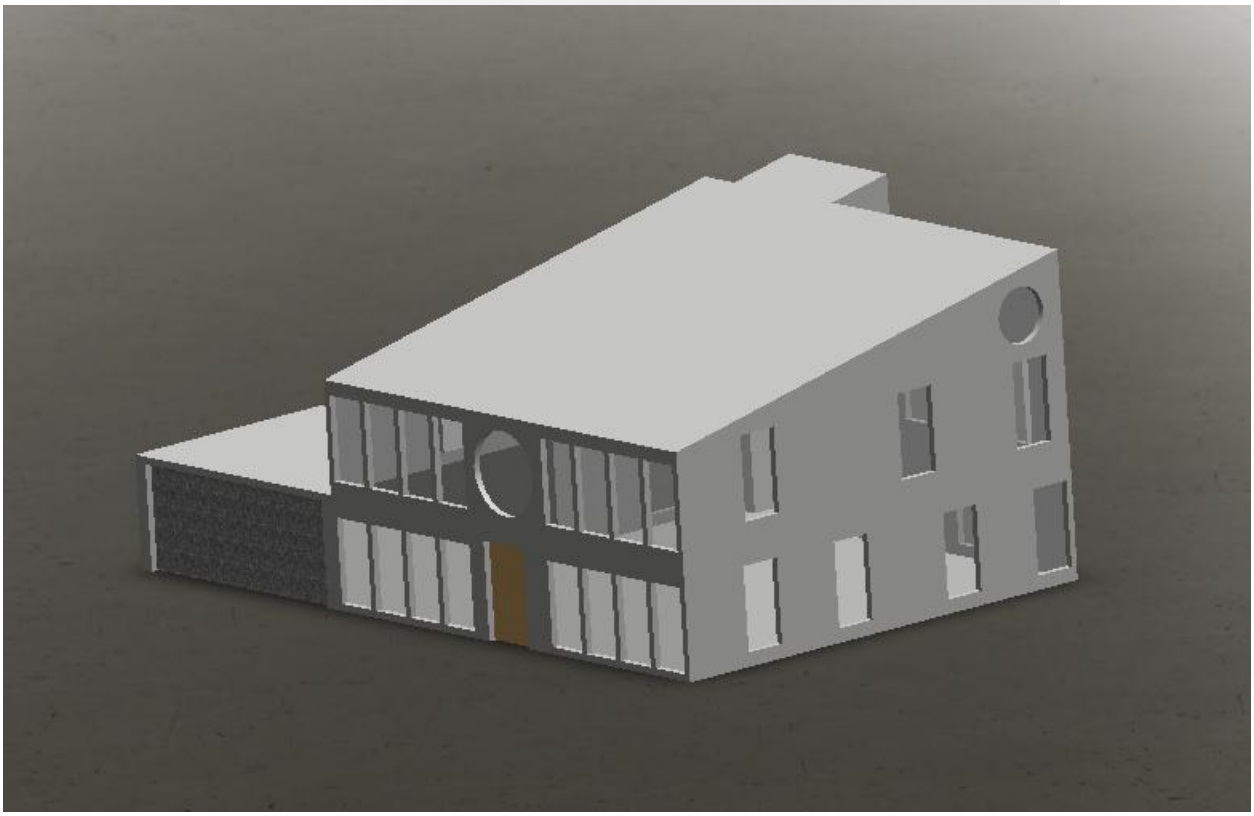
Penn State Center for Sustainability			Zero Energy Home Calculator	
	General Info		**Heating & Cooling**	
	Location	Harrisburg	Type of heating & cooling system	Electric geothermal heat pump
	Electricity cost ($/kwh)	0.1	**Solar Technologies**	
	Conditioned floor area (sq.ft.)	2554	Size of PV system (kw)	6.5
	Number of bedrooms	3	Solar water heater	Yes
	Envelope Details		**Behavior**	
	Wall construction	Double 2x4 with 10" foam	Water conservation	A lot
	Ceiling Insulation	R60	Uses clothesline	A lot
	Window type	Triple low-e	Thermostat setback	A lot
	Upper floor ceiling area (sq.ft.)	1267	Heat thermostat setting (F)	68
	North wall area (gross) (sq.ft.)	1184	Cool thermostat setting (F)	78
	East wall area (sq.ft.)	420		
	South wall area (sq.ft.)	736		
	West wall area (sq.ft.)	420		
	North window area (sq.ft.)	90		
	East window area (sq.ft.)	133.07		
	South window area (sq.ft.)	316.26		
	West window area (sq.ft.)	0		
	Air tightness	Tight with heat recovery		
	Major Appliances			
	Refrigerator	Best		
	Clothes Washer	Best		
	Dishwasher	Best		

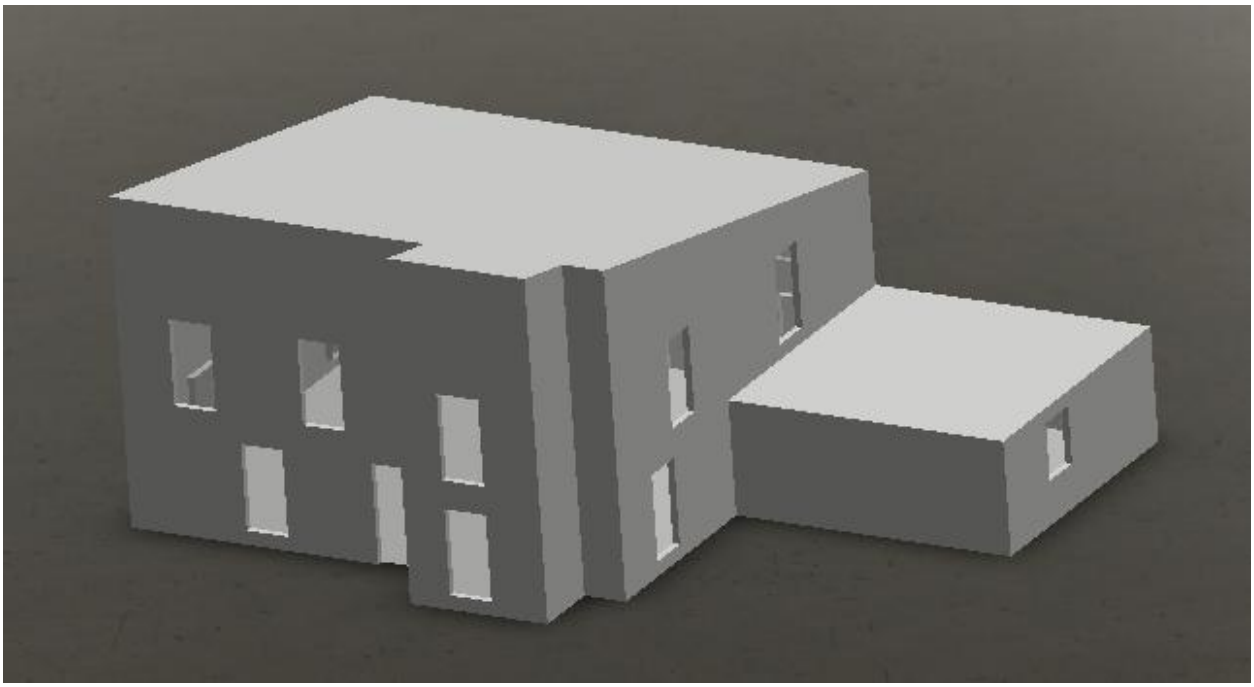


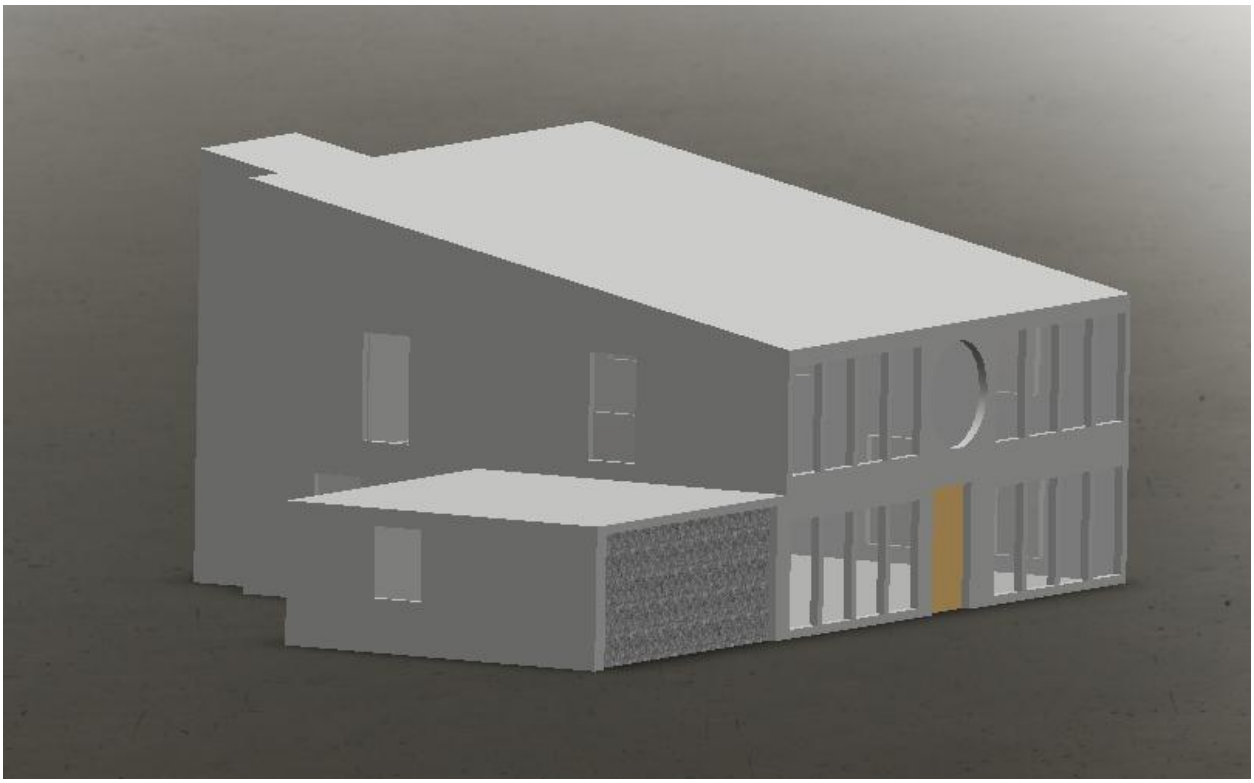

$600
$400
$200
$0
-$200
-$400
-$600
-$800
-$1,000
-$1,200
Annual Cost($)
Net
Solar
PV
$127
$162
$332
$89
-$165
$47
-$67
$96
-$233
-$854
Lights
Major appliances
Misc electric loads
Hot water
Heating
Cooling
TOTAL

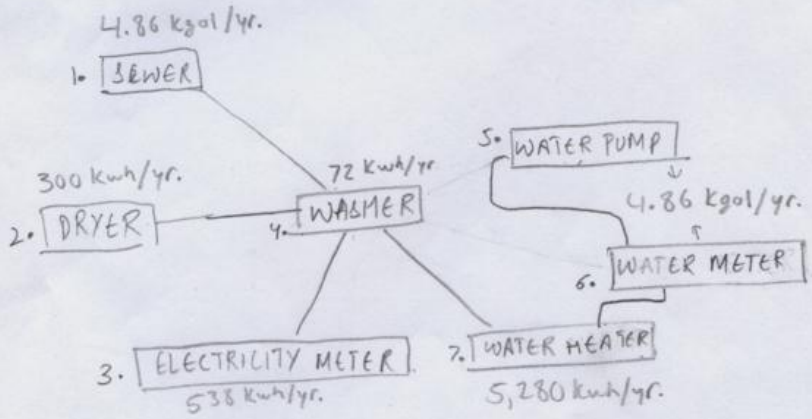
Design: Graphic Model of ZEH











Price (per yr.)

1. $29.00
2. $23.69
3. $49.00
4. $5.64
5+6. $19.00
7. $416.28

Total - $ 542.61

Electrolux

585 kwh/yr x $0.092/kwh = $53.82 + 19+29 = $101.82

Payback time = (849 − 749.99) / (119.15 − 101.82) = **5.71 years**

Electrolux and LG

LG → 773.31 kwh/yr x $0.092/kwh = 71.14452 + 19+29 = $119.15

GE and LG

669.42 kwh/yr x $0.092/kwh = 61.59 + 19+29 = $109.59

Payback time = (874.49 − 749.99) / (119.15 − 109.59) = **13.02 years**

$$LG = \frac{4.48}{2.41} \cdot .416$$

$$= 773.31 \ \frac{Kwh}{yr}$$

$$\text{whirlpool} = \frac{4.33}{3.21} \cdot .416$$

$$= 561.15 \ \frac{Kwh}{yr}$$

773.31 · .092
71.14452

561.15 × .092
= 51.6258$

$119.14452

$99.6258

(1074.60 − 749.99) / (119.14 − 99.63)

324.61 / 19.51 = **16.64 yr**

124.5 / 9.55 = 13.04 yr

61.59

109.59

$M + E + D = \frac{L}{ME\,F^{*}\,\text{No of cycle}}$

D - Energy req for removal of moisture.

M - Sum of mechanical energy for mechanical action of cycle.

E - Water heating energy of a cycle

Whirlpool WFW94HEX*+ $= \frac{4.33}{3.21} \cdot 416 = 561.15 \frac{kwh}{yr}$ 1074.60$

Electrolux EIFLW55*** $4.05/(2.88 \cdot 416) = 585 \frac{kwh}{yr}$ 849$

LG WT5001C* $= \frac{4.48}{2.41} \cdot 416 = 773.31 \frac{kwh}{yr}$ 749.99$

GE GFWH2405L* $= \frac{4.20}{2.61} \cdot 416 = 669.42 \frac{kwh}{yr}$ 874.99$

Payback

We will choose the Electrolux EIFLW55 washer because it will pay back in under 10 years and faster than every other washer compared to the cheapest LG WT5001C. The payback time will be 5.71 years.

Square footage:

$36 \times 35 = 1260$
$5 \times 13 = 65$
$1,325 - 96 = 1229$

$8 \times 12 = 96$

2nd floor

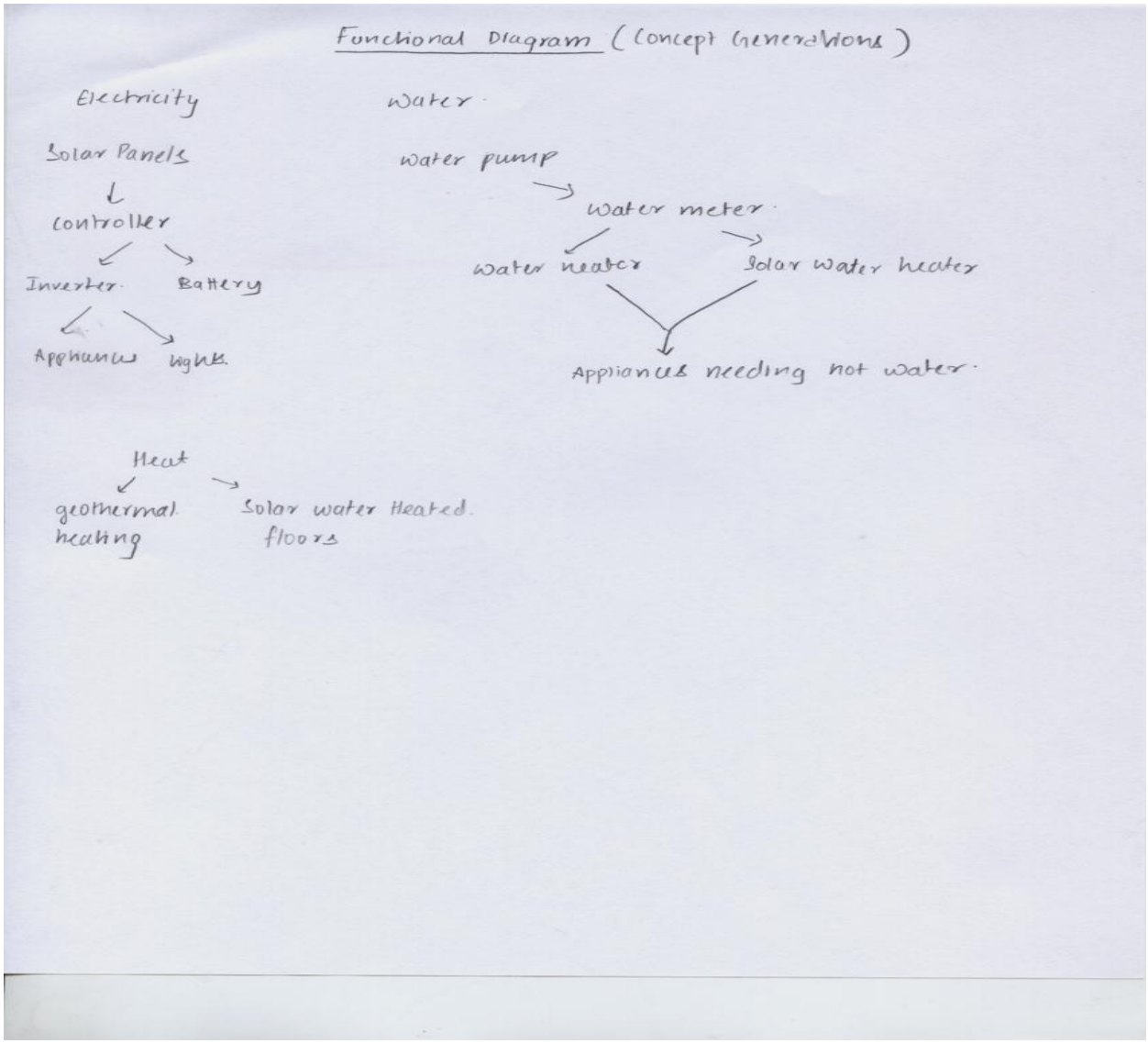
$36 \times 35 = 1260$
$5 \times 13 = 65$
1325

first floor

1229
$+ 1325$
$2,554$ sq ft

plus 20 x 20 garage

Concept Generation:



Concept Selection: We selected a two-story house with four bedrooms located in Pennsylvania.

North wall area = $36 \times 24 = 864$ sq ft $+ (20 \times 16) = 1{,}184$ sq ft

South wall Area = $\underbrace{(36 \times 16)}_{576} + \underbrace{(20 \times 8)}_{160} = 736$ sq ft

East wall Area = $\underbrace{(35 \times 8)}_{280} + \underbrace{\frac{1}{2}(35)(8)}_{140} = 420$ sq ft

West wall Area = 420 sq ft

North wall window = $(6 \times 3) = 18 \times 5 = 90$ sq ft

South wall window = $18 \times 16 = 288 + 3^2(3.14159265) = 316.26$ ft

East window area = $7 \times 18 = 126 + 1.5^2(3.14) = 133.07$ ft^2

Roof area (solar panel area) = 20 x 20 + 36 x 36 = 1696 sq feet

$\Downarrow$

244224 sq inches

1 sq inch of roof = 0.00007 kw

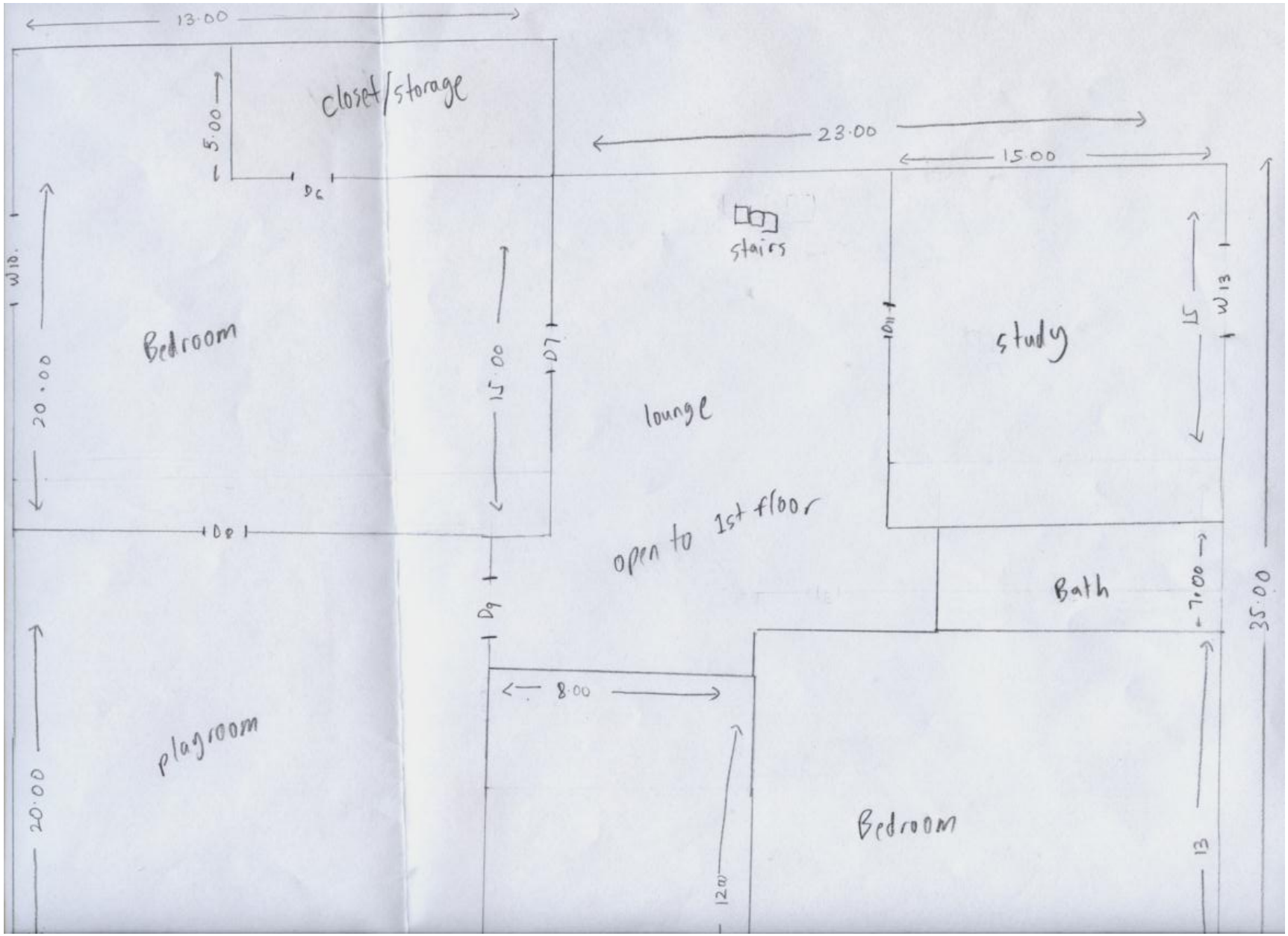
Roof output = 5 x .00007 kw x 244224 = 85.48 kw/day

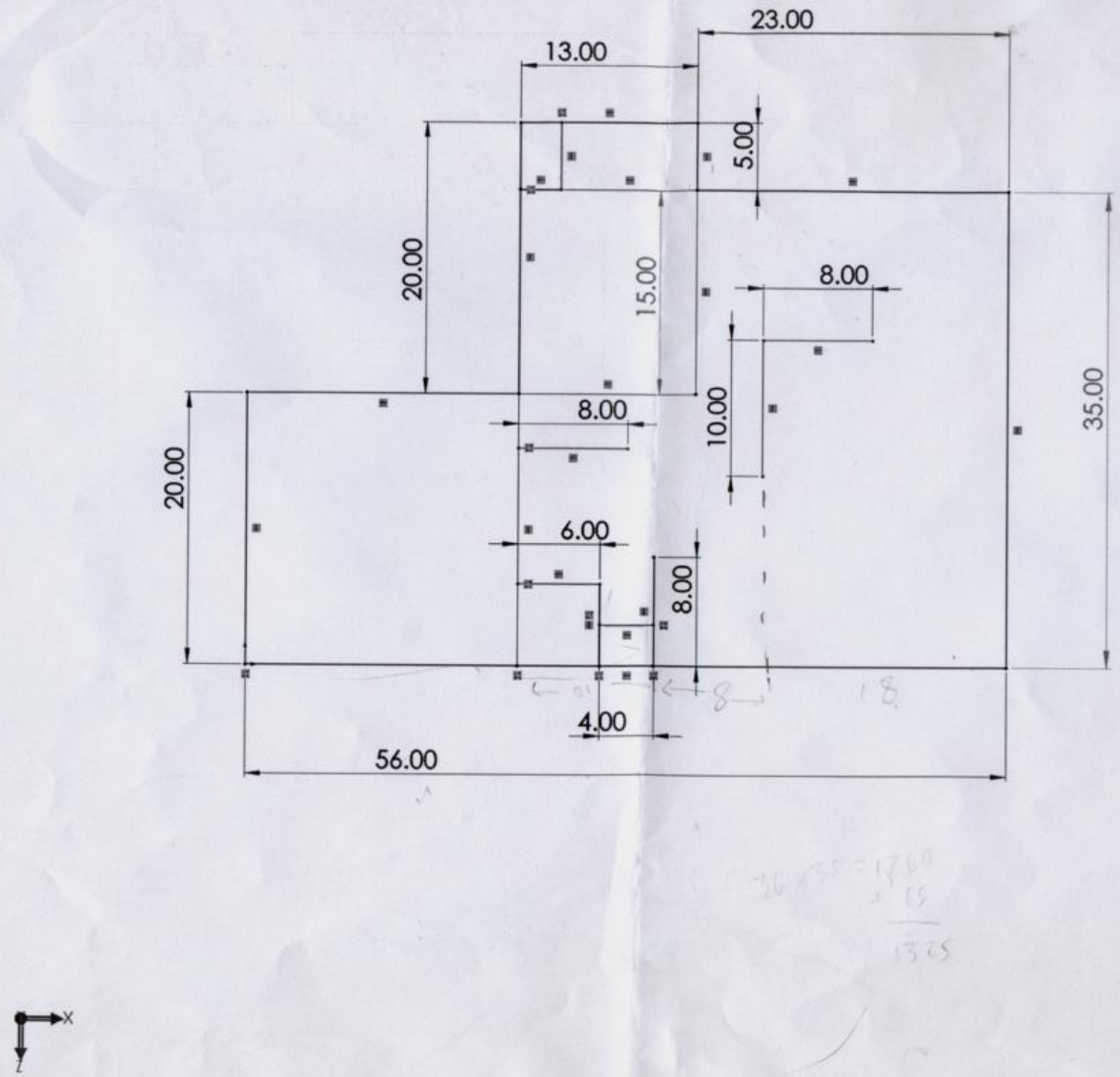
3.5616 kw/h

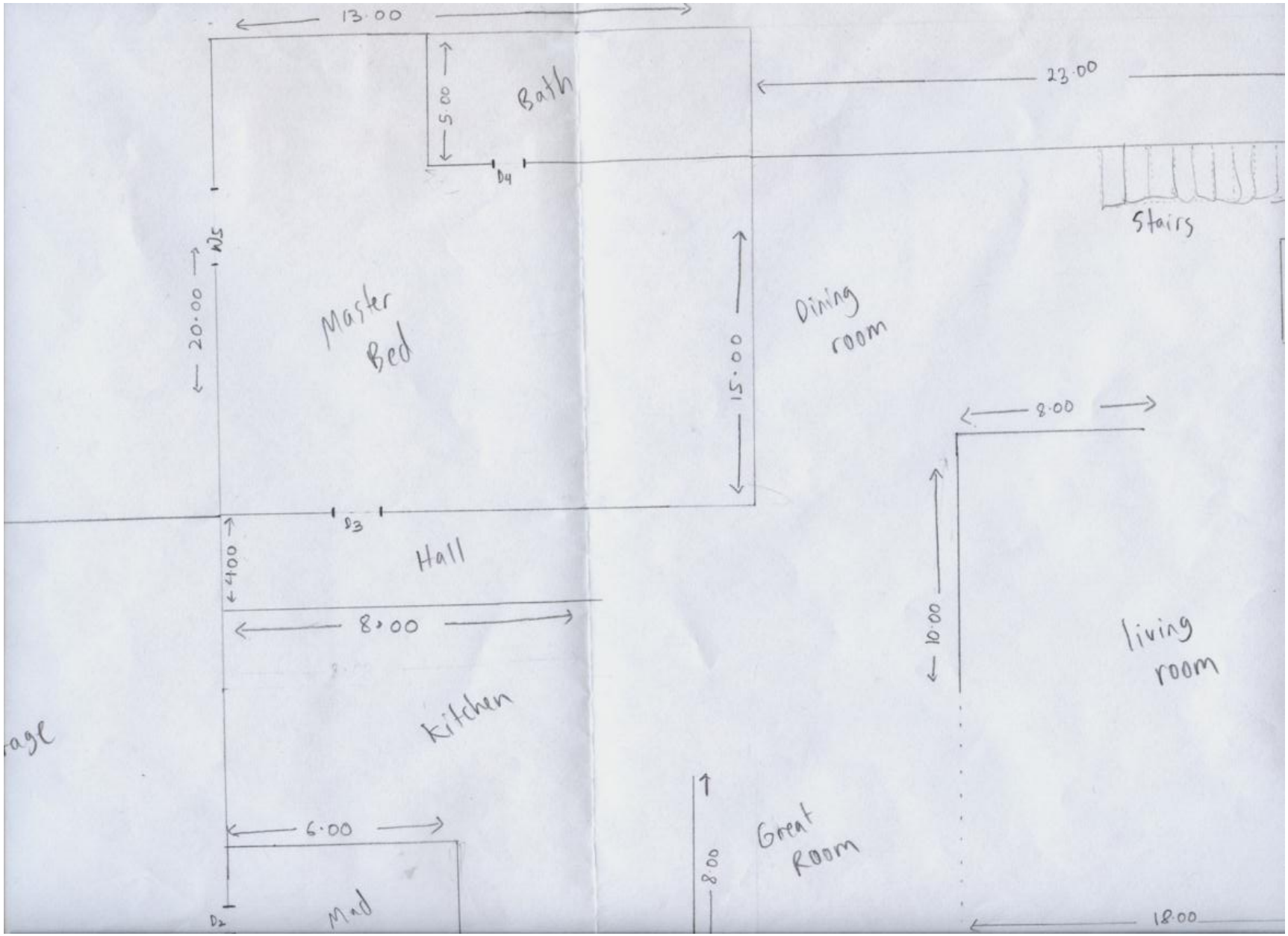
avg us household usage = 11000 kwh/yr

Our Roof Output per year = 85.48 kw/day x 365 days/year = 31,200.2 kw/year

Our house produces much more energy than the average U.S. household uses


13.00
closet/storage
5.00
D6
23.00
15.00
stairs
W10.
Bedroom
20.00
15.00
D7
lounge
D10
study
15
W13
D8
open to 1st floor
D9
Bath
7.00
35.00
8.00
playroom
20.00
Bedroom
12m
13


23.00
13.00
5.00
20.00
15.00
8.00
10.00
35.00
8.00
20.00
6.00
8.00
4.00
56.00
X
Z


13.00
5.00
Bath
D4
23.00
Stairs
20.00
W5
Master Bed
15.00
Dining room
8.00
D3
Hall
4.00
8.00
10.00
living room
Kitchen
6.00
8.00
Great Room
D2
Mud
18.00

Conclusion:

In conclusion, we created a zero energy house by combining solar energy via solar panels with geothermal energy. Other features of the house that contributed towards achieving zero energy were an overhang of the roof, lots of windows, seasonal plants that allow for shade only in the hot seasons, the use of LED lights, an induction stove, a heat recovery system, an energy efficient washer, and finally knowledge of sustainability actions such as using a clothes line and knowing water conservation.

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