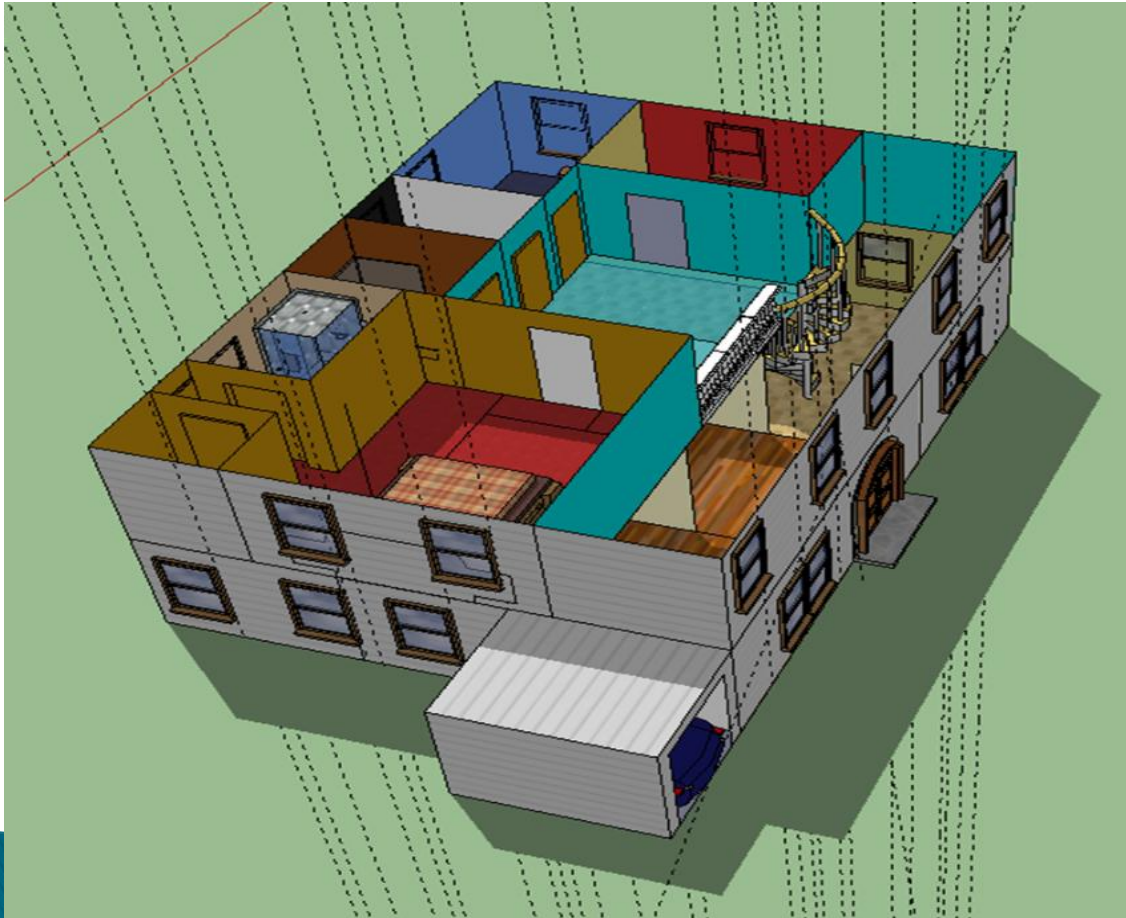


Zero Energy Home



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TEAM NUMERO UNO

March 18th 2010

Goals and Features

- ▶ Our goals were to:
 - Work together
 - Hear each other out
 - Divide the work evenly
 - Get things done early
 - Research different features
 - Provide a quality zero energy home
- ▶ The most important feature for us was making sure the house looked like a normal house.
- ▶ We wanted to show that a normal size house can be energy efficient
- ▶ We also wanted to incorporate some “fun” features to make it more attractive and set it above other houses

Project Overview

► Project Specs

- 1920 sq. ft
- 3 bedrooms/2.5 bath
- 2 stories
- Located: Harrisburg, PA
- R60 ceiling insulation
- Wall construction (10" foam)
- Triple low-e windows
- Air tightness: Tight with air recovery
- HVAC: Electric heat pump
- Solar water heating



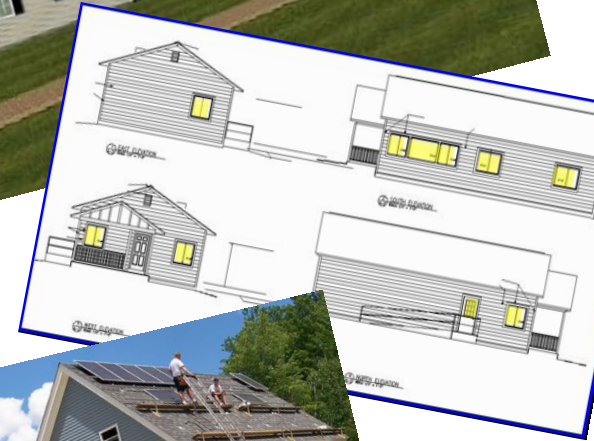
Project Overview

- R-Values of components used in house design

Element	Direction	Area	R-value	A/R
		(sq.ft.)	(hr-ft ² -F/Btu)	(Btu/hr-F)
Windows	N	128	4	32
	E	44.8	4	11.2
	S	128	4	32
	W	44.8	4	11.2
Doors	N	42	4	10.5
	S	0	0	0
Walls	N	640	62	10.3
	E	448	62	7.2
	S	640	62	10.3
	W	448	62	7.2
Ceiling	Up	1120	60	18.6
Floor	Down	1120	30	37.3
			Total A/R	187.8

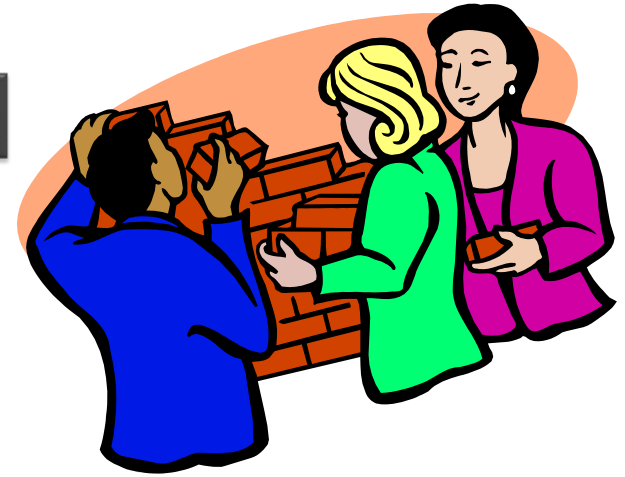
Research Summary

- ▶ Through research we found the typical zero energy home consisted of :
 - 3 Bedrooms about 3–4 people
 - 1500–2000 square feet
 - 5kW PV system
 - Higher R-values of around 60
 - 2 floors
 - Solar energy





Lessons Learned



- ▶ Through our research and group discussions, we learned that there was a lot involved to build a zero energy home, these lessons included:
 - Keeping the house at a normal size that would be enjoyable for a midsize family to live
 - Found out that there are innovative and alternative ways to utilize solar power
 - Constructing a house that had an R-Value of about 60
 - Don't go top of line in everything. It is necessary to research and compare
 - Make the house attractive

Analysis of Key Decisions– Envelope

- ▶ Calculated volumetric flow rate of air:
 - ▶ $89.6 \text{ ft}^3/\text{min}$
 - Specific heat of air: $0.24 \text{ Btu/lb-}^\circ\text{F}$
 - Air density: 0.075 lb/ft^3
 - Inside Temp: 70°F
 - Outside Temp: 20°F
- ▶ Heat transmission rate (The total heat rate needed to heat the fresh air flow from the outside temperature to the inside temperature)= **1.42 kW**
- ▶ The heat reduction thanks to the VAHR for warming the fresh air to $60^\circ\text{F} = \mathbf{1.14 \text{ kW}}$

Analysis of Key Decisions – Envelope

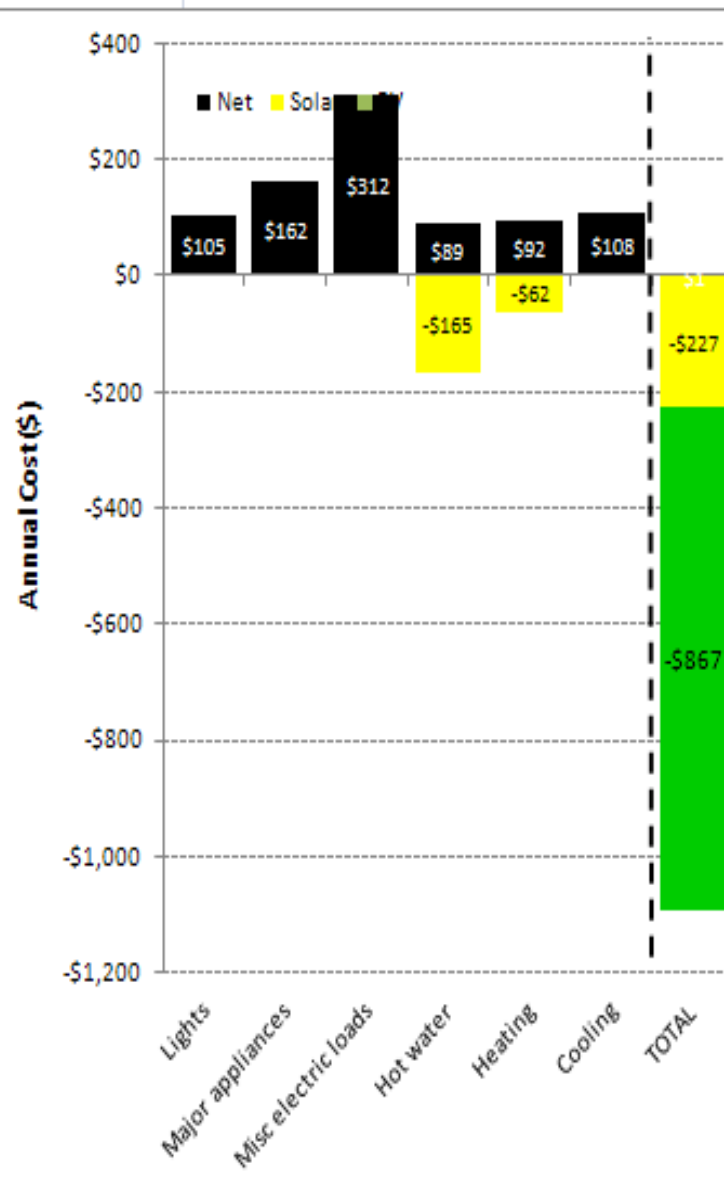
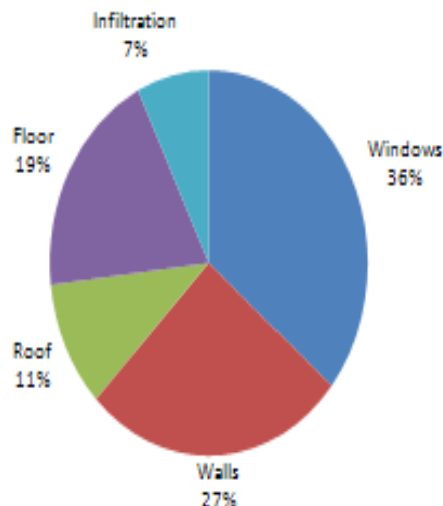
State Center for Sustainability

General Info	
Location	Harrisburg
Electricity cost (\$/kwh)	0.1
Conditioned floor area (sq.ft.)	1920
Number of bedrooms	3
Envelope Details	
Wall construction	Double 2x4 with 10" foam
Ceiling Insulation	R60
Window type	Triple low-e
Upper floor ceiling area (sq.ft.)	1120
North wall area (gross) (sq.ft.)	640
East wall area (sq.ft.)	448
South wall area (sq.ft.)	640
West wall area (sq.ft.)	448
North window area (sq.ft.)	128
East window area (sq.ft.)	44.8
South window area (sq.ft.)	128
West window area (sq.ft.)	44.8
Air tightness	Tight with heat recovery
Major Appliances	
Refrigerator	Best
Clothes Washer	Best
Dishwasher	Best

Zero Energy Home Calculator

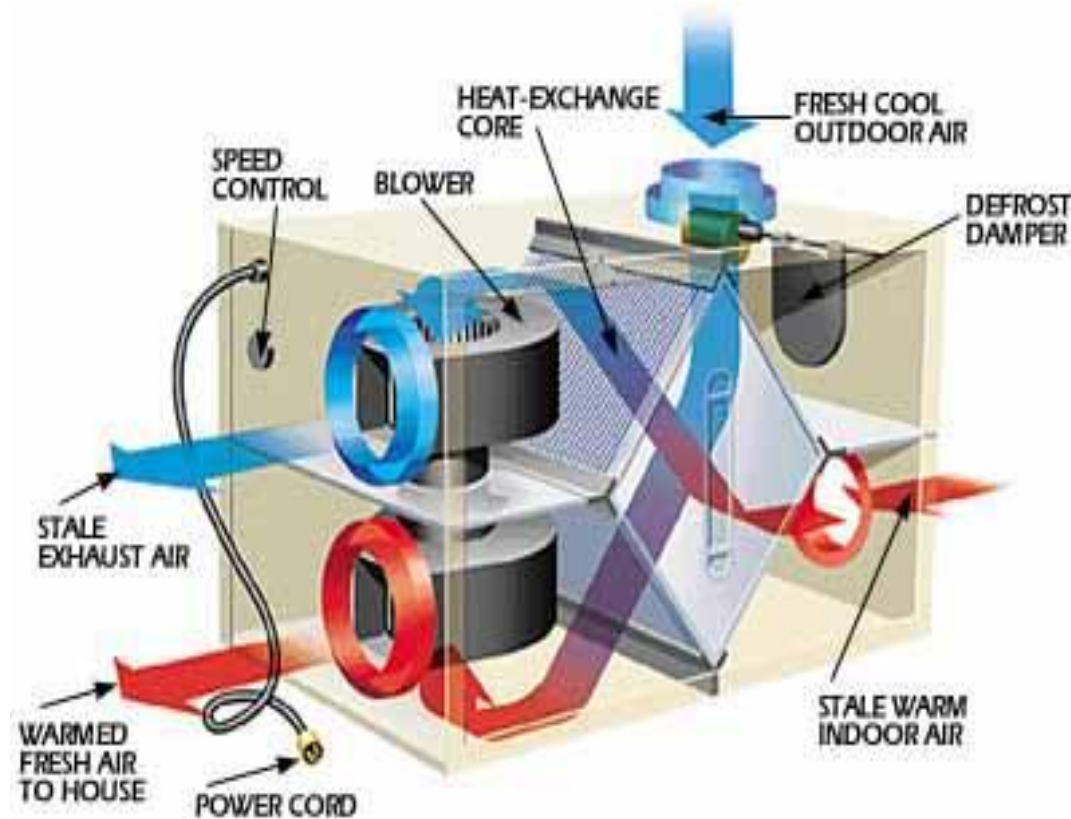
Heating & Cooling	
Type of heating & cooling system	Electric heat pump
Solar Technologies	
Size of PV system (kw)	6.6
Solar water heater	Yes
Behavior	
Water conservation	A lot
Uses clothesline	A lot
Thermostat setback	A lot
Heat thermostat setting (F)	68
Cool thermostat setting (F)	78

Envelope Heat Transmission



Analysis of Key Decisions – Envelope

- ▶ Air tightness: Tight with Heat Recovery
- ▶ Less mold/mildew
- ▶ Saves up to 40% of yearly heating costs
- ▶ Uses less energy/electricity



Appliances– Refrigerator

- ▶ Kenmore Black 25 cu. ft. Side-by-Side with PUR water Filtration
- ▶ \$704.99, 577kWh/yr, Energy Star qualified
- ▶ Cost effectiveness:
\$22.20/year
25.7 years to pay off



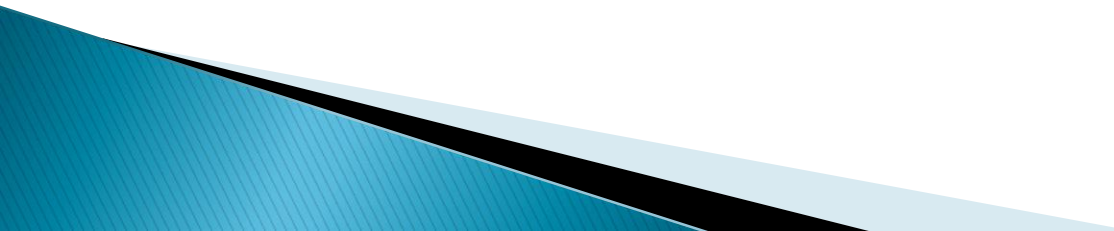
Appliances– Television

- ▶ JVC LT-46P300(LCD)
- ▶ 46"
- ▶ Energy star qualified



- ▶ Default power watts: 132.78w or .132kw x 4 hr = .528kwh x 365 = 192.72kwh/y
- ▶ Calibrated cost per year: \$24.89
- ▶ Price at Best Buy : \$1,268.99

Appliances– Television

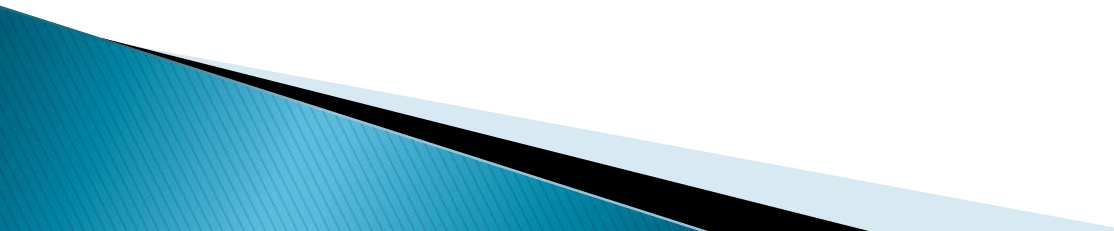
- ▶ Cost Effectiveness compared to Panasonic (not energy efficient & 715kwh/y)
 - ▶ Extra up front cost: $(1,268.99 - 899) = \$369.99$
 - ▶ Annual Savings = $(715 - 192.72)\text{kwh/y}(\$0.1/\text{kwh}) = \$52.23/\text{y}$
 - ▶ 7.08 years to pay for extra cost
- 

Appliance– Clothes Washer

- ▶ Whirlpool Ocean Blue Duet Sport® HT 3.7 I.E.C. cu. ft. Ultra Capacity Front-Load Washer ENERGY STAR®
- ▶ Model# WFW8400TE
- ▶ \$899.88
- ▶ Volume: 3.26 ft³
- ▶ 156 kWh/y



Appliance– Clothes Washer

- ▶ Cost Effective compared to the non efficient Clothes Washer
 - ▶ Extra Upfront Cost: **\$0.88**
 - ▶ Annual Savings: **\$17.40 / year**
 - ▶ Rate of Savings: **.05 years** (only \$0.88 price difference)
- 

Appliances– Dishwasher

- ▶ GE® 24-Inch Built-In Dishwasher

- ▶ 34in x 24in x 25-3/4in

- ▶ 324kWh/year

- ▶ \$299.00



- ▶ extra up-front cost= \$80

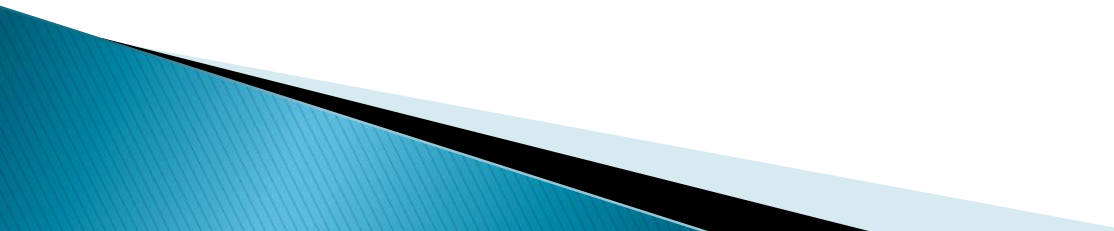
- ▶ savings = \$12.80/year

- ▶ 6.25 years to pay for the extra cost

Analysis of Key Decisions– HVAC

- ▶ Heating & cooling system of ZEH:
 - Electric Heat Pump
- ▶ HVAC–ground source heat pump
 - initial cost \$17500
 - Comparing to open–air heat pump systems
 - \$17500 initial compared to ~\$4000
 - 150%–200% more efficient
 - 5–10 years to make up price
 - lasts 25–50 years
 - rebates up to \$1500

Insulation– Polyurethane Spray Foam

- ▶ approx. R-value 6.2 /inch. Use for exterior walls.
 - ▶ Helps strengthen the structure of home by creating bonds between the floor, walls, and studs
 - ▶ Use vapor barrier on 'in facing' side of walls to prevent moisture of heated indoors from collecting in walls & insulation
- 

Insulation– Polyurethane Spray Foam



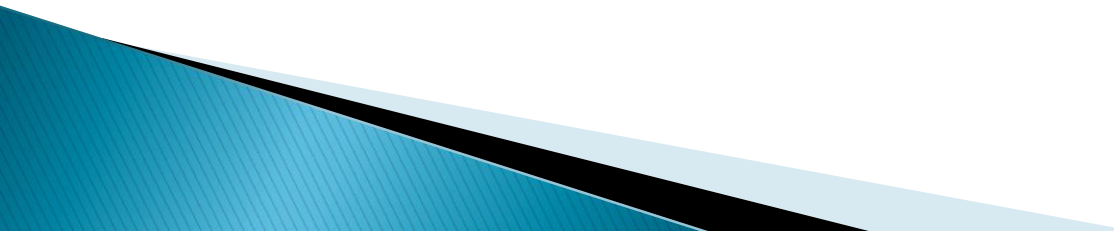
Creates a more effective seal than batt insulation – it can fill in cracks and services

Insulation– Polyurethane Foam Board

- ▶ approx. R-value 5.6 – 8/inch. Use for ceiling.
- ▶ Caulk seams and edges.
- ▶ Vapor barrier not usually necessary. Water vapor stays stable long enough to escape because of the high R-value and rigidity of the board.
- ▶ Code:
- ▶ Exterior walls: R-13
- ▶ Ceilings: R-38



Insulation– Polyurethane Foam Board

- ▶ Typical exterior wall insulation thickness is about 4 inches, so this would give our house an R-value of 24.8
 - ▶ About six inches of foam board will be needed to meet code. However more is most desirable
- 

Windows

Comparison of Energy Star windows (area of each window along with the prices)

Best—

American Craftsman, an Andersen Company 2392 Sliding Vinyl Windows

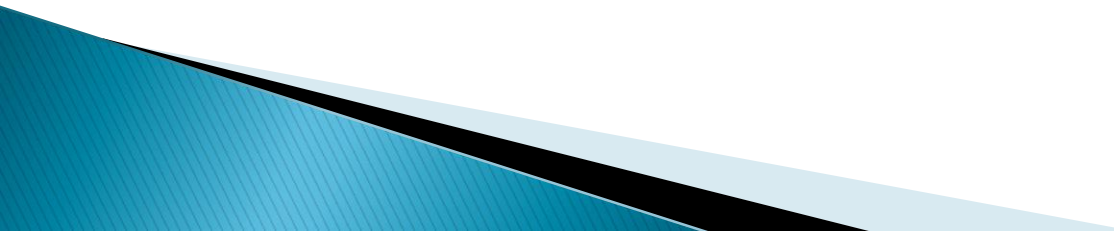
2 / 0 x 2 / 0, White, with LowE3 Insulated Glass,

Argon Gas and Screen


Home Depot for \$82 each.



Shower Head

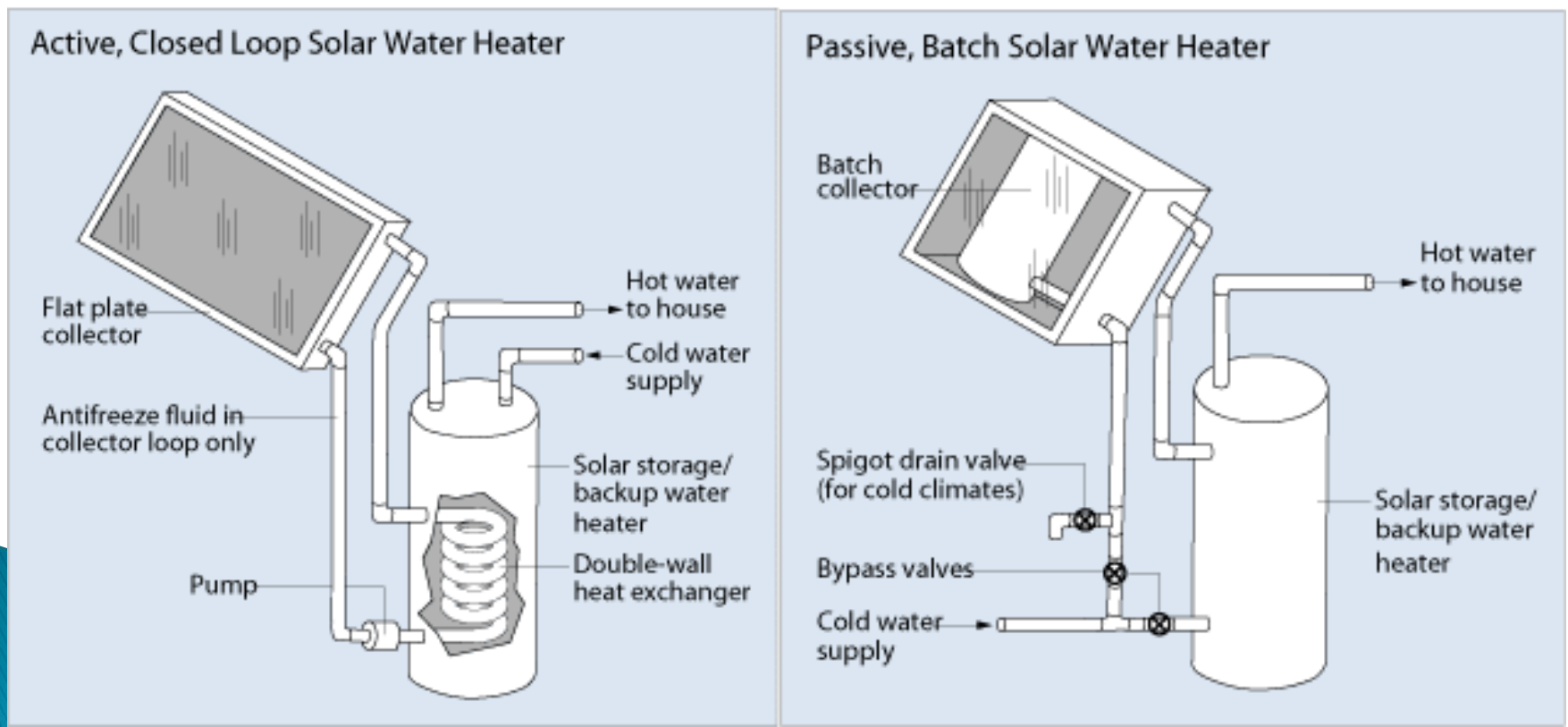
- ▶ Low flow shower head
 - ▶ Comparatively the prices for various shower head were very similar
 - ▶ We decided to choose the more energy efficient model in order to save more money on our water usage
- 

Shower Head

- ▶ After much researching, we found the best low flow shower head
 - ▶ Waterpik Original Shower Massage, Fixed Mount in Chrome
 - ▶ Energy Star qualified model
 - ▶ uses 2.5 gal/min
 - ▶ Lowe's for only \$17.87 (cheaper than other non-Energy Star models)
- 

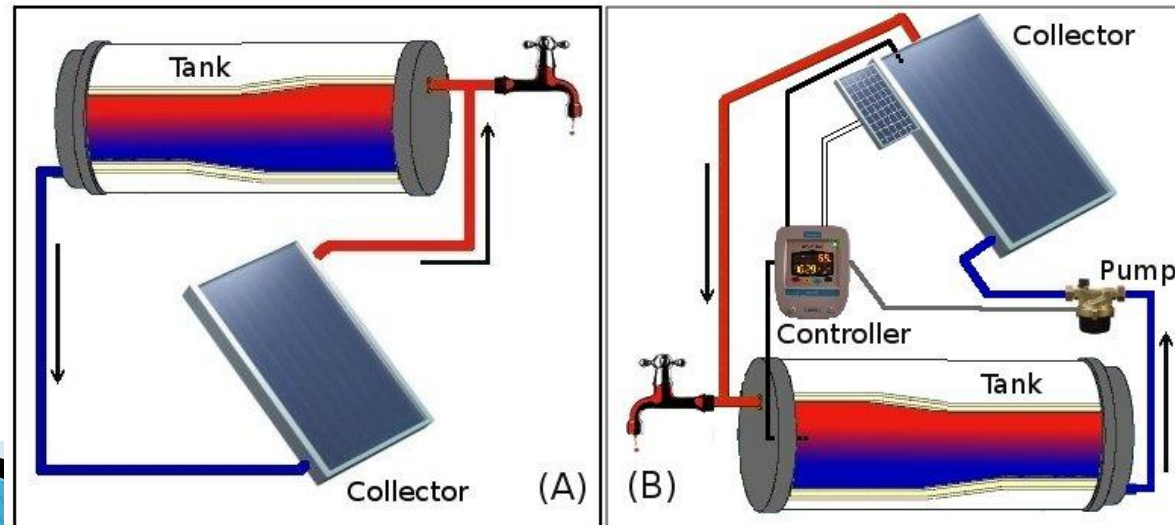
Solar Technologies

- ▶ ZEH PV system requirements
 - 6.6kw
 - required size of system: $6.6\text{kW}(63.5\text{ft}^2 / 1\text{kW}) = 419.1\text{ft}^2$



Solar Technologies

- ▶ Active and Passive Solar water heaters
- ▶ Active solar water heaters includes a pump which makes the system more efficient for it can keep the flow of hot water circulating throughout the system. This ensures that the water remains hot. A passive solar water heater does not contain a pump or any active form of “water movement.”

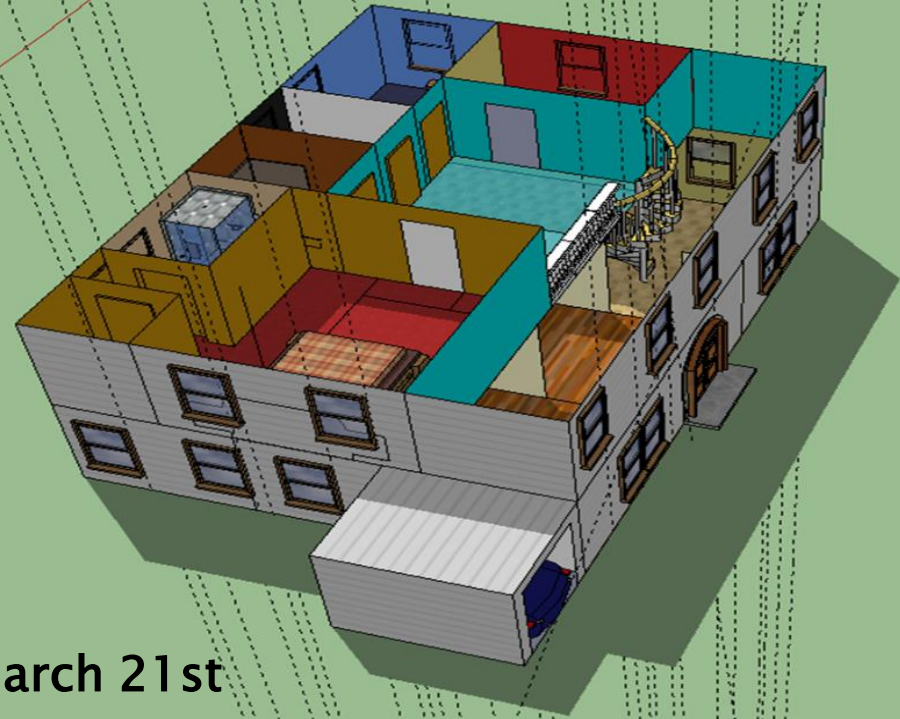


Behavior & Systemic Effects

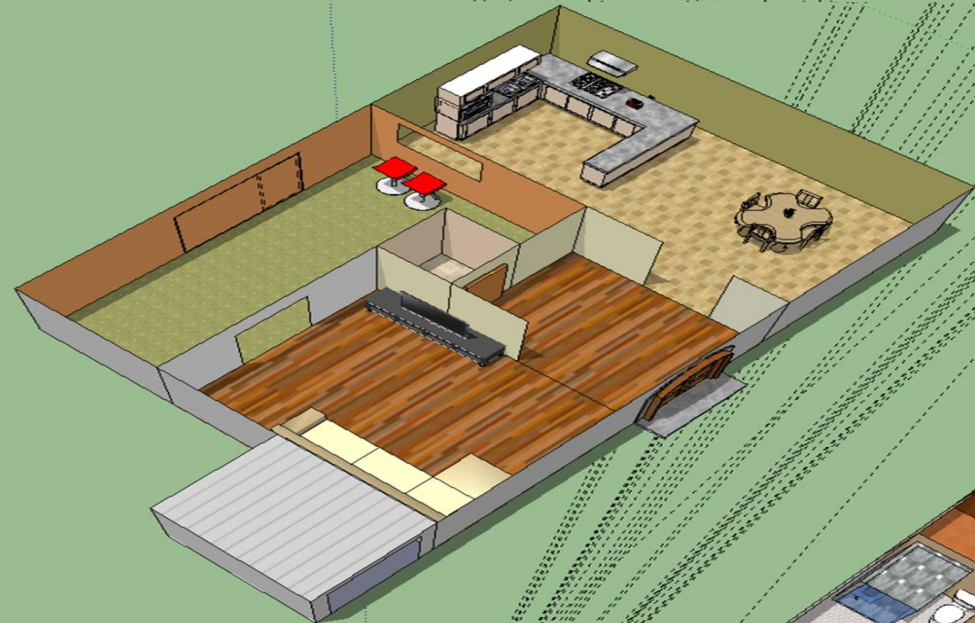


- ▶ Large windows by balcony as well as the glass floors, allow for more sunlight to enter the house, using less energy to heat the house, as well as saving electric from the conserving lightbulb usage.
- ▶ Also the appliances in the household will contribute a little to the heating of the house and allow for the furnace to not work as hard in some cases
- ▶ Also by using better appliances like a high efficiency clothes washer can help cut down on the costs and usage of electricity of the clothes dryer. Water conservation is also a result of using a better, more energy efficient appliance.
- ▶ The air recovery system contributes to less energy being used by the furnace and ensures that the house reaches its desired temperature.
- ▶ Insulation that has a high R value (ceiling-R60) ensures that less energy will be used for heating the house. Just by having a better quality of insulation, the energy from the furnace will be saved.

SketchUp Design



March 21st



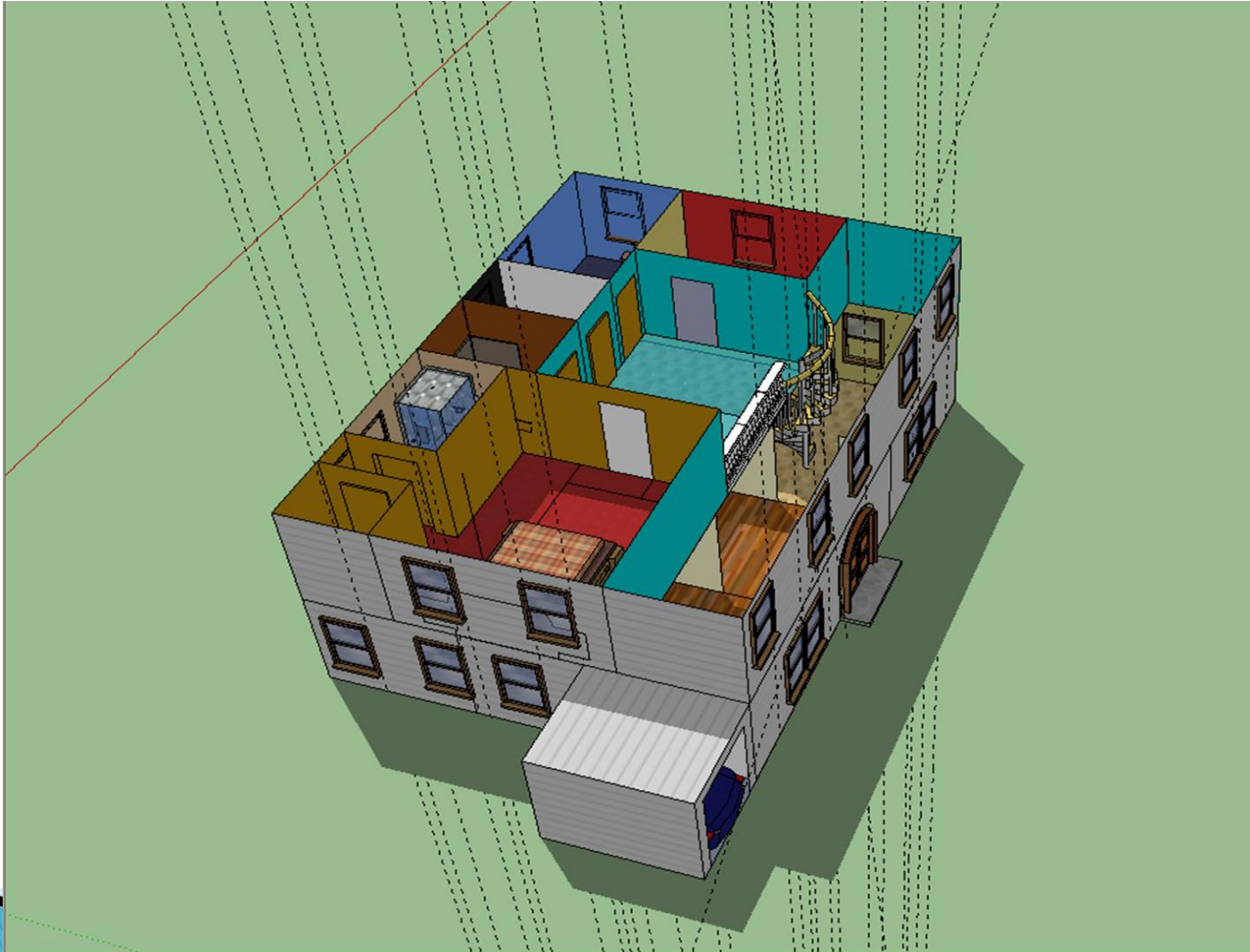
August 6th Shadow



December 21st Shadow



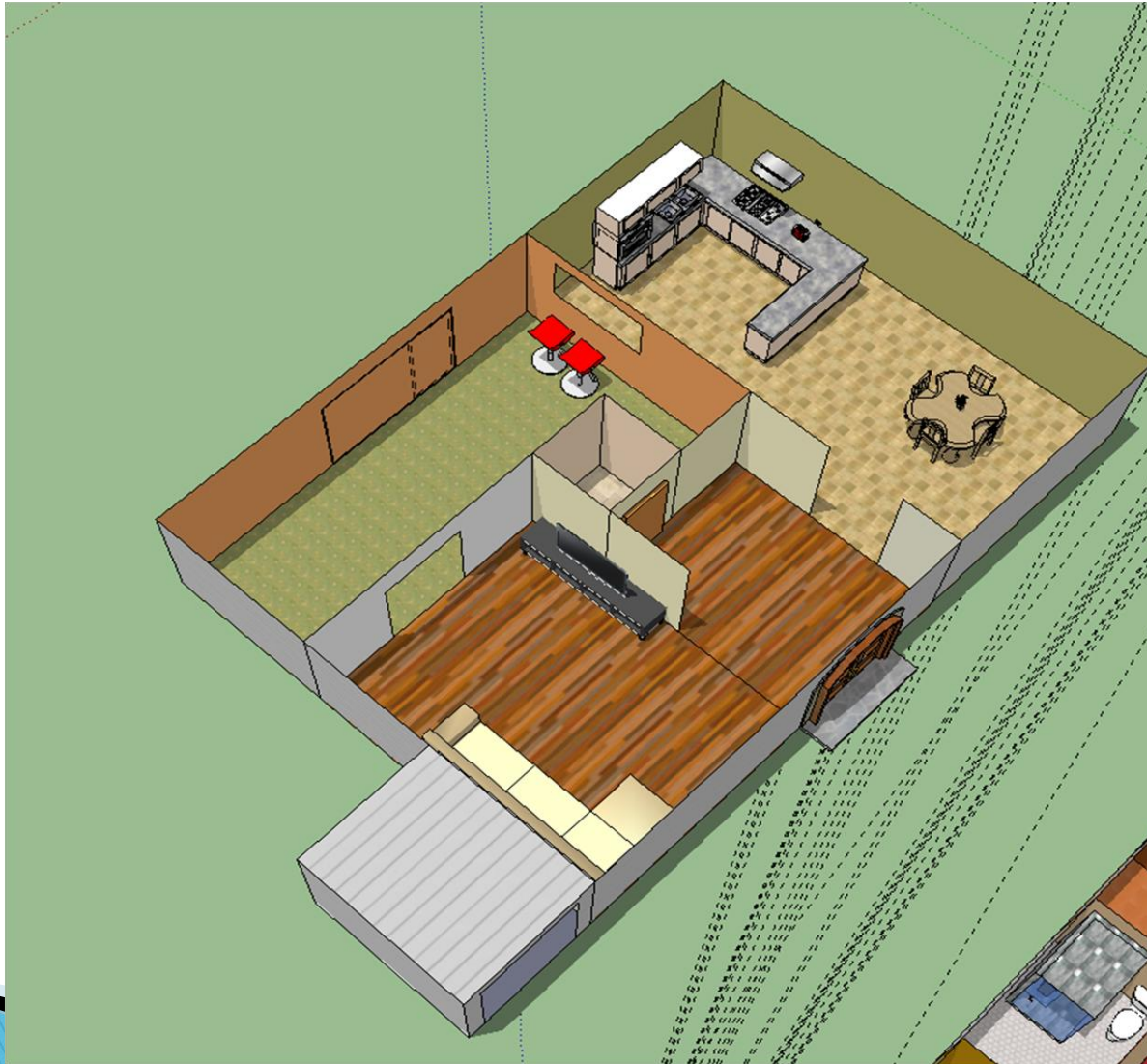
March 21st Shadow



Top Floor



Bottom Floor



Physical Model



Summary of Design– Most Important Aspects of Design

- We were very adamant about making the ZEH look like a “typical home.” We wanted our design to aesthetically pleasing to the eye and a place where real people would want to live.
- Many ZEH have a smaller amount of living space. We decided to build a home that was large enough for a family of 3–4 to live comfortably. This normal amount of living space ensured that the house would be enjoyed by a family without worrying about being crowded.
- The innovative design of our house made it fun and interesting. The use of a glass floor and second floor balcony makes the house unique and also contributes to the energy efficient design. We wanted to build a house that was creative and different than a typical house.
- Lastly, our house was designed to meet all requirements such as having a 20% (N/S) and 10% (E/W) of windows, as well as using a PV system.

Summery of Design– Greatest Challenges

- Working with Google Sketchup was a challenge. The file of our house was excessively large which made it near impossible for us to add a roof to our house. The computer always froze and sometimes closed without saving. Google SketchUp is a easy to use program, it just was not cooperating with our group.
- Researching specific components of a zero energy home was a little challenging. Some of the information was difficult to find online and a lot of the information given was either too vague or too in depth for our knowledge
- Finding cost effective appliances was also a difficult task. Some of the appliances on the web did not have all the specifics listed, making it hard to compare different types of models.

Summery of Design

Favorite Features



- ▶ George – The indoor balcony design so so you could see into the other ground floors.
- ▶ Janine– The glass floor on upper floor was unique and allowed for more sunlight to brighten the second floor.
- ▶ Haley– The use of an indoor balcony that allows more sun into the house. The windows in the front of the house allowed sun through to the upper and lower levels.
- ▶ Jess– The actual layout of the SketchUp model and how the house as a whole was designed. The finished project looked cooler than expected.

Conclusion



- ▶ Experience working in team like positions, which would be similar to many jobs
 - This helped us prepare to work in our future careers
- ▶ We learned a lot about the design of zero energy houses
 - Zero energy houses can be designed with many of the technologies available but there also needs to be consideration of conservation on the homeowners part. Conservation of water and electric is very important in living in a zero energy house.
 - Most complex items need to be sacrificed when living in a ZEH. We learned that it is not necessary to have top of the line appliances if they are not energy efficient.
- ▶ Utilizing renewable resources to increase house efficiency
 - This project showed us that it is building an energy efficient house with solar panels is actually a feasible task. Many are frightened by the thought of solar panels, but through this project we discovered that with work, it is possible to attain such energy efficient house.

Conclusion



- ▶ Cost effective housing
 - Through research we found that early anyone can afford a ZEH for there are wide price ranges from the \$100,000 to the \$300,000. Also we discovered that it is necessary to find alternative, possibly more expensive, appliances because in the long run they will use less energy and within several years, return money to you through savings.
- ▶ Applicable to the “real world”
 - Zero energy houses can look like everyday houses. Just because the ZEH is energy efficient, doesn't mean it has to look like its from outer space. We found it interesting that we were able to build a home that is actually livable in the “real world,” and not just virtually.