Zero Energy Home

EDSGN 100 Section 005

Team Number 3, Team Happy Valley

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Executive Summary

Team Happy Valley was founded in 2015 and is a growing manufacturer and developer of Zero Energy Homes. Our principal offices are located in State College, PA. Over the past few years, there has been a dramatic increase in the demand for Zero Energy Homes. As more and more people demand a Zero Energy Home, more Zero Energy Homes need to be built. The objective of this project is to design a Zero Energy Home that can comfortably house a family of four, all with a budget of $140,000. Our house must only use as much energy as it can produce in a year. In other words, the net consumption of our energy needs to be zero.

In the development of the design, several options were evaluated. Initial research on current Zero Energy Homes were conducted. We looked at multiple designs, and many different ways that were used to increase the efficiency of our house. This process of research was extremely helpful in our overall selection of the design and build of our house. After defining and ranking the customer needs and target specifications, our choice was narrowed down to one. A 600 square foot home, with two bedrooms, a bathroom, living room, a kitchen, and ten feet tall ceilings. We have no garage, just a driveway. All of our appliances are top of the line energy star rated appliances. We have rain water collection systems, solar panels, tons of windows, moving walls, and remote controlled shutters. Our house is one story tall.

There are several risks presented for this design. The highest risk of this project is potentially going over the budget. The budget for the house is $140,000. Currently, with the house we have in mind, it should cost $135,729 to build. This is a very affordable price, especially for a family of four. The risk of going over budget can be managed by making sure that throughout the whole build process, everything is followed exactly by the book, and mistakes are avoided at all costs. The final prototype is scheduled to be finished October 13, 2015. The house is scheduled to be built sometime in 2016.

Introduction

A Zero Energy Home is a high performance and highly efficient home which resides basely on renewable sources of energy. In this project the Zero Energy Home is located in Pittsburgh.

The Zero Energy home is one story tall and is designed for a family of four. It has Solar Energy as the main source of energy. Also, Geothermal energy is used as the source of the heating for the house.

The Zero Energy home also consists of rainwater harvesting system and is highly ventilated. Moreover, the insulation is also based on the latest technology.

The targeted customers are private contractors and government contractors.

It is highly eco friendly and also safe for staying.

Customer Needs Analysis

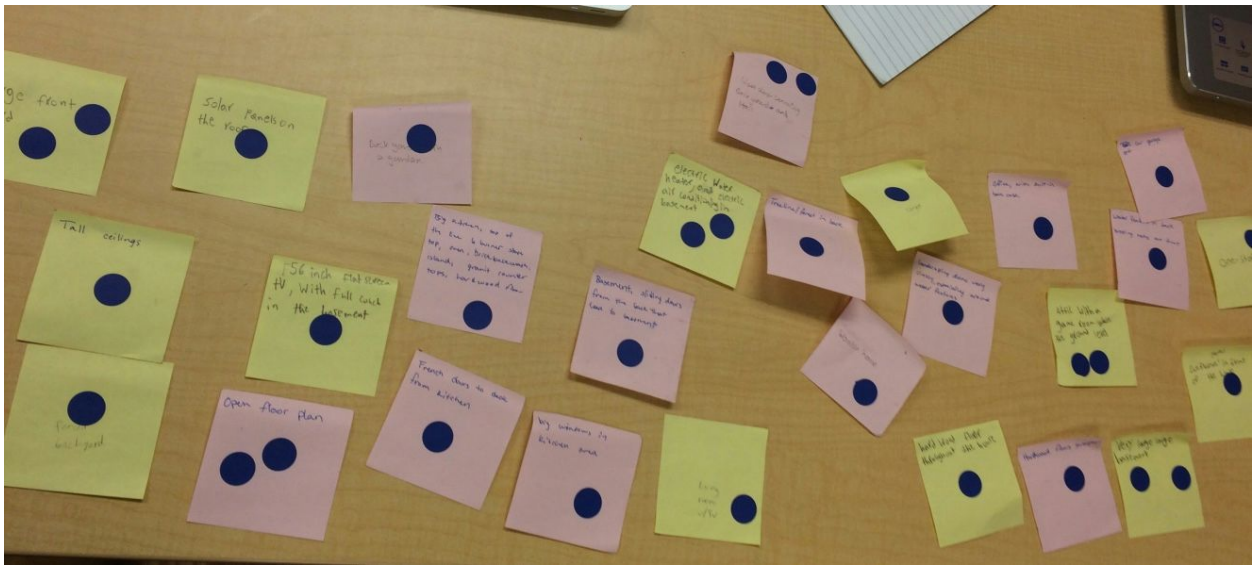
- Occupancy for four people
- Eco friendly
- Energy efficient
- Cheap energy
- Safe
- Affordable price range
- Rainwater harvesting system
- Efficient insulation
- Highly ventilated
- Constructed using green principles
- Attractive
- Car parking
- Security system

External Research

The External research done for our ZEH involved a preliminary research phase, and a additional research phase. For our preliminary research phase each member of our group picked two ZEH homes. This research included information on respective: Location, size, number of floors, number of bedrooms, type of heating system, main source of heating, size of the photovoltaic system, use of solar water heater, R-Values of the wall and ceiling, use of ventilation air heat recovery, and the predicted annual energy use. The additional research phase involved finding the average price of a typical cost effective ZEH home. Through the use of the school library online databases, we found the LexisNexis online database to be the most relevant to our problem. Than through the LexisNexis online database we found an Article named ZEH neighborhood about a ZEH neighborhood made in Austin texas, the average ZEH cost in the neighborhood ranged 100,000 to 125,000.

Concept Generation(Henry)

In order to Generate our concepts we used the results of a brainstorming activity in class, this involved each team member closing there eyes writing down as many ideas as they possibly could on individual sticky notes in a roughly 5 - 10 minute time frame, than after the time limit was up each team member took turns sorting the sticky notes into the categories they thought they best fit, there was no communicating during this process. After each team member was done sorting, and everyone agreed with the categories; lastly each team member put stickers on the sticky notes with the ideas they thought were the best. our group used a large amount of the ideas generated through the brainstorming activity in the compilation of our needs metric matrix.



Concept Selection(Henry)

Team happy valley's concept section involved a 4 step process: first constructing a consumer needs chart, secondly constructing a metrics chart, thirdly constructing a needs metric matrix, and fourthly constructing a benchmarking chart. Than we set goals our goal was to make a product that is economically accessible to green middle class consumers, and government/private contracting sectors looking to produce homes in climates like or similar to Pittsburg. Our ZEH will include economically viable Insulated walls (reduces temperature fluctuation), Geothermal heating (natural heat/cooling from underground), Solar panels (generates electricity from sunlight), and a solar water heater (heats water with the energy of the sun). The purpose of this was for it to pose as profitable for a private/government contractor, or cheaper for a nature loving middle class citizen. The total cost of our ZEH design is under 140,000 making it affordable to construct, and cheap for liquidation.

<u>Consumer needs chart</u> - The purpose of a customer needs chart is to name each need you wish to evaluate, and give it a ranking of Importance, and a number to allow the use of it in additional charts.

#	NEED	Importance (1 to 5) 5 being the best
1	Self sustainable in a Pennsylvanian climate	5
2	Cheap Energy (basically free)	4
3	Safe living environment	4
4	Under 140,000 dollars	5
5	Under 1000 sq. ft.	4
6	Constructed using green building principles	3
7	Meets the needs of a typical family of 4	5
8	Aesthetically pleasing (Attractive appearance)	4
9	Energy management system that informs owner of energy usage	2
10	Functional appliances	5

Conclusion - The result of this chart is it gives each customer need a number according to its respective order, and a quantifiable number based on its respective importance.

Metrics Chart - The purpose of a metrics matrix is to give each possible respective metric for the house a quantifiable unit, the importance of the respective metric in a quantifiable number, the numbers of respective needs the metric satisfies, and the metric number corresponding to each metric for use in future charts.

Metric #	Needs #'s	Metric	Importance (1 to 5) 5 being the best	Units
1	4,6,7,8	Single story house	4	$
2	3,4,5,6,7,8	600 square foot conditioned floor area	4	ft^2
3	1,2,3,4,6,7,8,10	Triple low-e window	3	$
4	1,2,7,9	4.5 PV system	3	KW
5	1,2,3,4,7	Heat thermostat setting	2	F
6	1,2,3,4,7	Cool Thermostat setting	2	F

7	4,6	Total house cost – 135,729	5	$
8	1,2,4	PV cost – 22,670	4	$
9	7,8	Upgrade Costs - 19,930	4	$
10	1,2,3,4	R13 insulated walls	4	$
11	1,2,3,7	Geothermal heat pump	3	$
12	7	Single car garage	4	$
13	3,7,9	Electric water heater	3	$
14	1,2,3,4	R40 ceiling insulation	4	$
15	8	Hot tub	1	$
16	8	Pool	1	$
17	1,2,4,7	First Solar– 270 (solar panel)	4	$
18	3,7,10	Home Security System	5	KWh/yr.
19	1,2,4,7,10	80 Gallon Solar Closed Loop H.W Sys	4	$

<u>conclusion</u> - The result of this chart is we can use its information to create a needs metric matrix to compare the needs of each prospective metric for our ZEH.

<u>Needs metric matrix</u> - The purpose of a needs metric matrix is to allow you to visually see the importance of each metric according to the amount of needs it satisfies.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Need	Single story house	600 sq ft condition	Triple low-e window	4.5 PV system	Heating system cost – 22,670	Cooling system cost – 135,729	Total house cost – 135,729	PV cost – 22,670	Upgrade Costs - 19,930	R13 insulated walls	Geothermal heat pump	Single car garage	Electric water heater	R40 ceiling insulation	Hot tub	Pool	First Solar – 270 (solar	Home Security System	80 Gallon Solar Closed

			onedfloorarea			ng	ng	29										panel)		oopH.WSys
1	Self sustainable in a Pennsylvanian climate			*	*	*	*		*		*	*			*			*		*
2	Cheap Energy (basically free)			*	*	*	*		*		*	*			*			*		*
3	Safe living environment		*	*		*	*				*	*		*	*				*	
4	Under 140,000 dollars	*	*	*		*	*	*	*		*				*			*		*
5	Under 1000 sq. ft.		*	*																
6	Constructed using green building principles	*	*	*				*												
7	Meets the needs of a typical family of 4	*	*	*	*	*	*			*		*	*	*				*	*	*
8	Aesthetically pleasing (Attractive appearance)	*	*	*						*						*	*			
9	Energy management system that informs owner of energy usage				*									*						
10	Functional appliances			*															*	*

Conclusion - from this chart we can deduce that the most important metrics for our design are: 600 square feet of conditioned floor area, Triple Low-e windows, a 4.5 kilowatt photovoltaic system, geothermal heating, heat thermostat setting, first solar - 270 (solar panel), home security system, and a 80 gallon solar closed loop H.W Sys.

Benchmarking - Is the comparison of one's product performance matrix to others in the industry, in order to access productivity and performance.

Metric #	Need's #'s	Metric	Importance (1 to 5) 5 being the best	Units	Team Happy Valley ZEH	Austin Texas ZEH neighborhood	Passive house retreat, New England	Lincoln Farm house, MA
1	3,4, 5,6, 7,8	Conditional floor area	5	ft^2	600	800	12,000	3,400
2	4,6	Total house cost	5	$	135,729	100,000	NA	NA
3	1,2, 3,4	Type of wall insulation	4	R	R – 12	NA	R-40	NA
4	7,8	Number of bedrooms	4	#	2	2	6	9
5	4,7, 8	Number of stories	4	#	1	1	1	2
6	1,2, 4	Photovoltaic system	4	KW	4.5	NA	4.1	13.8

Conclusion - from this Benchmarking chart we can deduce that our ZEH is out gunned compared to some of the house designs of some of the best in the industry, but the trade off is our design is cheaper than these designs, The Passive house retreat, NE and the Lincoln farm house MA, are so expensive there prices are not even listed. secondly our ZEH may be more expensive than the average ZEH home in Austin Texas neighborhood, but that is because our house comes with more modern cutting edge innovations that make it sustainable in a cold environment like Pittsburg, for example our 80 gallon solar, and geothermal. Through these implications we deduced that our house would be the most acceptable for government, or private contractor that want a very low risk, middle of the road ZEH home to produce for a cold environment.

Globalization - Our Zero Energy Home will be marketable all over the world due to the fact that it is designed to be net zero in a cold Pittsburg climate. I know this because countries with a cold climate will jump at a chance to buy a ZEH that produces net zero in a climate as cold as Pittsburg, secondly countries with warm climates will also jump at the chance to buy our

ZEH design do to the electricity resale benefit of selling extra electricity generated to their respective power companies.

Embodiment Design

The design of the house may seem simple on the outside, and that is true. However, this was a result of the budget. Our 600 square foot house is one story with two bedrooms and a bathroom. It is fit for a family of four. The parents sleep in the master bedroom and the two children sleep together in the other bedroom. The closets for the bedrooms are part of the walls.

There is not a garage as a result of the budget. Instead, the family must park their car in the driveway. The kitchen and living room are found in the large open space. Our cardboard model of the home was scale to the actual home. It was 2 ½ by 3 inches.

Energy Calculator

Our mission was to create the most energy-efficient home under budget. The zero-energy calculator was perhaps the most difficult part of the project. We had the freedom to create a house however we wanted, but it had to be under a budget of $140,000. In order to achieve this we had to sacrifice some luxuries. For example we chose not to have a garage. It was far too expensive. Some other things sacrificed were a pool and hot tub. These things would have been

nice, however, our objective was to put the environment first. What was lost with these things was gained with the appliances we were able to buy. All of the appliances in our home are 5-star energy rated products.

Final Design Description

Our final design is a 600 square foot home, with two bedrooms, a bathroom, a kitchen, and a living room. There is no garage, just a driveway next to the house. All of our appliances are top energy star rated appliances. We have several moveable walls on tracks, this includes closets. We have 10 feet tall ceilings, and minimal lighting as we are taking advantage of the

natural light by having tons of windows. There are remote controlled shutters to help block sunlight during the summer, and let it in during the winter.

Conclusions

Our house costs $135,729 to build. The house that we've constructed is a zero energy home, with a lot of our energy coming from solar panels. Using the engineering and design process, our team was able to work together and design and build a house that meets all of the requirements.

References

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