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ZERO ENERGY HOMES: An Initiative to Sustainable Environment

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Abstract - *A mid growing concerns about rising energy prices, energy independence and the impact of climate change there is a need for building with low energy consumption. About 40% of the world's energy is consumed by buildings; this underscores the importance of targeting building energy use as a key to decrease the nation's energy consumption. The building sector can significantly reduce energy use by incorporating energy-efficient strategies into the design, construction, and operation of new buildings and undertaking retrofitting to improve the efficiency of existing buildings. This can be achieved by introducing a concept known as zero energy building.*

A zero energy building is a building with greatly reduced energy needs through efficiency gains such that the balance of the energy needs can be supplied by renewable technologies. The net zero energy initiative offers a comprehensive solution to the current environmental challenges facing commercial and residential buildings. On-grid zero energy homes produce renewable energy on-site at a value equal to, or greater than, the building's total annual energy consumption. Here we are working on several renewable energy resources such as solar energy for a net zero energy building.

Key Words: Rising energy prices, energy efficient strategies, zero energy building, comprehensive solution, environment, renewable energy on site, energy consumption, etc.

1. INTRODUCTION

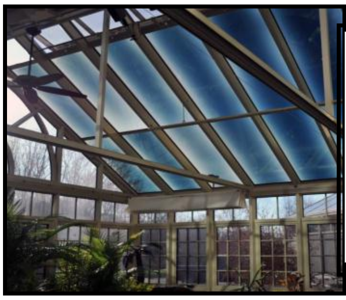
Sustainable, Eco and Green buildings try to use maximum benefit of the natural resources and consumes less energy than our current traditional house, while zero energy building concept is 100% use of natural resources and zero energy consumption. The first Zero energy building was built in north Texas. Zero energy buildings are environmental friendly home, and produce much energy than it's actually consumed, looks pretty conventional like any other house, but whole lot of strategies to bring it down to zero energy home. Zero energy buildings are economic, affordable houses and build for family with normal income and very healthy too. Now a day's world is focused on cost and economic construction. At the end of the year these houses produce more energy than used by the occupants. Puts an end to high summer utility bills. These houses take the construction industry to whole new levels.

1.1 Main Components of focus of Zero Energy Buildings-

1.1.1 Walls & Roof materials

- **Hollow Clay Bricks:**

Strength of 1 Hollow brick is similar to that of 9 clay bricks on top of that it has less mortar joints, hence less plumb & alignment with faster construction.



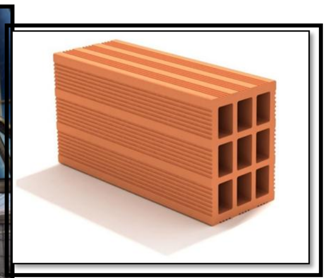


Fig -1: Glazing of window **Fig -2:** Hollow brick

- **Glazing of windows:**

In this Zero Energy House we are using high performance thermal glazing. This is based on electro chromic technology. It automatically switches between clear and tinted states.

Solar PV generates no pollution. The direct conversion of sunlight to electricity occurs without any moving parts. Photovoltaic systems have been used for fifty years in specialized applications, standalone and grid-connected PV systems have been in use for more than twenty years. Photovoltaic are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons.

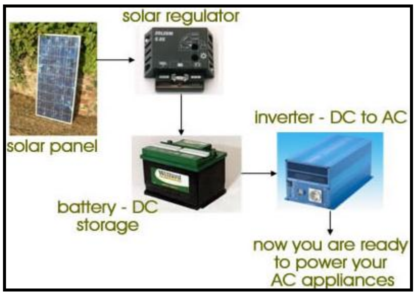


Fig -3: Solar Power Generation System

The average Indian house consumes 1500 kWh of electricity from the grid each year.

Source	Power generation (MW)	Share
Coal	27,498	58.26%
Hydroelectricity	67	0.14%
Renewable energy	Included in oil	
Natural Gas	5,677	12.03%
Oil	13,958	29.57%
Total	**47,200**	**100.00**

Table No. 1: Captive power generation

1.1.2 Domestic Hot Water System:

In current new buildings, Domestic Hot Water energy consumption is a big portion of total building energy consumption, being the second largest energy consumer in homes. Studies shows water heaters consume 20% of the total energy consumption of homes on average. In the base model building, the water heater is estimated to consume 29% of annual building energy. In case of a net-zero building minimizing or eliminating water heater energy consumption would be a breakthrough toward becoming energy neutral.

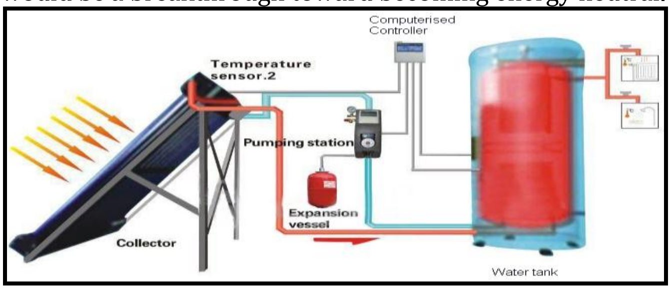


Fig -4: Domestic Hot Water System

1.1.3 Greywater System:

Water is becoming a rare resource in the world. It is therefore essential to reduce surface and ground water use in all sectors of consumption, to substitute fresh water with alternative water resources and to optimize water use efficiency through reuse options. Thus we are adapting greywater system. Greywater is commonly defined as wastewater generated from bathroom, laundry and kitchen. Consequent rapid growth in population & rapid industrialization causing increase in water demand, stress on water resources in India is increasing and per capita water availability is reducing day by day thereby increasing the opportunity of greywater reuse. Eg. - for flushing W.C.s.

Description	Q (l/cap/d)	Grey water production (l/cap/d)
Bathing	55	55
washing of clothes	20	20
flushing of WC	30	-
cleaning of house	10	5
washing of utensils	10	10
Cooking	7	-
Drinking	8	-
Total	**140**	**90**

Table No. 2: Production of grey water

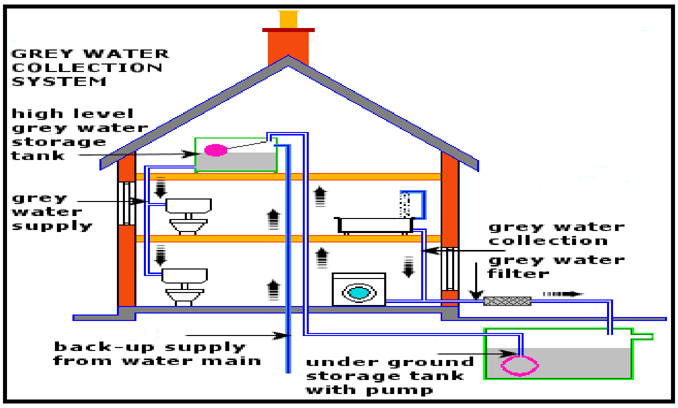


Fig -5: Schematic representation of grey water system

1.1.4 Rainwater Harvesting:

Most houses can rely on mains pressure to move water to where it is needed in the house. Using a rainwater tank, a pump is required to control distribution and this provides an opportunity to install an efficient product to reduce energy demand, helping us to achieve our Zero Energy goal. To move water from the tank to the toilets, washing machine and outside taps, we've installed a booster pump. The pump has a variable speed motor and is controlled by a sensor which determines how much water is required by measuring changing water pressure in the house as per demand. It also has an inbuilt stop function to stop operation on low demand and then restart on demand. This allows the Booster to consume up to 60% less energy than a comparable constant speed pump. This operation also means a constant pressure is maintained in the pipe system, regardless of fluctuating demand.

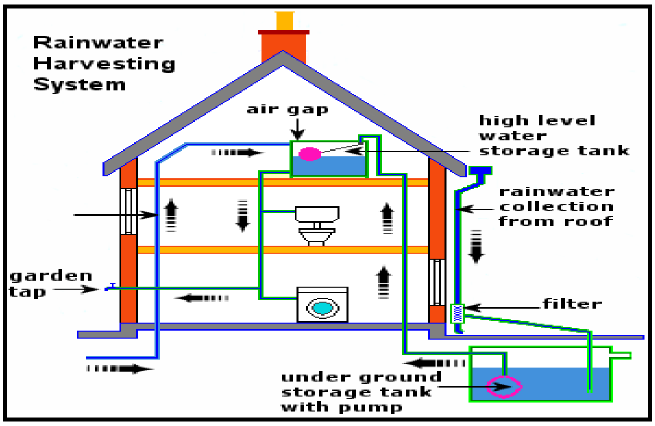


Fig -6: Schematic representation of rainwater system

1.2 Objective:

i. To design a building with zero energy concept.
ii. To eliminate the necessity of active energy loads on the building.
iii. To compare the zero energy building with conventional building.

1.3 Necessity:

The basic necessities of such a building are:

i. As the country is developing day by day the consumption of power is also very high.
ii. Now if we are going for zero energy building we can save energy locally which mean to save energy in global level.
iii. The use of this technology used in residential buildings has shown huge amount savings in the electricity bill.
iv. The proper design and alignment of the building can make the building cheaper than that of the conventional type of buildings.
v. Usage of hollow bricks and avoidance of columns and beams will result in lowering of temperature inside the building.
vi. To achieve sustainability.

1.4 Softwares Used:

1) Auto CAD 2) MS EXCEL 3) MS WORD 4) Sketch-up

2. METHODOLOGY

We are designing our Zero Energy House by planning and executing the methods of designing the house for the Zero Energy. Then we will be planning & designing the rainwater harvesting system & greywater management system of the house to reduce the use of water and for making a healthy environment. Planning & designing solar system to provide solar energy through solar panels also to include solar water heater. Calculating & estimating the cost required to construct a building with hollow blocks & glazing to windows & roofs.

2.1 Designing of Zero Energy Homes

First of all we have designed G+1 bungalow of 320 sq.m. plinth area on 20m x 25 m plot. We have used AutoCAD, sketch-up etc. for the designing and making 3D model.

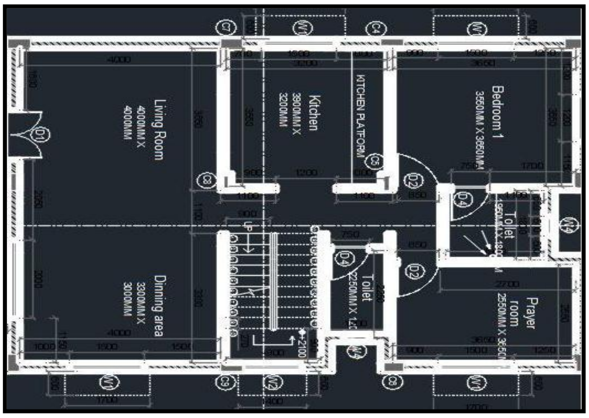


Fig -7: Ground floor Plan

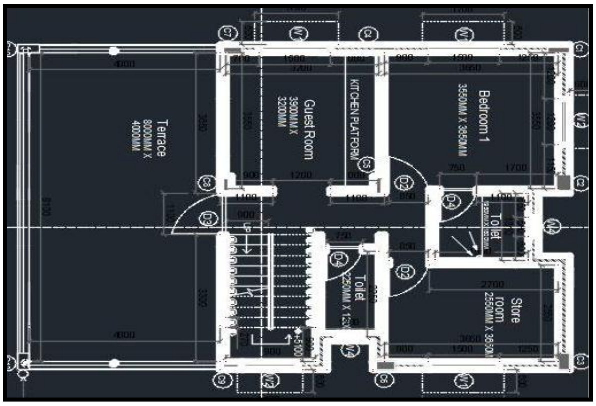


Fig -8: First floor Plan

2.1.1 Designing of Solar System

Power rating of each appliance that will be drawing power from the system.

2.1.1.1 Calculation of energy consumption:

The calculation of energy consumption for the Solar Panels are given below in Table No. 3

Particulars	Items	No.	Usage (hrs)	Voltage (w)	Consumption	Inverters
LR	LED	4	5	20	400	80
	Fan	2	5	50	500	100
	T.V.	1	5	80	400	80
Bed 1	LED	2	3	15	90	30
	Fan	1	10	50	500	50
Bed 2	LED	2	3	15	90	30
	Fan	1	10	50	500	50
Kitchen	Oven	1	1	900	900	900
	LED	3	4	15	180	45
	Exh.	1	4	50	200	50
	Mixer	1	1	450	450	450
Dining	Fridge	1	18	150	2700	195
	LED	4	4	20	320	80
	Fan	1	3	50	150	50
T 1	LED	1	1	15	15	15
T 2	LED	2	2	15	60	30
T 3	LED	1	1	15	15	15
T 4	LED	2	2	15	60	30
Pump		2	2	750	1500	1500
DY		1	2	90	180	90
PR	LED	2	1	15	30	30
Store	LED	2	1	15	30	30
Guest	LED	2	3	15	90	30
	Fan	1	10	50	500	50
Stairs	LED	2	5	15	150	30
Balcony	LED	2	3	15	90	30
	LED	1o	5	15	750	150
Total					**10850**	**4220**

Table No. 3: Calaculation of electricity usage

I. ***Power Inverter Sizing:***
Appliance total power draw = 4220 W
To provide a small buffer or margin your minimum size inverter choice should be around 4500W.
A modified sine wave inverter with a 4500W continuous power rating will therefore be your obvious choice in this specific solar system design.

II. ***Determining the Size and Number of Solar Panels***
Divide the total daily power requirement by the number of charge hours for that geographic region
eg. (10850×1.2)\5=2604 WATTS
250 Watt Solar Panel
Total watt/ 250 watt solar panel = $\frac{2640}{250}$
=11panels ~ 14 panels
Assuming = 14 x 250 W panels.

III. ***Number of Batteries***
250W panels produce 4.8Amps, thus 20x 4.8 A
= 96A x 6 Hrs. = 576.Ah
105Ah batteries, should be discharged to no more than 50%, thus we divide total amps by
105A x 50% = 50A.h
$\frac{576}{50A}$ = 11.52 x 105 Ah batteries.
=12 x 105 Ah batteries.
For ease of possible 24V or 48V configuration, this would mean 3 in series of 3 batteries.

IV. ***Size of Regulators***
Let's say we had 20A regulators at our disposal.
One 250W panel produces around 4.8Amps.
The regulators are put in series
20 x 4.8A=96
So, for 14 solar panels we would need 4 x 20 solar regulators.

- **Complete the solar power system**
Well we have the following:
 i. 14 x 250W solar panels
 ii. 4 x 20A solar regulators
 iii. 12x 105A.H deep cycle batteries(3 in series)
 iv. 1 x 3500W modified sine wave power inverter

2.1.1.2 Rate Analysis

Solar panels =Rs.32/W
Regulator = Rs 1800
Batteries = Rs 8000/series
Inverter = Rs 4800
Total Cost
Solar panels =14x250x32=Rs 112000
Regulator = Rs 1800
Batteries = Rs 8000x3=24000=Rs 24000
Inverter = Rs 4800

Total=112000+1800+24000+4800= Rs. 142600/-

The total cost of the solar panel is Rs. One lakh forty-two thousand six hundred for our residential building .In these solar panel cost is based on the solar panels, regulator, batteries and inverter. The output of solar panel can be expected to vary by 0.25% for every 5 degrees variation in temperature. In Zero Energy House, decrease in temperature for using of hollow bricks and solar panels produces the electricity. When compared to conventional building, the initial cost is high but in future the electricity cost is reduced.

Fig -9: Arrangement of solar panels

2.1.1.3 Domestic Hot Water System:

The total cost of the solar panel is Rs. Thirty thousand for our residential building .In these solar panel cost is based on the solar panels, regulator, batteries and inverter. The output of solar panel can be expected to vary by 0.25% for every 5 degrees variation in temperature. In Net Zero Energy House, decrease in temperature for using of hollow bricks and solar panels produces the electricity. When compared to conventional building, the initial cost is high but in future the electricity cost is reduced.

The placement of water heater is as shown in figure below.

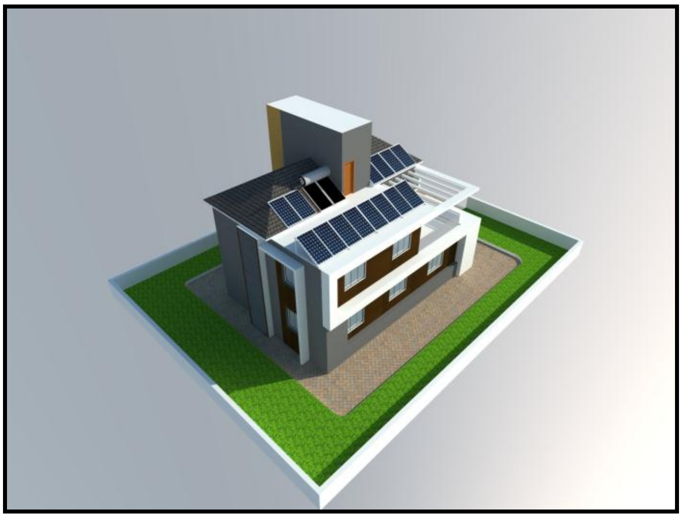


Fig -10: Arrangement of solar water heater

2.1.2 Designing of Rain Water Harvesting:

2.1.2.1 Tank:

Tank is generally circular in shape and is constructed in stone masonry in 1:3 cement-sand mortar. While small tanks of 3 to 4.22 m diameter and about 21-59 cum capacity are built by individual houses, larger ones of 6 m diameter and 200 cum capacity are built for the village communities. In both these cases the depth is kept equal to the diameter. The catchment of the Tank is treated in a variety of ways to increase the rain water collection. The commonly used materials are murrum, coal ash, gravel, pond silt, bentonite, soil-cement mix, lime concrete, sodium carbonate etc. Because of the constraints of availability of large open areas around the Tank and the unit cost of treatment, a circular strip of land of 12 m width around the tank is usually treated, the slope of which is kept as 3% i.e. a fall of 3 cm in a length of 1 m. This provides bulk of the requisite amount of water to fill the Tank. Remaining water is received from the natural catchment outside the treated area.

2.1.2.2 Site Selection:

Tank of about 21 cum capacity for an individual household should preferably be built in front of the house in an open area of about 10 m x 10 m size. Since the rainwater from this area is to be collected in the tank, the area should be such that human activity and cattle grazing may be prevented during the monsoon season to prevent pollution of water.

2.1.2.3 Site Preparation:

The selected area should be cleared of all vegetation i.e. grass, shrubs, bushes etc. A circle of 10 m diameter should be drawn to mark the rain-water-collection area (catchment area). For smaller Tank the catchment area should be suitably dressed to provide an inward slope of 3 cm in 1 m length towards the center.

2.1.2.4 Planning and Designing:

1. Water Requirement

A Tank of 21 cum capacity is usually adequate to meet the minimum drinking water requirements of a family of 6 persons for one year.

2. Water Availability:

Some part of the rainwater is lost due to evaporation and seepage into the ground. This loss varies with the amount of rainfall. For low rainfall the losses are high and for high rainfall these are low. Availability of rainwater for a Tank from a natural catchment can be computed.

3. Structural Design:

For 21 cum capacity:

(i) Foundation excavation: 3.9 m dia and 3.5 m depth.
(ii) Foundation concrete: 1:3:6 CC 250 mm thick.
(iii) Tank Wall: 1:2:4 CC Wall 150 mm thick with 5 mm Cement Plaster.
(iv) Tank Cover: Stone slab roof, at height of 1.0 m from G.L.
(v) Apron around Tank: 1:3:6 CC Apron, 1.0 m wide and 100 mm thick.
(vi) Deep Catch Pit at the bottom of Tank: 1000 x 250 mm
(vii) Slope of artificial/ treated catchment around Tank: 3% to 4% - a fall of 3 cm in a length of 1 m.
(viii) 3 Inlets and 1 Outlet in Tank wall at apron level: Size 0.6 x 0.3 m with Iron Bars and Expanded Metal
(ix) Opening at the top (for drawing water): Size 1.0 x 1.0 m

4. Data Requirement:

(a) Secondary data:

i. Monthly rainfall for about 10 years (Source: District Statistical Organisation)
ii. Percentage of utilizable rainfall i.e. Runoff coefficient (Source: State Water Resources Organisation or Central Water Commission)

(b) Primary data/ information:

i. Land surface characteristics
- Should be gently sloping or flat
- Sandy and firm
- Moderate absorption of water
- Easy to excavate upto about 6.5 m depth for Community Tank and 3.5 m depth for household Tank

ii. Availability of material for catchment treatment.

The water supply to the house using Rainwater Harvesting is as shown in figure.

Fig -11: Placement of rainwater harvesting tank

2.1.3 Schematic Diagram of a Grey Water Recycling System

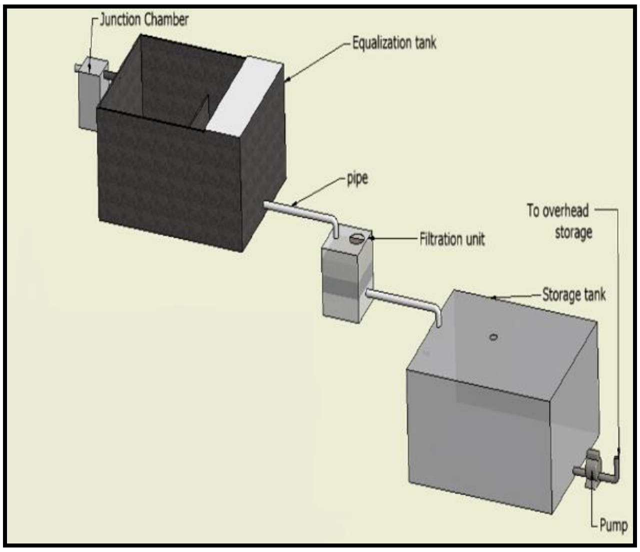


Fig -12: Schematic diagram of a grey water system

3. ESTIMATE

Approximate rate analysis proposed for Zero Energy Building is given in the Table No. 4:

Description	Quantity	Unit	Rate	Amount
Head Earth Work				
1.Earthwork in excavation of foundation upto 2m	197.50	Cum	130	25675
2.Earthwork in filling in foundation trenches	39.50	Cum	90	3555
3.Sand filling in plinth	44.43	Cum	80	3554.4
RCC work and PCC				
4.PCC for foundation	14.81	Cum	3500	51835
5.RCC concrete for column, beam, slab including skirting	53.52	Cum	6000	321120
6. 2.5 mm thick DPC	15.98	Sqm	170	27166
Brickwork				
7. B/M (Hollow) in superstructure 1:4	**2905**	**Nos.**	**90**	**261450**
7. B/M in 1:4	65.319	Cum	2300	150234
8. Mortar in B/M	20	Cum	2300	46000
Plastering work				
9. Internal plastering 15 mm thick plastic 1:6 mortar	560	Sqm	60	33600
10. External plastering 25 mm thick 1:6 mortar	259	Sqm	80	20720
Flooring work				
11. Flooring 20mm thick terrazzo tiles	163.5	Sqm	500	81750
12. Simplifying filthy and fictious porcelain coloured tiles in toilet and kitchen	82.5	Sqm	700	57750
13. 25 thick terrazzo work cast in situ with cement concrete 1:2:4	183.5	Sqm	420	76935.6
14. 7.5 cm thick terrazzo flooring in lime concrete 1½:2:7	163.7	Sqm	230	37850
15. Concrete chowkat with one side rebate in sill of window 100 mm*75 mm see with cement concrete 1:2:4	15.6	rm	38	593.8
Plastering work				
16. Decorative two coats cement concrete paint to approve quality	259.5	Sqm	32	8304
17. Applying plastic emulsion paint two coat including count primer on plastic surface	560.8	Sqm	45	25237
Steel and Iron work				
18. Tor steel Reinforcement for reinforced concrete including supply and binding wire	4.5	M.T.	5000	22500
19. Collapsible gate with 40*40*6 mm as top and bottom rail 20*10*2 mm vertical Kaman 100 mm open in fully stretched position 20*5*M.S. flats 38 mm steel rods	3	Sqm	1900	5700
20. M.S. ornamental grille of approved design weight above 14 kg per Sqm and upto 16 kg per joints continuously welded with M.S. flat bar for windows fitted fix	170	Kg	40	6800
TOTAL	**Rs.1509695.80**			

Table No. 4: Proposed Zero Energy Building

4. RESULTS AND DISCUSSION

I. **Cost of Conventional Building - Rs.10,06,879.50**

II. Total Cost of Zero Energy Building:

Cost of Zero Energy Building – Rs.11, 18,095.8/-
Cost of Solar System – Rs.1, 42,600/-
Cost of Solar Water Heater – Rs.30, 000/-
Cost of Rainwater Harvesting – Rs.64, 000/-
Cost of Greywater System – Rs.1, 55,000/-
Total Cost – Rs.15, 09,695.80/-

III. Due to use of, Hollow Bricks in Zero Energy Building the temperature has been reduced by 4°C as compared to Conventional Building

4.1 DIFFERENCE

Points of Comparison	Conventional Building	Zero Energy Building
Initial Cost	Low	Slightly high
Electricity	Requires an active source	Produced on its own
Resources	Easily available	Difficult
Operating Cost	High	Low
Maintenance	Low	High
Environment friendly	No	Yes
Ease of work	Easy	Difficult
Labour	No need	Required

Table No. 5: Comparison between Conventional building & Zero Energy Building

5. CONCLUSIONS

So here we can conclude that the initial cost of zero energy house is high but in future it will be economical and efficient as well. In comparison with a conventional building, zero energy house emits less greenhouse gases and cause comparatively less harm to environment. Renewable energy sources are used in Zero Energy Houses which is environmental friendly. Hence Zero Energy House is an initiative & effective solution to sustainable environment.

5.1 FUTURE SCOPE OF WORK:

So here we can conclude that the initial cost of zero energy house is high but in future it will be economical and efficient as well. In comparison with a conventional building, zero energy house emits less greenhouse gases and cause comparatively less harm to environment. Renewable energy sources are used in Zero Energy Houses which is environmental friendly. Hence Zero Energy House is an initiative & effective solution to sustainable environment.

REFERENCES

[1] "Zero Energy Buildings: A Critical Look at the Definition" Paul Torcellini, Shanti Pless, and Michael Deru, National Renewable Energy Laboratory; Drury Crawley, U.S. Department of Energy. National Renewable Energy Laboratory report: NREL/CP-550-39833.

[2] "A Common Definition for Zero Energy Buildings" Paul Torcellini, Shanti Pless, and Michael Deru, National Renewable Energy Laboratory US Department of Energy, September 2015.

[3] "Net-Zero Energy Buildings: A Classification System Based on Renewable Energy Supply Options." Shanti Pless and Paul Torcellini. National Renewable Energy Laboratory report: NREL/TP-5500-44586, June 2010

[4] "Net Zero Energy Solar Buildings". International Energy Agency: Solar Heating and Cooling Programme. 2014. Retrieved 25 June 2014.

[5] Sartori, Igor; Napolitano, Assunta; Voss, Karsten (2012): Net Zero Energy Buildings: A Consistent Definition Framework. In: Energy and Buildings.

[6] Voss, Karsten; Sartori, Igor; Lollini, Roberto (2012): Nearly-zero, Net zero and Plus Energy Buildings. How definitions & regulations affect the solutions. In: REHVA Journal 6.

[7] D. Kornack and P. Rakic, “Cell Proliferation without Neurogenesis in Adult Primate Neocortex,” Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[8] M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

[9] R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.

[10] K. Elissa, “Title of paper if known,” unpublished.

[11] en.wikipedia.org/wiki/Zero-energy building

[12] en.wikipedia.org/wiki/Electricity sector in India

[13] www.solarpanel.co.za/solar-power-calculator.html

[14] en.wikipedia.org/wiki/Photovoltaic system-components

[15] en.wikipedia.org/All India Installed Capacity of Utility Power Stations

[16] Training Material on Greywater Management by Ecosan Service

[17] energy.gov/energy saver/solar-water-heaters

[18] mnre.gov.in/schemes

[19] Training Material on Greywater Management by Ecosan Services

[20] “Design of an Improved Greywater Recycling System” by Mogaka Alphas Ombese, university of Nairobi.

[21] Rainwater Harvesting and Conservation Manual – CPWD, Government of India.

[22] https://m2ukblog.wordpress.com/2016/10/20/what-is-zero-energy-building-difference-between-green-building-and-zero-energy-buildings/.