# THE DESIGN AND COST ANALYSIS OF NET ZERO ENERGY RESIDENTIAL BUILDING

**P.R Satarkar[1], Shreyas S. Pimpalkar[2], Saurav G. Gondole[3], Pranav U. Wani[4], Tushar P. Tayade[5]**

*[1]Associate Professor, Department of Civil Engineering, AISSMS College of Engineering, Pune, Maharashtra, India. Savitribai Phule Pune University*
*[2-5]UG Students, Department of Civil Engineering, AISSMS College of Engineering, Pune, Maharashtra, India. Savitribai Phule Pune University*

---

**Abstract** - *Zero Energy Buildings is very crucial because they produce Energy that is beneficial for the environment and cost effective for the owners of the house. These types of buildings generate Equivalent amounts of input and output energy leading to a self-sustaining house with zero net energy. For this project, we are taking efforts to utilize and apply the engineering design we learned in 3-4 years of engineering in order to build a zero-energy building that meets a certain customer Zero Energy Buildings are very crucial because they produce Energy that is beneficial for the environment and cost effective for the owners of the house. These types of buildings generate Equivalent amounts of input and output energy leading to a self-sustaining house with zero net energy.*

*For this project, we are taking efforts to utilize and apply the engineering design processes we learned in 3-4 years of engineering in order to build a zero-energy building that meets a certain customer need analysis. Working in team of four we each researched and familiarized ourselves with the topic of Zero Energy Buildings (ZEB). We Used the information we acquired by doing some research to Design, a ZEB mode that explores several passive-solar design Strategies for facilitating the most heat retention with the need's analysis.*

***Key Words* – Net Zero Energy Residential Building, NZEB, Cost Analysis, Solar Energy, Payback Period, Electric Load, Energy.**

## INTRODUCTION

Self-sustaining energy is the key to building a better future. One of the biggest problems Towering over and gripping our nation today is the profuse and heavy consumption of Resources that are not only ridiculously expensive but also extremely Harmful to the environment[1](Szu-Chi-Kuan). To prevent the inevitable demise of our planet, many concerned Individuals have adopted eco-friendly polices integrating them into their Everyday lives. Although activities such as recycling paper, growing Organic food, and minimizing use of water and electricity have over the Years proved to be beneficial, none have provided a significant solution to This modern-day problem the way Zero Energy Buildings have [2] (K. Kahayan).

With so many different terms and so many ways to look at zero energy buildings there are inevitably many different definitions available. One of the basic definitions may be as follows: "A net zero-energy building (NZEB) is a residential or commercial building with greatly Reduced energy needs through efficiency gain the building is said to be a NZEB" [3] (Shanti Pleiss and Paul Tortellini).

- If its Total energy consumption = 0; i.e.
- Total energy use – Renewable energy =0
- If its Total energy consumption = 0; i.e.
- Total energy use – Renewable energy =0

[4].

As a group of four we firstly tried to collect as many as research papers and articles which are related with the concept of net zero energy building or green building. Then we went through the articles of various authors to get an overall idea of the concept. After getting enough idea we considered some important software which can be helpful in our project such as: 'Autodesk AutoCAD, Autodesk Revit'. The reason behind choosing Revit as our main software is it enables us to elaborate our thoughts on design of net zero energy building and it an integrated energy analysis feature which helped us to analyze the energy need of building. The problem of housing stock energy efficiency improvement becomes very important. Transition to low energy consumption buildings construction becomes a trend which in the nearest future will transform to the task of Applied Research in the field of design and construction [5-6]. Such exploration object is to design Buildings with zero energy consumption or close. The novelty of the project consists in an integrated approach of the house.

**OBJECTIVE**

1) To Plan and Design a "Net Zero Energy Residential Building"
2) To provide the detailed, ambitious, and clear definition of Zero Energy Building.
3) Technical solution of energy demand and energy Produced on site.
4) Comparing a Net Zero Energy Building with conventional Building.

**SCOPE OF PROJECT**

1) The building designed as a NET ZERO ENERGY BUILDING Produces its own electricity, thus it can save a huge amount in electricity bill.
2) These kinds of buildings are environmentally friendly reducing the environmental hazards (e.g., It would release zero carbon Content that would help in controlling global warming).
3) The design for the building should be such that the requirement of temperature regulation does not fluctuate throughout the year.

**RESEARCH METHODOLOGY**

1) Model of Net Zero energy Building using AutoCAD and Autodesk Revit soft-wares.
2)Implementation of ideas complementing to the NZEB i.e., Orientation, Sun compass, Renewable energy instruments etc.
3)Calculation of energy loads
4)Rate Analysis
5)final conclusion

**LIMITATIONS OF STUDY**

1)Initial cost can be higher – effort required to understand, apply, and qualify for ZEB subsidies.
2)Very few designers or builders have the necessary skills or experience to build net zero energy buildings.
3)Challenge to recover higher initial cost on resale of building – appraisers are uniformed – their model does not consider energy.
4)Climate – specific design may limit future ability to respond to rising or falling ambient temperatures (Global Warming).
5)Without an optimized thermal envelope embodied energy and resource usage is higher than needed.

**EXPECTED OUTCOME**

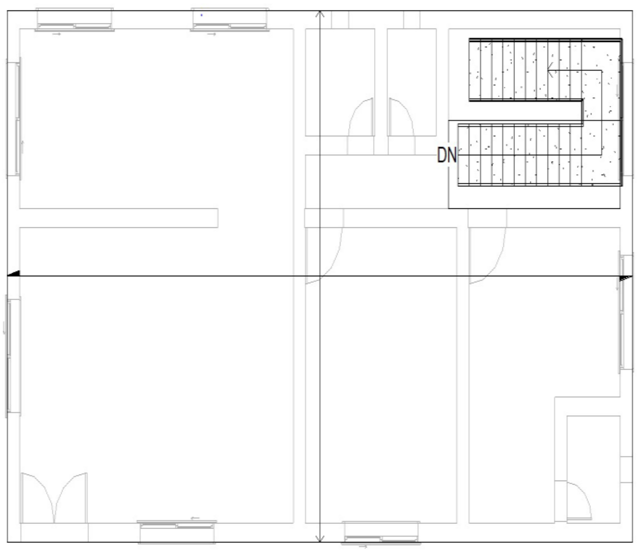
4) Higher resale value as potential owners demand more ZEBs than available supply.

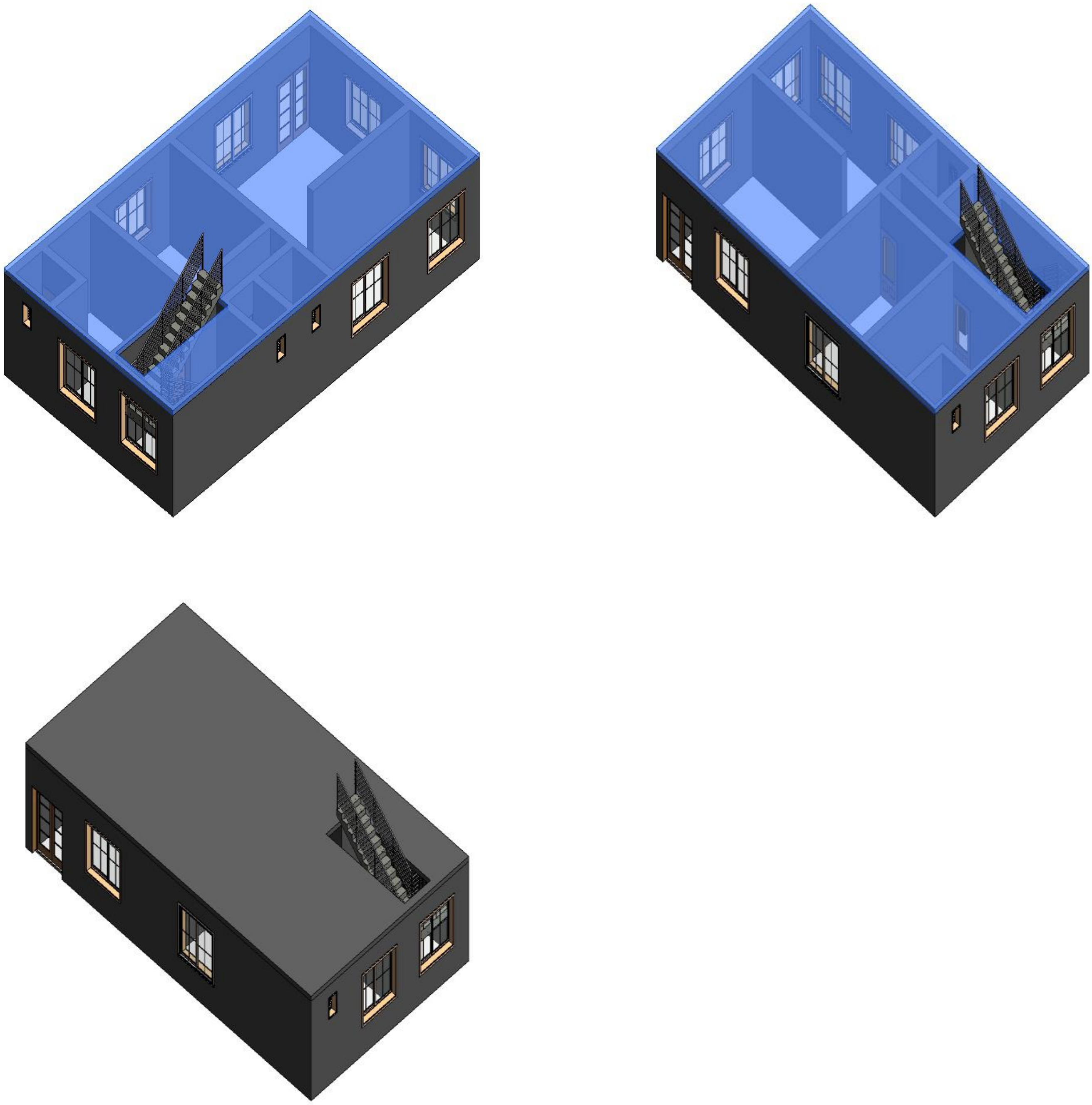
4) Higher resale value as potential owners demand more ZEBs than available supply.
2) Increased comfort due to more-uniform interior temperatures reduced total net monthly cost of living.
3) Reduced risk of loss from grid blackouts.
4) Higher resale v
5) Value of a ZEB building relative to similar Conventional building should increase every time energy costs increase.
6)Contribute to the greater benefits of the society.

**12 STEPS TO DESIGN NZEB**

1)Start with Smart Design.
2)Use the Sun for Solar Tempering.
3)Optimize with Energy Modelling.
4)Super-Seal the Building Envelope.
5)Super-Insulate the Building Envelope.
6)Use Highly Insulated Windows and Doors.
7)Create an Energy Efficient, Fresh Air Supply.
8)Select an Energy Efficient Heating and Cooling System.
9)Heat Water Wisely.
10)Install Energy Efficient Lighting.
11)Select Energy Efficient Appliances and Electronics.
12)Use the Sun for Renewable Energy.

**REVIT PLAN OF PROPOSED NZEB**





**REVIT MODEL OF PROPOSED NZEB**

**CALCULATION OF ELECTRIC LOAD**

| | | | | | | |
|---|---|---|---|---|---|---|
| **BATH** | | | | | | |
| **CHILDRENROOM** | LED | 2 | 4 | 15 | 120 | 30 |
| | FAN | 1 | 10 | 50 | 500 | 50 |
| **WATERPUMP** | | 1 | 1 | 750 | 750 | 750 |
| **WASHINGMACHINE** | | 1 | 1 | 90 | 90 | 90 |
| **EXTERNALLIGHTS** | | 10 | 2 | 15 | 300 | 150 |
| **FAMILYSEATOUT** | LED | 2 | 2 | 15 | 60 | 30 |
| | FAN | 1 | 2 | 50 | 100 | 50 |
| **TOTAL** | | | | | **=9930W** | **=3370W** |

| PARTICULARS | ITEMS | UNITS | USAGEINHR | VOLTAGE(W) | CONSUMPTION | INVERTOR |
|---|---|---|---|---|---|---|
| **HALL** | LED | 4 | 5 | 20 | 400 | 80 |
| | FAN | 2 | 5 | 50 | 500 | 100 |
| | TV | 1 | 5 | 80 | 80 | 80 |
| | | | | | | |
| **2-BEDROOM** | LED | 4 | 3 | 15 | 60 | 60 |
| | FAN | 2 | 10 | 50 | 100 | 100 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **2-MASTERBEDROOM** | LED | 4 | 3 | 15 | 60 | 60 |
| | FAN | 2 | 10 | 50 | 100 | 100 |
| **KITCHEN** | LED | 2 | 4 | 15 | 120 | 30 |
| | FRIDGE | 1 | 18 | 200 | 3600 | 200 |
| | MIXER | 1 | 1 | 450 | 450 | 450 |
| **TOILET, W.C,** | LED | 10 | 3 | 6 | 180 | 60 |

**TOTAL COST**

- Solar panels = Rs 8000 per 250W Panel
- Regulator = Rs 1800
- Batteries = Rs 8000/Series
- Inverter =Rs 4800

**TOTAL COST**
- Solar Panels' = 8 x 8000= Rs 64000.
- Regulator = Rs 1800.
- Batteries = 6400x5 = Rs 32000.
- Inverter = Rs 4800

(64000+1800+32000+4800)
= Rs 1,02600
Total Cost of Solar system are Rs 1,02,600 or One Lakh Two Thousand Six Hundred

**OUTPUT FOR 25 YEARS**
P(lifetime) = P(rated) * e*where, -0.005 is the rate of power degradation per year
= (3214*25) *0.885
=71,115 units

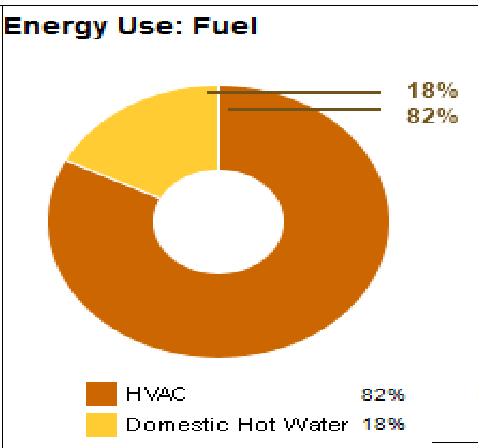
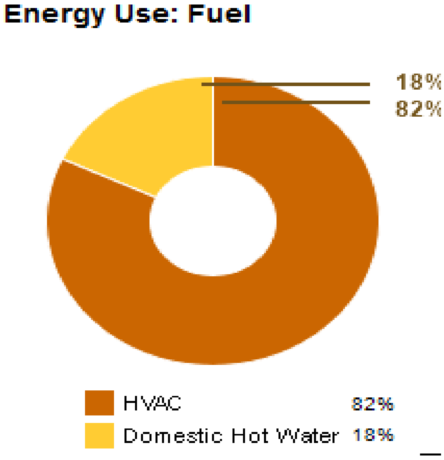
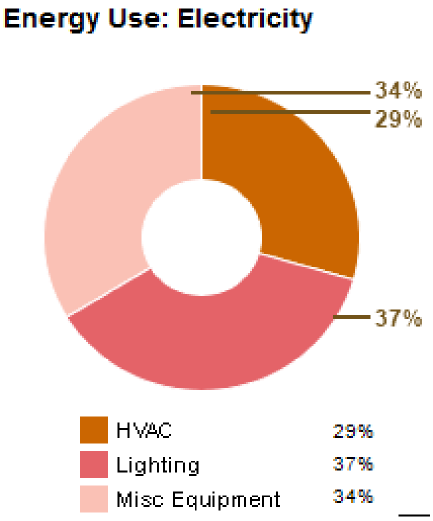
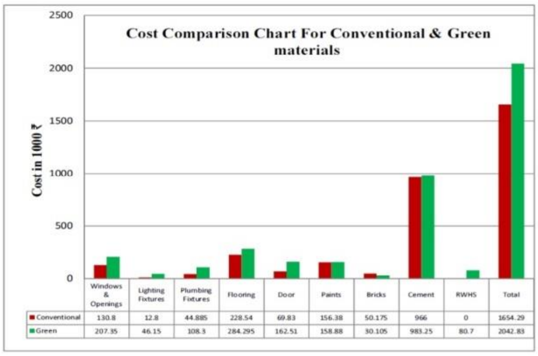
**COST PER UNIT PER SYSTEM**
cost per unit = total investment cost / actual units generated
= 107000/71110
= 2.56 Rs

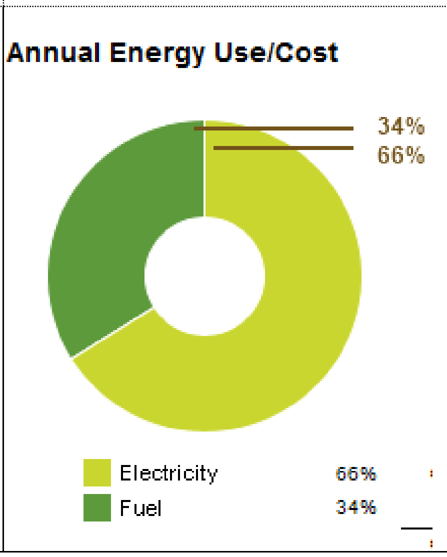
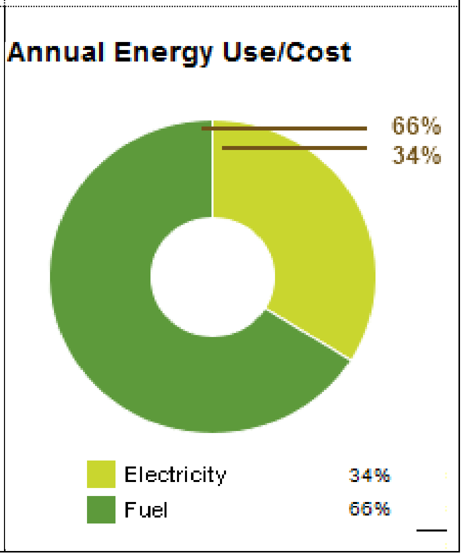
**EXPECTED CONCLUSIONS**
Normal Temperature Outside
= 32.00C
Room Temperature of Traditional Building = 31.40C
Room Temperature of Green Building = 29.30C
Reduction in Temperature for Traditional Building = 0.60C
For Green Building = 2.70C
Difference between Reductions in Temperature of
Traditional and Green Building = 2.20C

Difference between Reductions in temperature of Traditional and Green Building = 4.85C

**COMPARISON OF NZEB WITH CONVENTIONAL BUILDING**

| Parameters | Season | Winter | | | Summer | | |
|---|---|---|---|---|---|---|---|
| | Time | Morning | Afternoon | Evening | Morning | Afternoon | Evening |
| Air-contaminants(ppm) | *GB* | 0.45 | 1.21 | 1.73 | 1.28 | 1.87 | 1.36 |
| | *CB* | 4.23 | 4.48 | 4.67 | 6.64 | 6.68 | 6.38 |
| | *Difference* | 3.78 | 3.36 | 2.94 | 5.36 | 4.81 | 5.02 |
| Temperature(oC) | *GB* | 20 | 21.8 | 19.4 | 27.33 | 31.86 | 26.33 |
| | *CB* | 12.26 | 12.28 | 11.3 | 42.66 | 48.66 | 45 |
| | *Difference* | 7.74 | 9.52 | 8.1 | 15.33 | 16.8 | 18.67 |
| Humidity(%) | *GB* | 56.71 | 54.01 | 56.51 | 52 | 54 | 52.66 |
| | *CB* | 58 | 57 | 54.6 | 74 | 79 | 78 |
| | *Difference* | 1.29 | 2.99 | -1.91 | 22 | 25 | 25.34 |
| Noise (dB) | *GB1* | 40.66 | 52.66 | 46 | 64 | 73.6 | 62 |
| | *CB1* | 43 | 41 | 44.66 | 64.33 | 68 | 64.45 |
| | *Difference* | 2.34 | -11.66 | -1.34 | .33 | -5.6 | 2.45 |
| Light (Lux) | *GB1* | 854 | 941 | 874 | 1015 | 1208 | 987 |
| | *CB1* | 226 | 245 | 237 | 346 | 368 | 366 |

<table>
<tr>
<td>Fuel use</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>Electricity use</td>
<td>
</td>
<td>
</td>
</tr>
</table>

| | Building NZEB | Building CB |
|---|---|---|
| **Area($m^2$)** | | |
| Revit | 380 | 400 |
| GBS | 380 | 400 |
| Analytical area | 380 | 380 |
| **Building Performance Factors** | | |
| Weather station | 171411 | |
| People | 78 | 306 |
| Exterior window ratio | 0.25 | 0.29 |
| Electrical cost (Rs/kWh) | 6.612 | |
| Fuel cost (Rs/kWh) | 4.682 | |
| **Energy Use Intensity** | | |
| Electricity(kWh/$m^2$/yr.) | 125 | 109 |
| Fuel(kWh/$m^2$/yr.) | 64.17 | 212 |
| Total(kWh/$m^2$/yr.) | 189.17 | 321 |
| Annual energy use/cost |  |  |





**ENERGY SAVINGS**

The savings in the energy will be 78% per year, which is near about 1,00,000 per year.

The life of the LED fixtures will be more than 17 years (50000/8/365=17.12). Same way the life of the tube light is about 5.14 years (15000/8/365=5.14) and that of the CFL is about 2.05 years (6000/8/365=2.05).

| Sr. No. | 8ItemName | Cost in Convention -al Home (₹) | Cost in Green Home (₹) | Difference (₹) |
|---|---|---|---|---|
| 1 | Windows and Openings | 1,30,800 | 2,07,350 | 76,550 |
| 2 | Lighting Fixtures | 12,800 | 46,150 | 33,350 |
| 3 | Plumbing Fixtures | 44,885 | 1,08,300 | 63,415 |
| 4 | Flooring | 2,28,540 | 2,84,295 | 55,755 |
| 5 | Doors | 69,830 | 1,62,510 | 92,680 |
| 6 | Paints | 1,56,380 | 1,58,880 | 2,500 |
| 7 | Bricks | 50,175 | 30,105 | -20,070 |
| 8 | Cement | 9,66,000 | 9,83,250 | 17,250 |
| 9 | Rain Water Harvesting System | 0 | 80,700 | 80,700 |
| **Total (`)** | | **16,59,410** | **20,61,540** | **4,02,711** |

**CONCLUSION**

1) If the Home is Constructed as a ***Net Zero Energy Residential Building*** in this project, the total cost increases by **4,02,767**, in addition to the total construction cost of
the *Conventional home* which is found to be **31,07,415**.

2) The percentage increase in total construction cost is **14%**

3) The ***saving*** in money, which is about **11,000,00** will be the clear *saving* after the payback period of LED fixtures is completed.

4) Water saving is about **365 (say, 350) litre/day**.

**5) Payback period,** considering savings only in the electricity bills, is found to be **10 years.**

6) So, on the bases of the above figures, it can be concluded that: –

***"If the intention is to construct a new Home to live in, it is advisable to go for a Net Zero Energy Home rather than the ordinary conventional home. Because, the percentage increase of 20% in the total cost is not a negligible amount when the intention is just to renovate or retrofit an Old Home".***

**REFERENCES**

[1] Suze-Chi-Kaun et al. "A study of BIPV net-zero energy building" Vol.-3,No. 1 (May 1998)

[2] K. Kushiyaki et al. "A Study on Conceptual Approach to Zero Energy Building in Modern Era" Vol-2, issue-2 (Feb 2005)

[3] Tortellini P., Pleiss S., Dru M. and Crawley D. Zero Energy Buildings: "A Critical Look at the Definition", Vol.-1, National Renewable Energy Laboratory and Department of Energy, (US). (July 2006)

[4] Marszal A. and Heisenberg P, "A literature review on ZEB definitions", Aalborg University, Vol.1 (Dec. 2009)
[5] Laustsen J. "Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings". Vol-1, International Energy Agency (IEA). (March 2008)

[6] Satori I, Napolitano A, Marszal A, Pleiss S, Tortellini P, Voss K. "Criteria for definition of net Zero Energy Buildings" Vol. 1, (2010).

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

[8] World Business Council for Sustainable Development, August 2007, "Energy Efficiency in Buildings: Business Realities and
Opportunities Retrieved: (2007-09-05)".

[9] "Solar Decathlon". Wikipedia, the free encyclopaedia

[10] Honda. "Honda Smart Home US". Honda Smart Home US. Retrieved (2016-03-04).

[11] Salmo, Jaime; Widen, Joakim; Candanedo, Jose A.; Sartori, Igor; Voss, Kasten; Marszal, Anna Joanna, "Understanding Net Zero Energy Buildings: Evaluation of Load Matching and Grid Interaction Indicators", (2011)

[12] Beauro of Energy Efficiency," The Energy Conservation Building Code (ECBC)" - (2007)

[13] National Building Code (NBC). Interaction Indicators. Proceedings of Building Simulation" 2011: 12th Conference of International Building Performance Simulation Association. (May 2011)