DESIGN OF PASSIVE HOUSE STANDARDS AND RENEWABLE ENERGY TO ACHIEVE ZERO ENERGY BUILDING

[1*]**Kanthamani KH**
[1*] Dept. of E.E, School of Engineering, Central University of Karnataka-585367, Karnataka, India,

Abstract— This paper presents the process of design a building with minimum energy consumption by using passive house standards in Zero energy building. A net zero-energy building (ZEB) is a structure that has very reduced energy needs through self-sustenance and efficiency. Passive house standards are the one way to arrive zero energy building. Passive House is a term, that refers to a rigorous, voluntary standard for energy efficiency in a building, reducing its ecological footprint (human impact on Earth's ecosystems). It results in ultra-low energy buildings that require little energy for space cooling or heating. Ultra-low energy building is a building that does not use any power (energy) from the grid (external power supply), it produces its own and sometimes may produce surplus energy also. This study utilizes the Passive House Standards for Zero Energy Building.

Index Terms— Passive house standards, Zero energy building, Passive House Planning Package (PHPP).

I. INTRODUCTION

In developed countries, 20-40% of the total energy demand is consumed by the building sector. Also the ever increasing CO2 emission in building sector has led to formulation of various regulations, making energy efficiency a prime objective. This brought the concept of ZEB's (or net zero energy building) to get recognized and popular internationally, attracting an increasing number of research and demonstration projects, Bringing it more closer to a realistic solution for reduction of energy in the building sector. A net zero-energy building (ZEB) is a structure that has very reduced energy needs through self-sustenance and efficiency.

It is a complex concept with a number of existing approaches being closely related with its different aspects (LEED, BREEAM etc.). Also there are no clear methodologies for calculations yet, making it very difficult to achieve the net zero stature in the current scenario. Furthermore the approach is gradually shifting from being voluntary to being mandatory, leading to development of a strong relationship between the design of the building and its energy performance. However, before the introduction of the ZEB in the building codes and standards, a common and explicit definition needs to be established, and also a standard methodology for calculation for a zero energy building should be developed. (A.J. Marszal a, 2011).

The commonly used renewable energy sources are – Solar PV (Electricity), Solar Thermal (ST), and, space heating. Apart from these, small wind turbines and hydro-power systems are also used at some places. Unlike wind mills, biomass, and hydroelectricity, PV or Photo voltaic can be used almost everywhere. Taking into consideration the use of PV, we can see that the installment of these actually envelopes the facade of the building, thus affecting the aesthetics. Also when a building is more than two floors in height, enveloping just the facade surface isn't enough to cover all the energy that is required to run the building, thus the roof is also used to install PV. Still, for very high towers like the Eternity tower (93 floors), the PV generator on the roof should be approximately 46 times bigger than the building's physical footprint. So, as the installment of these sources actually affect the architecture and aesthetics of buildings, various steps are being taken to contain them as far as possible. For example the concepts of 'Net Zero Energy Neighborhood Building' (PV occupy surfaces of other buildings in the neighborhood) and 'Net Zero energy Landscapes' (can be used as landscape elements in the neighboring lands). (Adhikari, 2014).

Passive House and Zero energy building concept, both essentially working on the same idea, that the heating/cooling energy of the building can be maximized or minimized though high insulated and proper air tight of the building. Passive house provides some criteria and design principle on the other hand ZEB gives guidelines for measurement and implementation ensure to calculate source energy. Passive house is the one which provides comfortable interior climate without utilizing any active heating or cooling system. ZEB is working on the principal of integration of on-site renewable energy system so that it produces enough energy on an annual basis. This study eventually concludes that both passive house and ZEB play a very important role in minimizing energy consumption and maximize the building efficiency.(Dhenesh Raj, 2014). Passive strategies should be developed during the building design process itself, that would cut the load on the energy required for running the building efficiently. For example taking into account a small housing cluster in a hot area, the concepts like cross ventilation, using vegetation as buffer (for killing the heat in waves and also providing oxygen), using water bodies in landscape, narrow corridors with proper shading, etc would actually reduce the load on the energy sources as lesser energy would be used to make the building cooler and lighted during the day. Thus, both designing a building and making it energy efficient run hand in hand, or it can be said that designing a building such that it actually increases the efficiency of the building to reduce the energy required for its smooth functioning is now becoming a major concern and priority for architects and governments. (Adhikari, 2014).

For a building to be considered as a passive house, it should meet the following criteria.

1. Passive house requires less than 15 kW/m2 per year for heating or cooling which is mainly related to living space and the heating or cooling load limited to maximum of 10 W/m2.
2. Primary energy demand should not exceed 120 kWh/year for all domestic applications such as heating, cooling, hot water and domestic electricity/m2 of usable living space.
3. Air-tightness should be no more than 0.6 air changes per hour at a pressure of 50 Pascal's.
4. In summer and/or warmer climates, excessive temperatures may not occur more than 10% of the time.

Passive building includes a set of design principles used to attain an affordable, comfortable and ultra-energy building and it is designed and built in accordance with the following five building-science principles (Key Factor):

1. Air tight building envelope (no air leakages)
2. High efficiency windows and doors
3. Proper insulation
4. Heat recovery ventilation
5. Thermal bridge free construction

The organization of the thesis is as follows. Passive House and Zero energy building concepts are discussed in Section 1. Methodology of design and implementation of the building with minimum energy consumption by using passive house standards in Zero energy building is given in the Section 2. Conclusion is given in the Section. 3.

II. Methodology to Design of Proposed System

This section deals the methodologies of PHPP and SAP and its comparison and advantages.

2.1 Method 1: Passive House Planning Package (PHPP) :

The Passive House Planning Package is the official design tool for 'Passive house' standards of the independent organization 'Passive House Institute' founded by Dr Wolfgang Feist in Germany. It consists a large number of worksheets as it is designed for energy balance for different types of buildings in different, depending on the project not all the worksheets may be necessary. Prepares an energy balance and calculates the annual energy demand, cooling demand, and Primary energy demand, some PHPP calculations are based on the assumption that the building under consideration.

2.2 Method 2: Standard Assessment Procedure (SAP) :

It is a methodology used by the Government to assess and compare the energy and environmental performance of dwellings. SAP was developed by the Building Research Establishment (BRE) for the former Department of the Environment in 1992, as a tool to help deliver its energy efficiency policies. The SAP methodology is based on the Building Research Establishment Domestic Energy Model (BREDEM), which provides a framework for calculating the energy consumption of dwellings. It calculates the typical annual energy costs for space and water heating, and lighting. Assessing energy efficiency in terms of both CO_2 emissions and fuel costs.

2.3 Comparison between PHPP and SAP :

1. PHPP provides both space heating and cooling information while SAP provides only space heating information.

2. PHPP default internal heat gain is 2.1 W/m^2 while the SAP gives 5.9 W/m^2.

3. The required data for windows (including glazing and framing) and shading are considerably more detailed in PHPP and SAP does not provide any specific data for windows and shading.

4. PHPP maintains 20^0C default internal temperature while in SAP the internal temperature has to be calculating based on the heating system, heating requirement and living area of dwelling.

5. Space heating demand in PHPP is based on monthly and annual method respectively for each region and in SAP uses only annual method.

2.4 Advantages of the Passive House Planning Package :

- Energy balance calculation in the common Excel format
- Easy and direct data input, in a flexible way where required
- Validates result accuracy
- Detailed manual with tips for energy efficiency
- Interface for import/export of data from/into other programmes

2.5 Methodology Flowchart:

Flow chart of the proposed system methodology is given by Fig. 1

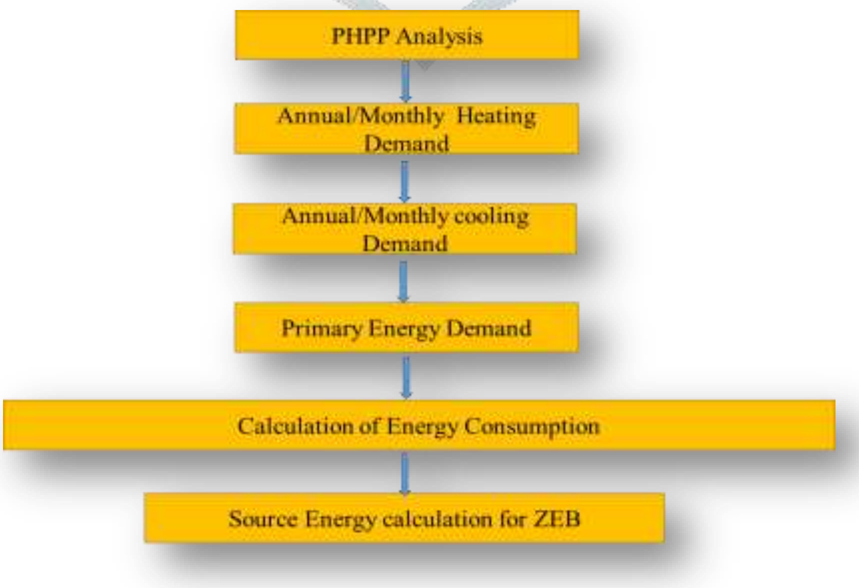

Fig 1: Project Methodology

2.6 PHPP Method Flow-chart:

Flow chart of PHPP Method Flow-chart is given by Fig. 1

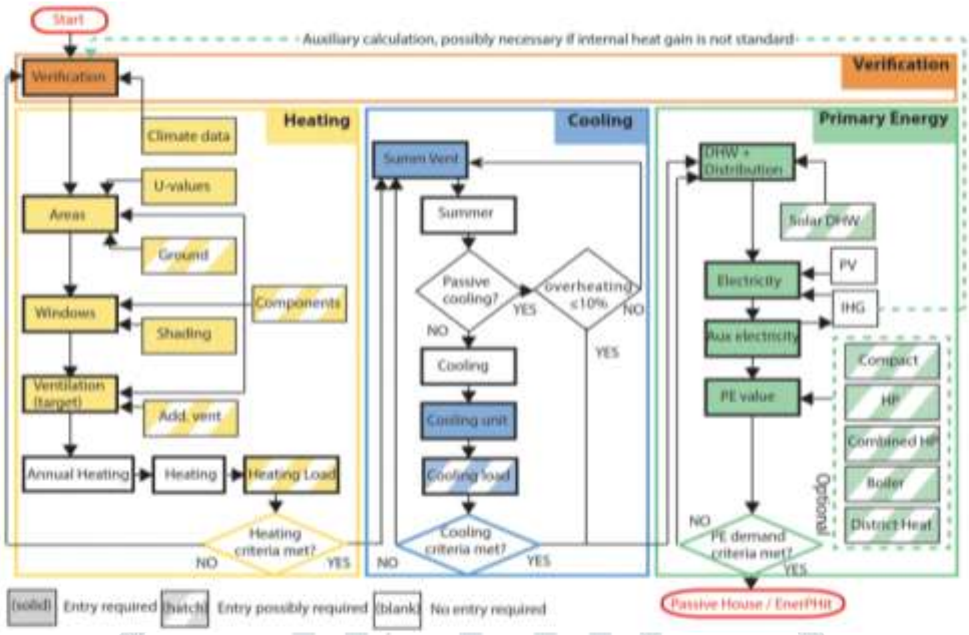

Fig: 2: PHPP Flow chart

[Source:https://passipedia.org/planning/calculating_energy_efficiency/phpp__the_passive_house_planning_package]

2.7 Design a Photovoltaic Module to achieve ZEB:

A) Solar radiation incident at Darmstadt :

The daily solar radiation incident (kWh/m^2.day) and corresponding temperature (^{0}C) data of Darmstadt are obtained from the PVsyst software, is shown in Fig.3.

B) Panel generation factor:

Panel generation factor = Daily solar radiation / standard test condition irradiance for PV panel. From the Fig.2 , the daily radiation is incident at Darmstadt = 3.269 = 3.269*1000/1000 = 4.88388.

C) Energy required :

Energy required from PV module will be daily energy demand of the building and compensation for the system losses which is generally taken as 30%, therefore the total energy required will be

Daily Demand of the building = 43.2 kWh/31 (Total Energy Demand)
= 1.3935 kWh/day

Energy required = daily energy demand of the building + compensation for the system losses which is gen. 30%
= 1.3935+ ((30/100)*1.8)
=1.3935 (1+0.3)
= 1.3935 * 1.3 = 1.8116 kWh

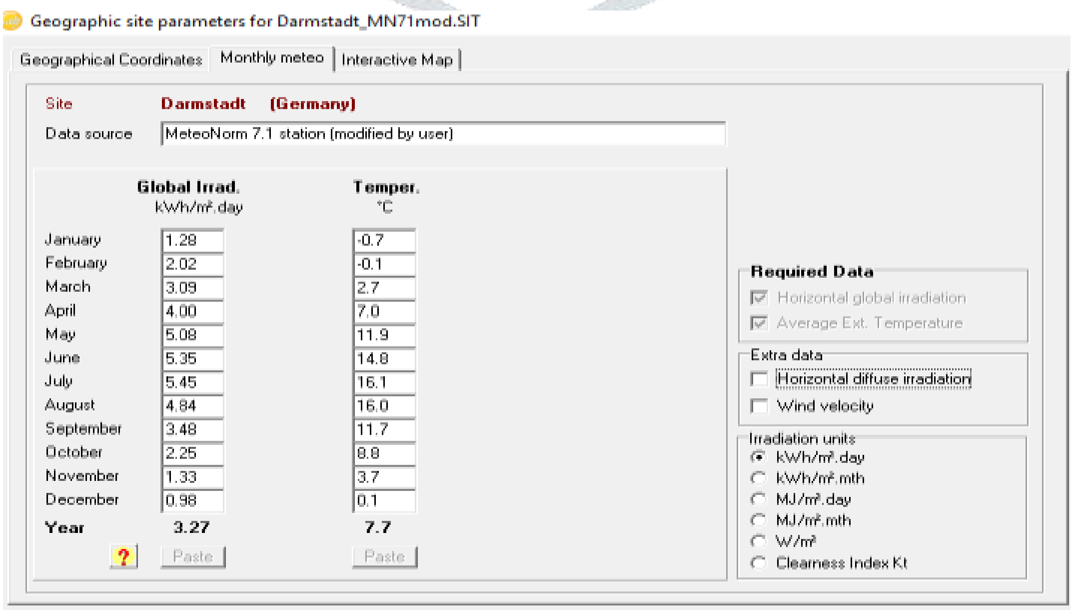

Fig.3 . Daily solar radiation incident at Darmstadt [Source : PVsyst software]

D) Watt peak rating for PV module:

Basically system sizing is depends upon the energy required from the PV module and panel generation factor.

Watt peak rating for PV module = Energy required from PV module / Panel generation factor = 1.8116/3.269 = 0.566 kWh

E) No. of Module required to achieve the Energy Demand :

No. of module required = total watt peak rating / PV module peak rated output

= 0.566*1000/250

= 2.26 ≈ 3 module

F) Inverter Rating:

Inverter Size = Watt peak rating for PV module = 0.566 * 1.3 = 0.7358 kW

Number of inverters = Inverter size / rated power of an inverter

Number of inverters = 0.7358 kW/ 1k = 1 inverter

III. Conclusion

In this paper , process of design a building with minimum energy consumption by using passive house standards in Zero energy building has given. A net zero-energy building (ZEB) is a structure that has very reduced energy needs through self-sustenance and efficiency and contributes less greenhouse gases to the atmosphere compared to the conventional building and reduces dependency on fossil fuels all these goes towards increasing building energy efficiency. Passive house standards is the one way to arrive at zero energy building.

References

[1] Adhikari, R.S, Aste, N, Del Pero, C, & Manfren, M, 2012, 'Net zero energy buildings: expense or investment?', Energy Procedia, vol. 14, no. , pp. 1331-1336.

[2] Marszal, A.J, Heiselberga, P, Bourrelle, J.S, Musall, E, Voss, K, Sartori, I, & Napolitanoe, A, 2011, 'Zero energy building – a review of definitions and calculation methodologies', Energy and Buildings, vol. 43, no. 4, pp. 971-979.

[3] Scognamiglioa, A, Gardeb, F, & Røstvikc, N, 2014, 'How net zero energy buildings and cities might look like? new challenges for passive design and renewables design', Energy Procedia, vol. 61, pp. 1163-1166.

[4] Peterson, K, Torcellini, P, & Grant, R, 2015, 'A common definition for zero energy buildings', Energy efficiency and renewable Energy, pp. 1-16.

[5] Dan, D, & Dhenesh Raj, A.R, 2014, 'Passive house design- an efficient solution for residential buildings in Romania', Energy Procedia, vol. 44, no.4 , pp. 214-219.

[6] Moutzouri, E, &Tuohy, P, 2011, 'Comparison between PHPP and SAP& Elaboration of monitored data for two dwellings with different insulation levels', Sustainable Energy: Renewable Energy Systems and the Environment, pp. 1-79.

[7] https://passipedia.org/planning/calculating_energy_efficiency/phpp__the_passive_house_planning_package

[8] insituarchitecture.wordpress.com

[9] https://passipedia.org/planning/calculating_energy_efficiency/phpp_the_passive_house_planning_packag

[10] http://energy.gov/sites/prod/files/2015/09/f26/A%20Common%20Definition%20for%20Zero%20Energy%20Buildings_0.pdf

[11] http://zeroenergy.com/passive-house-retreat

[12] http://energy.gov/sites/prod/files/2015/09/f26/A%20Common%20Definition%20for%20Zero%20Energy%20Buildings_0.pdf

[13] http://www.esru.strath.ac.uk/Documents/MSc_2011/Moutzouri.pdf

[14] http://mnashrae.org/downloads/Presentations/2008_sussem_teian_passivehaus_phpp.pdf

[15] https://www.scribd.com/document/266447957/PHPP2007-English-Demo

[16] https://passipedia.org/planning/calculating_energy_efficiency/phpp__the_passive_house_planning_package

[17] https://www.gov.uk/guidance/standard-assessment-procedure

[18] https://en.wikipedia.org/wiki/Standard_Assessment_Procedure Energy Efficiency and Conservation Division Agency for Natural Resources and Energy Ministry of Economy, Trade and Industry, December 2015

[19] http://elrondburrell.com/blog/passive-house-planning-package-phpp/