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Passive House and Nearly Zero Energy Buildings

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Abstract: **Passive house and nearly zero energy buildings concept essentially based on the same idea, that the heating/cooling energy in the building can be minimized or maximized through airtight and well insulated building shell. Passive house is a standard and gives specific recommendations in regard to the achievement of heating/cooling energy savings. The passive house concept as known today is result of experience from many years of nearly zero energy house construction. Further, the second one is rather a guideline and rarely specified in practical values (e.g. heat load or space heating minimum).**

A passive house is one in which a comfortable interior climate can be maintained without active heating and cooling systems. While other houses might employ a passive solar design or use alternative energy sources such as wind and solar power to minimize their environmental impact. Nearly Zero Energy Building (nZEB) principle is based on the integration of high energy efficiency level and renewable energy systems causing the remaining energy needs of the building seem negligible (almost zero). The aim of the study by suitable case study/ examples is to take into account all financial, legal, technical and environmental aspects and to meet and save the present and future challenges. The research method used is through literature review of mostly peer-reviewed papers and standard specifications.

Keywords: **Passive house, Nearly Zero Energy Building, high energy efficiency, environmental, renewable energy**

1. INTRODUCTION

Passive House is a building which is designed and built with modern insulation and building materials and techniques .Designing a passive house, using the passive house elements, such as triple-pane windows with krypton as gas with insulated frames, and double-sized insulation materials makes a passive house more expensive than a regular house, but the cumulative cost of any annual expenses makes it more feasible in the long-term.

2. NEED OF PASSIVE HOUSE

2.1 It is needed as it saves both in energy and costs.
2.2 As it provides better thermal comfort .
2.3 As it provides excellent air quality.
2.4 It uses renewable energy sources without harming the environment.

3. CONCEPT OF PASSIVE HOUSES

The concept of the passive house was born in May 1988 from the collaboration between the Swedish Bo Adamson and the german Wolfgang Feist.Passive houses are spread mainly in Germany, Austria and the Netherlands and other Northern European countries.There are many examples in Italy too. In Austria, in 2015, the passive house standard will be required for all buildings.

4. MAJOR FEATURES CONSIDERED OF ARCHITECTURAL DESIGN IN PASSIVE HOUSE:

ORIENTATION: The appropriate orientation of the building allows maxium solar radiation. In summer the south facade is shined less than the east and west facade, but in winter the south facade is shined more than east and west facade. South facade is much more suitable for the use of maximum solar energy.

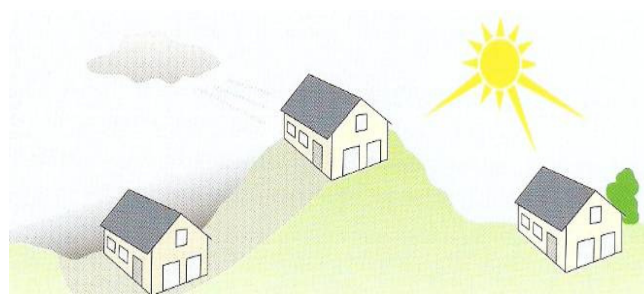

Fig 1:Maximum part of building should be south facing

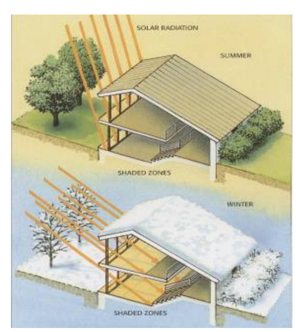

Fig 2:Trapping of Solar Heat

4.2 SAVING OF SOLAR ENERGY: At night when sun is not available, the buildings use the heat which is stored at Daytime.

4.3 FORM OF BUILDING: In a passive house it is very important that the external surfaces are in relation to the volume of the building as far as possible. The relationship between surface area and volume is expressed by form factor, which should be close to 1.00, this is when the object is compact and simple. Especially favorable factor has the building with square and round forms.

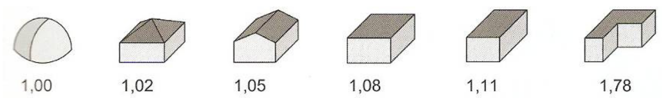

Fig 3: Different Forms of buildings

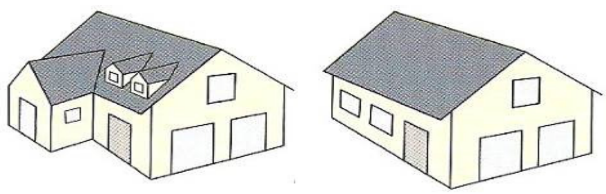

Fig 4: Simlpe Form of building can have max. sunlight

4.4 TECHNOLOGY OF CONSTRUCTION: For the construction of passive houses, mainly there is use of solid and lightweight construction. The construction is masive from brick block, filled with perlit and block from the light concrete. Outer insulation must be thick enough. Wood is frequently used material.

Fig 5: Light weight construction of buildings

Fig 6: Wood construction

4.5 THERMAL INSULATION: Thickness of thermal insulation depends on the composition of the wall and is 25-40 cm. It is very important that thermal-insulative layer goes on continuously all around the house and overlaps frames of windows and doors, which are also the thermal insulation.

5. CHARACTERISTICS OF A PASSIVE HOUSE INCLUDES THE FOLLOWING:

5.1 Heavy insulation: The most important component of a passive house is a layer of highly efficient insulation that wraps continuously around the building envelope -- even beneath the concrete slab in the basement -- reducing heat transfer between indoor and outdoor spaces.

5.2 Design without thermal bridges: The heated air inside a house will follow the path of least resistance to the outside of the house, known as a "thermal bridge." Conventional homes offer plenty of them, in the form of inefficient windows, poorly insulated walls or cracks under doors, but passive house design eliminates them through superior insulation and efficient windows and doors.

5.3 Airtight construction: Passive houses feature airtight construction to prevent moist room air (or humid outside air, in warmer climates) from penetrating into the home's construction where it can cause mold, affect inside air quality and even structural damage.

5.4 Ventilation: Another important component of passive house design is its efficient central ventilation system, which continually exchanges moist, "polluted" inside air for fresh, filtered outside air to maintain a comfortable, consistent temperature and humidity level.

5.5 Passive heating technology: Perhaps the most ingenious part of the passive house concept is its ability to heat (or cool) the inside spaces with nothing but fresh exterior air. As fresh, cold air enters the house through the ventilation system, it is heated by the warm air it passes on its way out.

5.6 High-efficiency windows: Efficient windows are essential to the passive house design. The specific windows used vary from climate to climate, but triple-paned windows with low-e glazing, argon gas and insulated frames are common.

5.7 Passive solar gains: Passive solar gain -- that is, the good old warmth of the sun -- is the primary source of heat for a passive house, so the situation of the home on the lot and the size and position of windows are important factors.

Passive House is a compact, very well insulated, airtight, thermal bridge free building with heat recovery ventilation system.

6. PASSIVE HOUSE IS A LOW-ENERGY BUILDING WHICH FULFILLS THE FOLLOWING REQUIREMENTS:

The building annual heating/cooling energy must not be more than 15 kWh/m² or to be designed with a peak heat load of 10 W/m².

6.1 Total primary energy consumption (primary energy for heating, hot water and electricity) must not be more than 120 kWh/m² per year;

6.2 The building must not leak more air than 0.6 times the house volume per hour ($n50 \leq 0.6$ / hour) at 50 Pa (N/m²) as tested by a blower door.

6.3 Passive House standard has developed by German Passive House Institute in Darmstadt.

7. PASSIVE HOUSE ADVANTAGES:

- Better indoor climate
- even temperatures in the rooms
- no drafts in the rooms
- no need of fan coils, free interior design, high windows
- better sound insulation
- until 10 times lower heating/cooling costs
- small carbon footprint
- independence of growing energy prices
- until 30% higher resale value
- budget only 10 % higher

EXAMPLES OF PASSIVE HOUSE:

Fig7:Passive House Darmstadt Kranichstein

Fig 8: Hall of residence „ Burse“ on the main campus of the University of Wuppertal

Fig 9:Passive House building complex in the St. Pauli district, Paul-Rosen street, Hamburg.

Fig 10: Single-family Passive House

8. A NEARLY ZERO-ENERGY BUILDING (nZEBs) is a building that has a very high energy performance. This energy required is covered to a very significant extent by energy from renewable sources, which is produced on-site or nearby. It is the European concept of Nearly Zero-Energy Buildings.

The Directive on the energy performance of buildings (EPBD) stipulates that by 2020 all new building constructed within the European Union after 2020 should reach nearly zero energy levels. This means that inless than one decade, all new buildings will demonstrate very high energy performance and their reduced or very low energy needs will be significantly covered by renewable energy sources.

European Union had set guidelines (2010/31/EU), starting in 2021 that new buildings must achieve the nearly zero-energy standards. These buildings will have very low operational energy demand. As a consequence of this requirement, the relative impact of construction and disposal increases in terms of the entire life cycle.

From the 19th century onwards, consumption, especially of non-renewable resources, constantly increased due to the commencement of industrial development and a change in life styles. Since the 1960s, awareness about the limitation of natural resources has been growing. Therefore, the resulting evidence of the limited capacity of nature of the energy supply and increasing waste problems are the two most important reasons for the development of LCA in the late 1960s and early the 1970s.

The overarching objective of this study is to contribute to a common and cross-national understanding on:

- an ambitious, clear definition and fast uptake of nearly Zero-Energy Buildings in all EU Member States;
- principles of sustainable, realistic nearly Zero-Energy Buildings, both new and existing;
- Possible technical solutions and their implications for national building markets.

9. **The benefits of implementing nZEBs are wider than simply energy and CO2 savings. They can be summarised as follows:**

9.1 QUALITY OF LIFE : The quality of life in a nearly Zero-Energy Building is better. As an adequate design of the building and a high quality construction include cost-saving that covers the additional costs of an energy-efficient building.Higher quality of life through better (thermal) comfort. The nearly Zero-Energy Building provides good indoor air quality. Fresh filtered air continuously delivered by the ventilation system. It is more independent of outdoor conditions (climate, air pollution). Concerning the noise protection, the thick and well-insulated structures provide effective sound insulation.

9.2 AMBIENT BENEFITS: arise through reduced energy demand that reduces wider environmental impacts of energy extraction, production and supply.

9.3 ENVIRONMENTAL BENEFITS: There are environmental benefits from improving local air quality.

9.4 SOCIAL BENEFITS : arise through the alleviation of fuel poverty.

9.5 HEALTH BENEFITS: are possible through improved indoor air quality and reducing risks of cold homes, particularly for those on low-incomes or for elderly householders

9.6 MACRO-ECONOMIC BENEFITS: arise through the promotion of innovative technologies and creating market opportunities for new or more efficient technologies.

9.7 PRIVATE ECONOMIC BENEFITS: higher investment costs may be outweighed by the energy savings over the lifetime of the building (the building offers less sensitivity to energy prices and political disturbances. When a building is sold, the high standard can be rewarded through a re-sale price up to 30% higher in comparison to standard buildings

9.8 JOB CREATION: can arise through the manufacturing and installation of energy efficiency measures and of renewable energy technologies.

10. BUILDING EXAMPLES OF NZEBS.

Fig 11: Residential Building Renovated to a Plus Energy Building in Kapfenberg / Austria (in 2012/13)

Fig 12: Vocational school in Amstetten, Austria

Europe aims at bringing about drastic reductions of greenhouse gas emissions in the residential and service sectors of about 90% compared to 1990 by 2050. Nearly Zero-Energy Buildings are a major element of European climate policy. Already by 2021, every new building in Europe has to meet this standard.To support the national efforts, this study proposes a 2020 roadmap for nZEB implementation . It takes into account all necessary improvements at the level of policies, building codes, capacity building, energy certification, workforce skills, public information and research. To allow for a coherent and sustainable transition, all proposed measures should get implemented in parallel. They are interlinked and ensure an overall consistence of the proposed implementation package, trying to preserve a balance between the increase in requirements and support policies.

12. TECHNICAL SCHEME FOR NEARLY ZERO-ENERGY BUILDINGS

- Energy efficient envelope
- Use of passive heat sources & passive cooling
- Energy efficient appliances
- Use of renewable energy sources on-site
- Off-site supply of renewable energy

13. CONCLUSIONS

Starting in 2021 only buildings with very low operational energy demand may be built; therefore, the ecological optimization of construction and disposal of nearly zero-energy buildings will be crucial next step. In order to face the main challenges of the building sector, limited resources as well as the energy-efficiency and a sustainable building stock, a life cycle view is required. As already noted in the review of literature, the current applied life cycle assessment methodology began in the 1970s in the packaging industry. Today the ISO 14040 and ISO 14044 is the only internationally standardized method for assessing potential environmental impacts. In addition, the LCA-approach and limitations are common. Furthermore, in Germany the energy construction standard has been continually developed by law since 1977 and will be updated in 2014 with a tightening in 2016. Only nearly zero-energy buildings may be built as of 2021 according to EU guidelines (2010/31/EU).

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