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ÚSTAV POZEMNÍHO STAVITELSTVÍ

HOUSE WITH TATTOO STUDIO

RODINNÝ DOM S TETOVACÍM ŠTÚDIOM

NZEB- PASSIVE HOUSING

BACHELOR'S THESIS

BAKALÁRSKA PRÁCA

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1. INTRODUCTION

In recent decades, growing concerns about climate change, pollution, and energy consumption have increasingly emphasized the need for energy efficiency in construction. Traditional buildings, which consume large amounts of energy for heating, cooling, and lighting, contribute to rising greenhouse gas emissions that significantly impact global warming. This issue was further exacerbated by energy crises, such as the one in the 1970s, which highlighted the need to reduce dependence on fossil fuels and seek alternatives to traditional construction practices.

In response to these challenges, new standards and regulations were introduced focusing on building energy efficiency, including the concept of passive houses and later the NZEB (Nearly Zero Energy Buildings) standard. These standards began to be implemented as a response to the growing demand for reducing energy consumption, lowering CO2 emissions, and ensuring a sustainable future. Regulations such as the European Parliament and Council Directive 2010/31/EU on the energy performance of buildings (EPBD II) defined minimum energy performance requirements for buildings and set the target that all new buildings should meet the nearly zero-energy standard by 2020.

This trend aims to create energy-efficient and eco-friendly buildings that combine modern technologies, such as heat pumps, photovoltaic panels, and high-quality insulation, to minimize energy consumption. This paper will explore the reasons why passive houses and NZEB have become crucial solutions in modern construction, as well as the challenges and benefits these standards bring in the context of sustainable development and environmental protection.

2. PASIVE HOUSES

2.1 DEFINITION OF PASIVE HOUSE

Passive houses are characterized by very low energy demand and high-quality indoor environments. To meet the parameters of a passive house, it is essential to carefully combine several key principles and ensure that none are overlooked. Proper orientation of living spaces towards the sun and efficient utilization of solar gains, with protection against summer overheating, are crucial. Optimal thermal insulation, triple-glazed windows, and the elimination of thermal bridges ensure excellent thermal protection. An airtight building envelope minimizes heat losses, while controlled ventilation with heat recovery maintains a healthy indoor environment. A small, energy-efficient heating source and the use of renewable energy sources complete the sustainable energy system of the house.

2.2 ENVELOPE OF PASSIVE HOUSING

A passive house features a highly insulated building envelope, ensuring excellent thermal protection with high-quality windows, typically triple-glazed. The heat transfer coefficient of the construction must meet the standards recommended for passive houses. Thermal bridges are minimized and designed to prevent significant heat losses. To further reduce heat losses and maintain optimal thermal-humidity performance, airtightness is monitored, with an air exchange rate of $n50 \leq 0.6\ h^{-1}$ at a pressure difference of 50 Pa. Airtightness is measured using the Blower Door Test method.

2.3 WHAT IS BLOWER DOOR TEST METHOD?

The Blower Door Test is a diagnostic tool used to measure the airtightness of a building. It involves mounting a temporary, airtight frame with a fan into an exterior door. The fan creates pressure differences (positive or negative) by blowing air in or out, and sensors measure how quickly air leaks into or escapes from the building. This test is essential for identifying air leakage points, improving energy efficiency, and ensuring that buildings, especially passive houses, meet specific airtightness standards.

2.4 HEATING AND VENTILATION IN A PASSIVE HOUSE

A passive house has very low heating system requirements. Thanks to excellent insulation of the building envelope and its orientation to the cardinal directions, it makes use of passive solar gains in winter, which further reduces the demand on the heating system. Heat sources with low output are typically used for passive houses, such as heat pumps combined with solar systems and photovoltaics, but electric heating is also an option. These systems can be supplemented with, for example, a fireplace. Passive houses are known for their high indoor air quality, which is mainly ensured by mechanical ventilation that provides a continuous flow of fresh air. To minimize heat loss, the ventilation system is equipped with a heat recovery unit that transfers heat from the exhaust air to the incoming air through a heat exchanger.

2.5 SHAPE OF A PASSIVE HOUSE

Passive houses are not just "ultra-modern" cube or rectangular buildings. While a spherical shape would be the most efficient for this type of building, it may not seem practical. However, the shape of the house can contribute to reducing heat loss. The simpler the building's shape, the less surface area there is through which heat can escape, and it also minimizes the potential for errors during construction, insulation, and operation. A passive house can also be more complex, with alcoves and dormers – it can have any shape. However, keep in mind that this will likely increase construction costs. Proper insulation and creating an airtight envelope for a more complex house can be challenging and may not always be successful.

A two-story house has lower heat loss than a single-story house. Heat transfer from the ground floor warms the upper floor, so less energy is needed for heating the upper floor. The upper floor also helps prevent cold air from entering the ground floor.

The roof of a passive house is usually flat or has a slight slope. Flat roofs are smaller than pitched roofs, which reduces the area through which heat can escape. However, it is still important to insulate a flat roof. The thickness of the roof insulation in passive houses should be around 40 cm if using standard thermal insulation (e.g., polystyrene or mineral wool).

This type of roofing allows for the creation of an eco-friendly house in the truest sense. Your typical roof could be transformed into a green or walkable roof. When considering these types of roofs, it's important to think about the load-bearing capacity of the house's structure. Depending on the type of green roof (extensive or intensive), the weight of the roof can range from 100 to around 500 kg/m² (including the weight of waterproofing, drainage systems, insulation, soil, plants, and water). Keep this in mind during construction and ensure the structure is designed to handle the weight.

2.6 PASSIVE HOUSE REQUIREMENTS

Here are the key requirements:

1. Maximum heating demand - 15 kWh/m² per year for heating.
2. Maximum total annual energy consumption - 120 kWh/m² per year for all energy needs (heating, hot water, electricity, cooling).
3. Thermal transmittance (U-value) - U-value of the building envelope (walls, roofs, floors) must be below 0.15 W/m²K.
    - Windows with triple glazing, with U-values below 0.8 W/m²K.
4. Airtightness - Maximum 0.6 air changes per hour at a pressure of 50 Pa (blower door test).
5. Heat recovery ventilation - Mandatory use of heat recovery ventilation systems to ensure a high indoor air quality while minimizing energy losses.

6. Energy balance - The building must achieve an energy balance where energy consumption is minimized, and heat is sourced from passive sources (e.g., solar radiation).
7. Solar energy use - Maximized use of solar radiation through windows to minimize heating energy needs.

3. NEARLY ZERO ENERGY BUILDING

3.1 DEFINITION OF NZEB

A Nearly Zero-Energy Building (NZEB) is a building that meets strict requirements for the energy efficiency of the building envelope and utilizes technical systems that enable efficient regulation of heating, ventilation, and lighting. These buildings cover their energy needs primarily from renewable energy sources or even produce energy on-site (electricity, heat).

The requirement for the construction of NZEBs is based on a European directive that mandates that, starting from January 1, 2020, all new buildings must be nearly zero-energy buildings. This type of building is characterized by very low energy demand, with the energy consumption mostly covered by renewable sources.

At the European level, the key document is the European Parliament and Council Directive 2010/31/EU on the energy performance of buildings. At the national level in the Czech Republic, the requirements of this directive were transposed through amendments to Act No. 406/2000 Coll. on energy management and specified further by Decree No. 264/2020 Coll. on the energy performance of buildings. In 2018, Directive 2010/31/EU was amended by Directive 2018/844/EU.

The obligation to design and implement NZEBs, which has applied to large state-owned buildings since 2016, does not mean that all new buildings must meet passive standards or have a zero balance between consumed and produced energy.

3.2 ENVELOPE OF NZEB

The building envelope of a Nearly Zero-Energy Building is crucial for minimizing energy losses and achieving low energy demand. It includes walls, roofs, floors, and windows, designed to have high insulation capacity, prevent thermal bridges, and minimize heat loss. Emphasis is placed on thermal insulation, airtightness, and the effective use of natural light and solar gains. Windows and doors must have a low heat transfer coefficient, and the roof may include photovoltaic panels. A well-designed envelope contributes to the energy self-sufficiency of the building.

3.3 HEATING AND VENTILATION IN NZEB

NZEBs, heating and ventilation systems are designed to ensure minimal energy consumption while maintaining indoor comfort. These systems play a critical role in achieving the nearly zero-energy standard by being energy-efficient and often integrating renewable energy sources.

Efficient heating systems, such as heat pumps (air-source or ground-source), are commonly used in NZEBs. These systems extract heat from the environment and use less energy than conventional heating methods. Underfloor heating is another energy-efficient option, providing even heat distribution. Additionally, the building's design often maximizes passive solar heating by using large south-facing windows to capture solar energy and reduce the need for active heating.

Ventilation in NZEBs is managed through Mechanical Ventilation with Heat Recovery (MVHR) systems, which allow fresh air to enter the building while recovering heat from the outgoing stale air. This reduces the need for additional heating. The airtight building envelope minimizes air leaks, and controlled ventilation ensures good indoor air quality without wasting energy. Some NZEBs also use demand-controlled ventilation, which adjusts airflow based on air quality, further optimizing energy use.

Together, these heating and ventilation strategies ensure that NZEBs maintain comfort and indoor air quality with minimal energy input, making them both energy-efficient and environmentally friendly.

3.4 PARAMETERS FOR NZEB

The key parameters are:

1. Energy demand: NZEBs must have very low energy consumption, but it is not as strictly defined as for Passive Houses. The energy demand for heating must be low, but maximum consumption varies according to national regulations.
2. Use of renewable energy sources: NZEBs must use renewable energy sources (e.g., solar panels, wind turbines, geothermal heat pumps) to cover at least part of their energy needs.
    - Renewable energy may be locally produced or sourced from the grid.
3. Thermal transmittance (U-value): U-value of the building envelope must also be very low, similar to that of Passive Houses, but the requirements may be less strict.
4. Ventilation and insulation: High-quality ventilation systems with heat recovery or other technologies that minimize heating needs are required.
    - Thermal insulation must be sufficient to achieve very low energy consumption for heating.
5. Legislative requirements: As of 2020, all new buildings within the EU must meet NZEB standards. These standards include low energy consumption and a high share of renewable energy sources.
    - Specific values may vary by country, but the focus is on extremely low energy consumption.
6. Energy balance: Energy balance should be as efficient as possible, with minimal energy losses, and part of the energy needs should be covered by renewable sources.

4. COMPARISON

The comparison between a Passive House (Passivhaus) and a Near Zero Energy Building (NZEB) involves several key aspects, such as energy efficiency, technologies, materials, and legislation.

Passive House is stricter in terms of energy consumption requirements, specifying maximum values for heating and overall energy use. It focuses on minimizing energy losses through high-quality insulation, ventilation with heat recovery, and optimal solar energy use.

NZEB has broader standards and greater flexibility in using renewable energy sources. The primary goal is to achieve very low energy consumption, but it is not as strictly defined as in the case of a Passive House. NZEB buildings are expected to cover part of their energy consumption from renewable sources.

Below are the main differences between these two concepts:

1. Energy Demand

- Passive House: Extremely low energy demand for heating (15 kWh/m² per year) and very low overall energy consumption. The focus is primarily on optimizing thermal comfort and minimizing energy needs.
- NZEB: The energy demand is very low, but the main emphasis is on balancing the energy consumed and produced. It may also involve the use of renewable energy, although energy consumption is not always as strictly defined as in the case of a Passive House.

2. Technologies

- Passive House: Uses passive technologies like heat pumps, heat recovery ventilation systems, high-insulation materials (triple-glazed windows, thick thermal insulation), quality seals, and highly efficient lighting systems.
- NZEB: Uses various renewable energy sources such as solar panels, wind turbines, and geothermal systems to balance energy consumption. While the Passive House focuses on reducing heating needs, NZEB also emphasizes energy production.

3. Standards and Legislation

- Passive House: This standard was developed in Germany and has an international certification system. The regulations are stringent and set a level that ensures exceptional energy efficiency.
- NZEB: This standard is defined by the European Union, and each member state has the right to set specific regulations for NZEB. Many countries, including the Czech Republic and Slovakia, have implemented directives requiring new buildings to meet this standard by 2020.

4. Indoor Environmental Quality

- Passive House: Ensures maximum comfort through excellent temperature regulation, humidity control, and fresh air supply provided by a heat recovery ventilation system.
- NZEB: Indoor environmental quality depends on the technologies used, but the focus is more on balancing low energy consumption and energy production. Passive comfort may not always be a priority.

5. Maintenance and Costs

- Passive House: Requires regular maintenance of technical systems like heat recovery ventilation and pumps, but overall operational costs are very low.
- NZEB: Requires monitoring of renewable energy systems and may have higher initial costs, but long-term energy savings are significant.

6. Advantages and Disadvantages

- Passive House:
    - Advantages: Extremely energy-efficient, comfortable indoor environment, low operational costs.
    - Disadvantages: Higher initial costs, need for detailed and high-quality construction, limited options for architectural customization.
- NZEB:
    - Advantages: A combination of energy efficiency and renewable energy sources, reduced carbon footprint.
    - Disadvantages: Technological and legislative flexibility may lead to varying qualities, the need for monitoring and managing energy systems.

5. CONCLUSION

The current definition of a Near Zero Energy Building (NZEB), as defined by the Czech Republic, is far from "zero" and represents only a mild tightening of the existing requirements for new buildings. In many cases, the energy consumption of NZEBs significantly exceeds that of low-energy houses, let alone Passive or Zero Energy houses, with which it is often confused. The obligation to use renewable energy sources is only marginal for NZEBs. This is demonstrated by the fivefold higher primary non-renewable energy consumption requirement compared to what is recommended by the European Commission. Furthermore, the current NZEB definition does not compel architects to design a well-thought-out and energy-efficient building concept but merely requires a higher quality thermal envelope.

The most technically advanced standard, guaranteeing high indoor environmental quality, remains the requirements defined for Passive Houses using the PHPP methodology. This methodology has been tested in real-world operation across thousands of Passive Houses worldwide, aiming to achieve realistic operational parameters. Achieving Passive House standard requires a carefully planned building concept that is compact in shape, free from thermal bridges, and utilizes solar radiation to minimize heating energy consumption. These buildings will always be classified as category A – exceptionally energy-efficient, meeting the criteria for the New Green Savings program as well as legislative NZEB requirements. On the other hand, an NZEB will only rarely be a low-energy or even Passive House and will most often be classified as category B – very energy-efficient.

In the future, it is expected that the legislative requirements for NZEBs will tighten in line with the recommendations of the European Commission or the now-established and economically verified concept of very low energy consumption buildings defined in the New Green Savings program.

6. RESOURCES

https://stavba.tzb-info.cz/pasivni-domy

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