The first passive house using Steico wood frame technology, in Milanówek Poland, certified by the Institute in Darmstadt

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1. Introduction

This house in Milanówek (226.6 m²) is the first certified passive house in Poland constructed using prefabricated wood frame technology, comprehensively using Steico construction and insulation materials.

The main assumption of this investment, apart from meeting the criteria for a passive house (energy demand: < 15kWh/m²/year and building airtightness: n_{50}<0.6 1/h), was to provide maximum comfort, which is mostly influenced by the quality of air temperature, moisture and oxygen content.

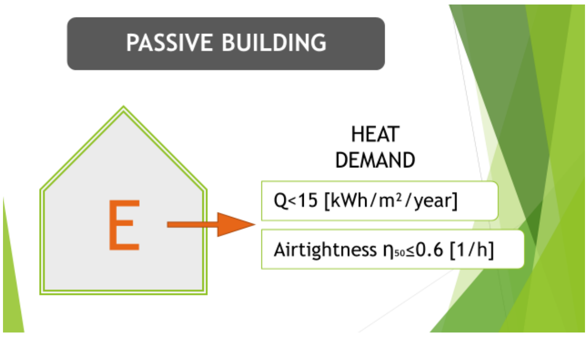


Figure 1: Requirements for a passive house.

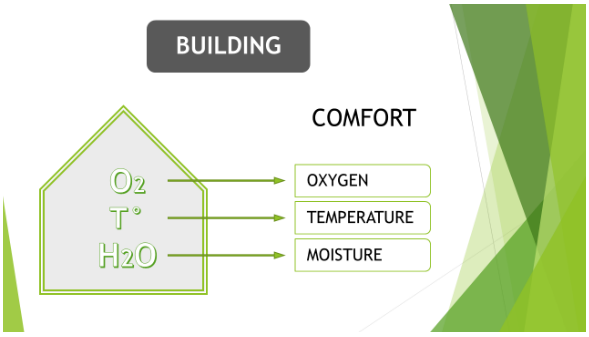


Figure 2: Requirements to ensure comfort in a building.

1.1. Comfort

Thermal comfort is achieved within a narrow range of air temperature, 15-20ºC, and wall temperature, 17-40ºC. The optimal solution is a wall temperature of 19ºC to ensure thermal comfort with an air temperature between 16-20ºC. Further wall heating will not improve comfort; rather, it just absorbs the extra energy.

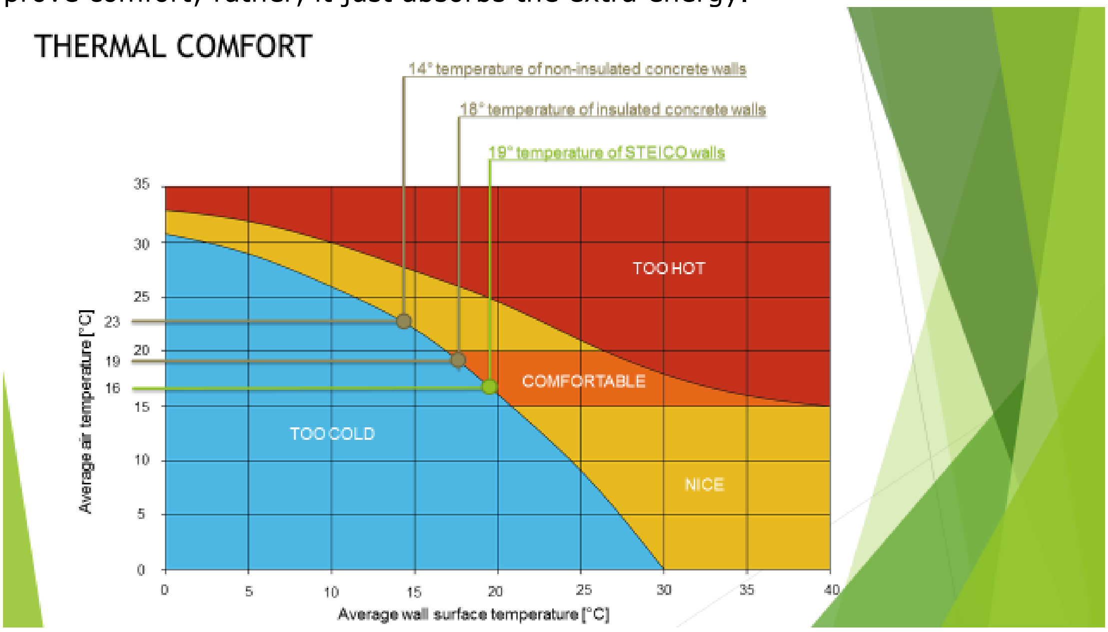


Figure 3: Air temperature vs. wall temperature.

1.2. Wall and roof

Meeting the requirements of a "warm wall" in the passive house in Milanówek was possible through the use of wood derived products based on Steico construction and insulation materials. Such a system permits delivering thermal comfort in buildings with a relatively lower internal air temperature.

Wood fibre insulation materials are characterized by a large heat capacity (2100 J/kg*K), i.e. the ability to store energy. Thus, diurnal fluctuations in external temperature have practically no impact on thermal parameters inside the building. Due to the small amount of energy required to replenish losses in winter and to cool the building down in summer, buildings constructed with Seico technology are not only comfortable but also economic to maintain.

An additional advantage of this system consists in the possibility of obtaining a low heat transfer coefficient with a relatively thin partition. In the passive house in Milanówek we obtained a wall heat transfer coefficient U=0.099 W/m^2*K, with a total partition thickness of 43.5 cm (including 42 cm of insulation material). The roof heat transfer coefficient U=0.089 W/m^2*K, with a total partition thickness of 55 cm (including 43.5 cm of insulation material), along with a final roofing panel and an internal finishing panel over framing grids.

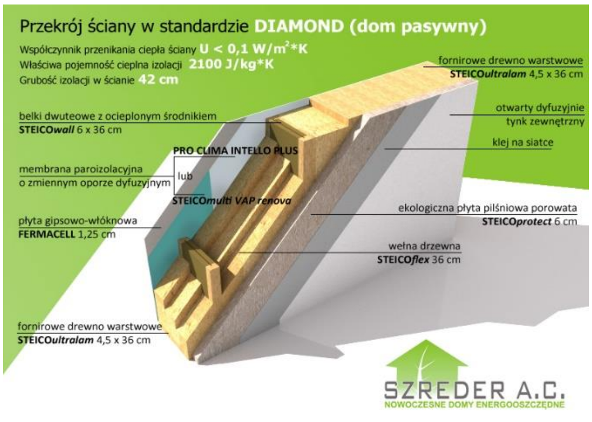


Figure 4: Wall

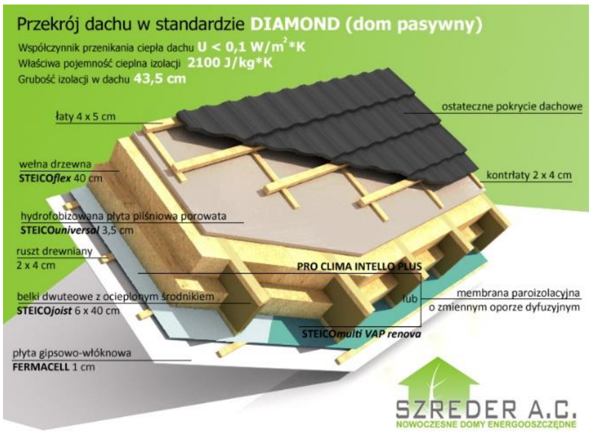


Figure 5: Roof

1.3. Foundation slab

The foundations of the passive house in Milanówek comprised a composite self-supporting foundation slab of 40 cm thick Bachl extruded polystyrene (XPS) on the ground and 20 cm thick XPS around the slab. Underfloor heating was mounted directly on the bottom insulation with top 20 cm thick layer of poured concrete serving as a supporting and accumulation element. Energy for heating is delivered through an air-to-water heat pump by Ariston.

Figure 6: Foundation slab

The slab is heated to 22°C. In conjunction with the "warm walls" this provides full thermal comfort while maintaining a low internal air temperature of 16-20°C. By comparison, convection (radiator) heating and its associated distribution of temperature inside the building would be much more difficult and expensive to reach such thermal comfort.

With low air temperatures, energy losses in the building are much less than for higher temperatures. Energy demand is directly proportional to the partition area and temperature difference between either sides. In a building with convection (radiator) heating, the area of partition with a greater difference between internal and external temperatures is much larger. In addition, if we take into consideration that energy losses connected with ventilation increase with the increase in internal air temperature and increase in ventilation intensity, underfloor heating looks a better solution, also in terms of energy demand.

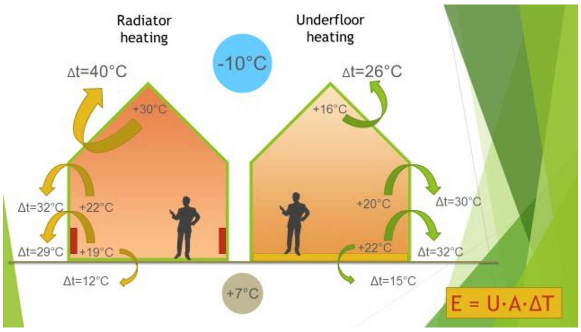


Figure 7: Impact of the heating system on energy. losses

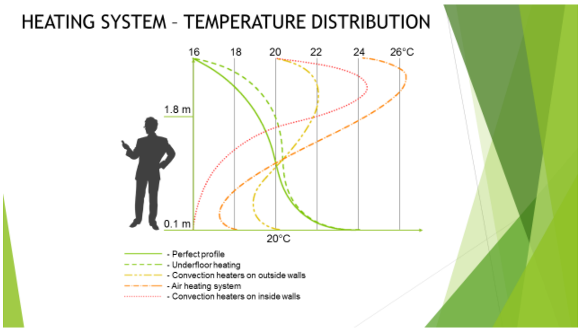


Figure 8: Temperature distribution for various heating systems.

1.4. Mechanical ventilation with heat recovery

Meeting the thermal requirements of a passive building can only be achieved through mechanical intake and exhaust ventilation with heat recovery. This task is to continuously supply fresh air, and to remove used air and excess moisture from the building.

Selection of a ventilation unit is connected with the volume of the building and the number of occupants. Changing the entire volume once per hour is generally considered the maximum system rating. Air that flows through the recuperator recovers energy, but does not mix. The more efficient the recuperator, the lower are the ventilation losses.

In the passive house in Milanówek we installed a recuperator by Zehnder (550 m^3/h), certified by Passivhaus Institut in Darmstadt. In addition to lower energy losses connected with ventilation, we also provided the system with GGHE (ground glycol heat exchanger) that uses the energy in the ground. In summer we put excess energy into the ground, lowering the temperature of fresh air getting into the building. In winter, in turn, we take energy from the ground, raising the fresh air temperature.

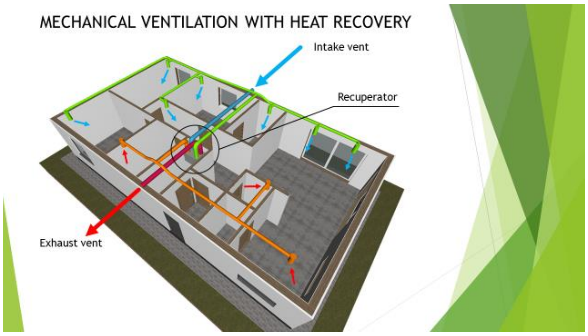


Figure 9: Mechanical ventilation with heat recovery.

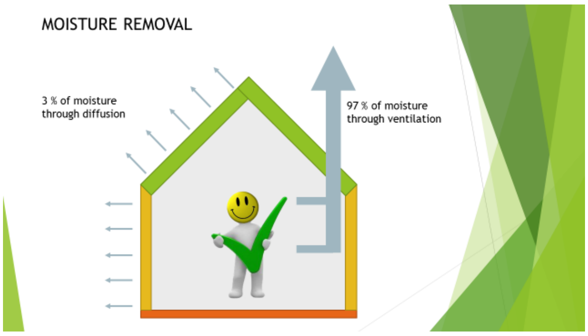
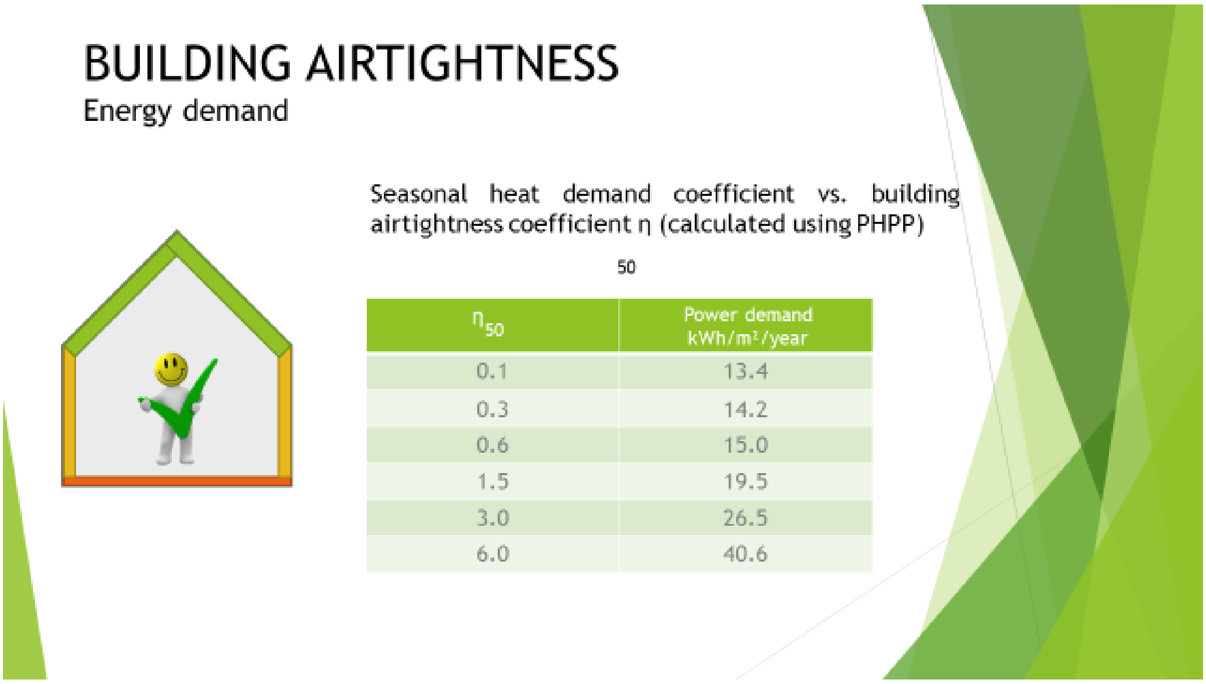


Figure 10: Moisture removal.

2. Building airtightness

A key parameter of a passive building is its airtightness, verified through Blower Door tests. It consists of creating a pressure difference of 50 Pa between the inside and outside of the building, and then measuring the stream of air flowing through the gaps in the partitions. The air exchange rate for a passive building may not exceed 0.6 times the volume per hour. In the passive house in Milanówek the airtightness test result was n_{50}=0.45 1/h.



n_{50}	Power demand kWh/m²/year
0.1	13.4
0.3	14.2
0.6	15.0
1.5	19.5
3.0	26.5
6.0	40.6

Figure 11: Impact of building airtightness on energy demand.

A pressure of 50 Pa in natural conditions corresponds to a wind of about 30 km/h, causing a pressure difference between the partitions of the building. Air goes through any gaps, cooling the building down in winter or overheating it in summer. Additionally, due to the gap in the partition, water evaporates in winter through convection, causing condensation and deterioration of the insulation parameters of the construction materials, which can lead to biological corrosion.

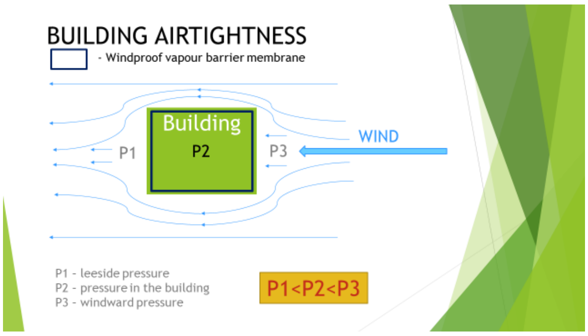


Figure 12: Pressure distribution caused by wind

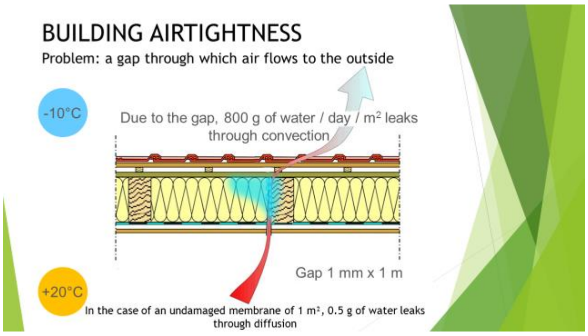


Figure 13: Damp partition due to the gap

Figure 12: Sealing the walls and ceiling.

3. Summary

In the passive house in Milanówek heating demand does not exceed 15 kWh/m^2/year. In fact, owing to the technology used in the exterior partitions, a properly selected ventilation system with our own glycol ground heat exchanger, and with the low temperature under-floor heating powered by a heat pump, we have constructed a building that uses less energy than the PHPP calculations of heat demand had shown.

Figure 13: Passive house in Milanówek, Poland.

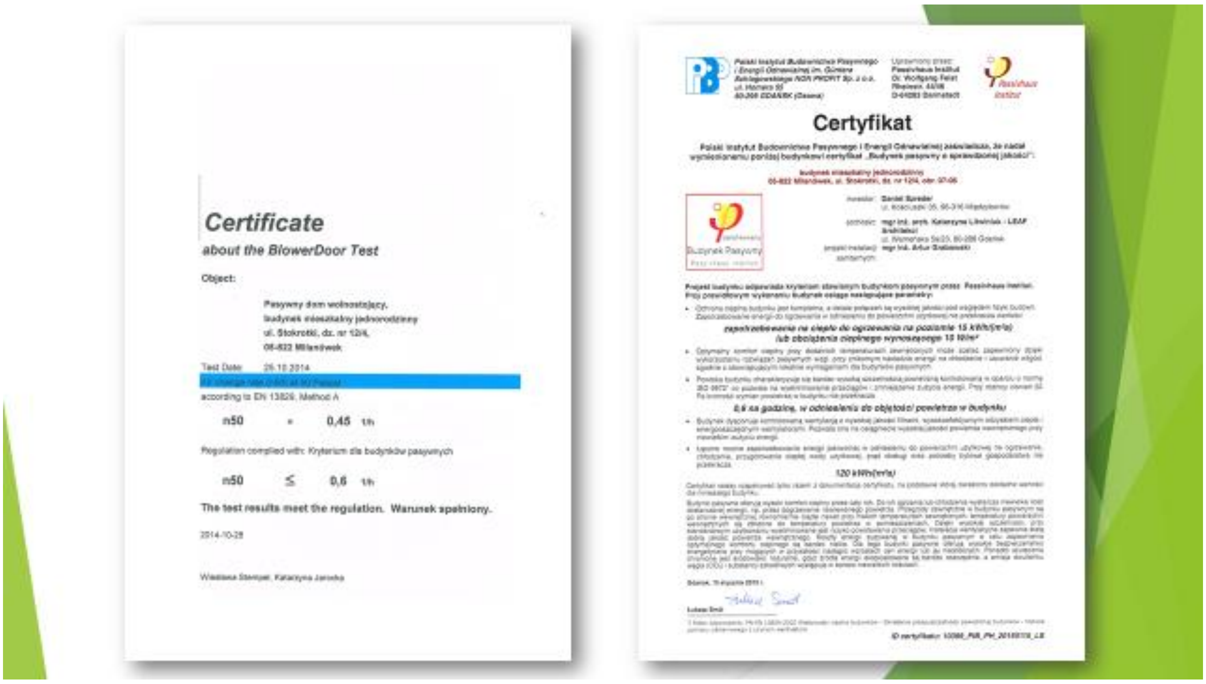


Figure 14: Certificates confirming the airtightness and passive compliance of the building.