Energy-Efficient Buildings in Slovakia: Green Atrium

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Abstract. Power management is very necessary, as well as the environment. Construction of low energy and passive houses, however, both of these requirements can be fulfilled. Project Green Atrium is the first passive apartment building in Slovakia that meets the requirements for passive buildings. In many cases also it achieved superior results as desired. Exceptional properties of Green Atrium have been achieved through these parameters: heat consumption for heating, heat transfer coefficient of walls and infiltration through leaks of building.

Keywords: Energy-efficient buildings · Green atrium · Low-energy · Passive buildings

1 Introduction

Low-energy house has a common form of construction especially abroad; it ensures energy efficiency, environmental protection, quality structures and high living comfort. In the Slovak Republic, however, this trend promotes the construction of a very slow pace, despite the fact that construction technologies and theoretical knowledge is not enough. The basic criterion by which we divide the category of energy-efficient homes into several groups is the heat consumption for heating. Compared with a conventional house, which achieves power consumption of 100–195 kWh/(m^2.a) have energy-efficient homes several times lower power consumption [1].

Slovakia was in January 2006 adopted a law on energy performance of buildings and on amendments to certain laws. It entered into force on 1 January 2008. The law follows the Directive of the European Parliament and of the Council of the European Union 2002/91/EC of 16 December 2002 on the energy performance of buildings. This directive restricts the burning of non-renewable natural resources, thus wants to contribute to a reduction of carbon dioxide. The Directive aims to improve the energy performance of buildings (EPBD) 15 reducing energy consumption for heating, hot water preparation and lighting, taking into account the efficiency of costs incurred for the construction and operation of buildings. A crucial source of energy required for residential buildings in Slovakia combustion of non-renewable natural resources, and thus carbon dioxide emissions [2].

A. Leon-Garcia et al. (Eds.): Smart City 2015, LNICST 166, pp. 842–850, 2016.
DOI: 10.1007/978-3-319-33681-7_75

Energy consumption of buildings is assessed according to valid STN 73 0540-2/2,002th. Its contents are the requirements of thermal protection and energy label of the building. In this case, it is only a theoretical value, which does not take into account the method of heating, regulation or adequate ventilation. Just adequate ventilation plays a major role in energy-efficient buildings. Today it is known only to control energy consumption for heating buildings, in the future, however, do justice to the control of energy use for cooling, hot water, operation of buildings, construction and operation of buildings [2].

Institute for energy-efficient houses that exists in Slovakia is defined as non-political, voluntary, leisure NGO. The aim of its activities is mainly supporting the construction of passive houses and architecture considerate to the environment, dissemination of information on energy-passive houses between professional and also the general public [2].

Vodiková [1] states that division according to distance energy consumption:

Energy-saving house - with heat consumption 50–70 kWh/(m^2.a). Parameters of the house can be achieved by appropriate austerity measures such as increased thermal envelope values, the targeted use of solar products and reducing energy consumption by installing solar collectors. The heating system is mostly the conventional, performance, and energy consumption, however, are low.

Low-energy house - with heat consumption 15–50 kWh/(m^2.a) requires more action. Of course there should be not only high quality thermal insulation jacket and passive and active use of solar energy as well as mechanical ventilation with heat recovery and air preheating heat or low temperature heating system with a connection to solar collectors. On a proposal from the house requires a clearly defined low-energy system concept with a maximum optimization of the individual components.

Passive house - the heat consumption from 5 to 15 kWh/(m^2.a) has a perfect thermal insulating building envelope. Thanks to mostly do without a conventional heating system. The residual heat demand arising as a result of the natural heat escaping from buildings is mostly provided by heat recovery from the outgoing air recovery. It can also be applied for production of energy from heat pumps, solar energy and biomass. The concept of passive houses projected total energy demand (for heating, hot water and electrical operation) of less than 40 kWh/(m^2.a). 14 heat recovery from solar radiation and the use of ventilation systems with heat recovery in passive houses cover up to 80 % of heat consumption.

Zero house - a house with near-zero energy for heating (0–5 kWh/m^2). It is used therein exclusively local renewable resources. Zero houses in the summer so they can produce excess electricity, which in winter consumption. Stocks of energy are stored either in large-scale solar collectors or photovoltaic panels are used to supply the public network [1].

2 Passive Buildings

Passive House is an advanced variant of the low-energy house. Due to the very low heat demand is there any excess heat. It can be left out expensive heat storage, which saves not only investment but also operating costs. These are then used to improve the

thermal insulation and mechanical air exchange [3]. With high isolated system of external walls, three heat-insulating glazing in quality frames decreasing specific heat demand less than 15 kWh/(m^2). The house is passive and is therefore able without heating and hence without expensive storage tank to maintain the required temperature. Designation passive house recalls also its largest source of heat - the sun's radiation, which is obtained dimensioned southern windows passively and instrumentation equipment [3].

Passive House provides pleasant comfort in every season and the clean fresh air in the interior at very low operating costs. Incremental investment cost of the user to return at low operating costs [4].

Hudec [4] sets out the essential features of a passive house:

- orientation of the glass facade to the south,
- compact design without unnecessary breakdowns.
- high quality insulating windows (triple insulation)
- perfect thermal insulation and air tightness of the house,
- quality solution of thermal bridges.
- controlled ventilation using heat recovery,
- classic heating system is missing.

Hudec [4] also states the basic criteria for passive house (values for Central European climatic conditions):

- Specific heat demand for heating $\leq$ 15 kWh/(m^2.a)
- The maximum heat output of 10 W/m^2,
- Heat transfer coefficient of all solid external structures of U $\leq$ 0.15 W/(m^2 K).
- windows with a U-value $\leq$ 0.8 W/(m^2 K) with glass and the value of G $\geq$ 50 %
- tightness in total must not exceed 0.6 times the air changes per hour,
- ventilation heat recovery unit with efficiency greater than 75 %;
- The overall annual primary energy consumption (heating, domestic hot water, ventilation and electrical appliances) must not exceed 120 kWh/(m^2)

The functionality of passive house it is necessary to provide the necessary air tightness of the house envelope. It is necessary to avoid leaks and holes that arises unasked heat transfer. What is important is the use of the ventilation system with a high-efficiency heat recovery. Bad construction project or carelessness can cause heat loss and condensation in structures that result in the breakdown [4].

The standard sets the overall permeability of the building envelope as the total value of the n50 the air exchange rate at a differential pressure of 50 Pa. Airtightness of the building is the greater, the smaller this value. For passive house with forced ventilation with heat recovery is the recovery limit n50, N = 0.6 h^{-1}. At 50 Pa for one hour in a building not designated more air than 60 % of the total volume of the building [4] (Table 1).

The higher the permeability means the higher the heat loss. According to approximate calculations, heat loss caused by marginal permeability in passive houses around 3.5 kWh/(m^2.a). It is in the overall specific heat demand for heating 15 kWh/(m^2.a) a significant part. Interestingly comparison with conventional buildings, which have a natural ventilation value N50, N = 4.5 h−1, which means infiltration of the

Table 1. The recommended total value of the air exchange rate n50 at 50 Pa pressure differential.

Ventilation in the building	N50, N (h−1)
Natural	4,5
Forced	1,5
Forced heat recovery	1

Source: Tywoniak [5, p. 46].

annual loss of about 26 kWh/(m^2.a), it is more than 1.5 times the specific heat for heating a passive house [4].

Typical gaps and air can flow freely from the interior to the exterior; they are erroneously transferred joints of building elements, such as joint window frame with masonry. The moisture flow, which is a structural case exfiltration of indoor air loading, may adversely affect the wetting of the building envelope. This ultimately causes a drastic reduction in the thermal performance of the building envelope and also the formation of mildew and wood decaying fungi [5].

The aim of this paper is to compare whether the first passive apartment house in SR - Green Atrium met the requirements of the applicable standards for passive buildings. The second order to calculate energy savings and return on investment when purchasing an apartment in the building Green atrium.

3 Project Green Atrium

Project Green atrium in Trnava is the first apartment building in passive standard in Slovakia. It is located in a lucrative and popular part of Trnava with major construction of family houses, not far from the centre and also known Trnava natural area – Kameny mlyn.

Multifunctional residential building green atrium consists of two objects. The first object is called reconstruction. brownfield, so the former printing plants. Building type is brick. Architecture based on simple material structure preserving the original shape of the production building [6] (Fig. 1).

3.1 Layout Solution

Green atrium is composed of several functional units. These are apartments, commercial space, administrative space, parking in the basement of the building and common areas for residents of the house, used for joint and private activities - party. In the basement are the underground garage (63 parking spaces), storage areas belonging to apartments, basements and energy core of the building. On the ground floor there are three apartments in the building wing, office space and commercial premises. On the first floor there are three apartments in the building wing, lounge, kitchen and children's play area in the gallery above commercial premises. On the last two floors there are just dwellings in Part A. The flats are mainly small flat, 1, 2 and 3-room. On the roof of a residential building is the "party" room. On the staircase on the roof are a small kitchen and a pergola.

Fig. 1. Green Atrium (Trnava) (Source: Author)

3.2 Technology and Economy

Green building is an atrium planted by a combination of the latest technology the most logical way to save everything, but even makes user experience and minimize energy costs. Green atriums technology in not only energy. The biggest added value of the energy savings is provided through multiple technologies. This is a heat pump with energy piles, photovoltaic panels, cogeneration unit, the combustion gas generates electricity and the waste heat is used for hot water and heating, the wall and ceiling capillary heating and cooling, outdoor blinds and measure all the energy in real time online management. The Green atriums are available courtesy heating and cooling and also the possibility of reheating in a heat recovery unit. Computing the need for heating in the flats is up to 14 kWh/m^2; with the requirement of the standard is 150 kWh/m^2. Ecological aspect of the project is also reflected in the fact that at least 95 % of the original building will recycle material - either reintroduced per fraction and subsequently used. The rest is waste collection.

Heat Pump. The heat pump is a device that the temperature difference and electricity produces heat or cold. Medium pump with different temperatures, and thus one kilowatt of electricity produced 3 to 4 kW of heat. The object is to use the heat pump earth/water. The energy contained in the ground has been used through the so-called energy piles, which are located under the building and at the same time serve as a basis.

Photovoltaic Panels. On the roof of the house are photovoltaic panels, which generate electricity from the sun. This is then distributed to the needs of the heat pump. During a very significant part of the year except coldest months the heating energy produced exclusively from renewable sources.

Recovery Ventilation. Each apartment includes a ventilation unit with heat recovery. This provides tremendous comfort in terms of user characteristics flat. One-ventilated intelligent IT equipment that heat from the exhaust air transmits the supply of fresh air. The result is a perfectly flat vented. This benefit is especially important in the winter months when the open window blows cold air comes to the formation of mold from a lack of ventilation during sleep breathed air in the bedroom. Cost ventilation at an average 70 m^3 of air per hour heat recovery saves 2200 kWh per year, which is around 150 Euros.

Outdoor Blinds. In traditional new multi-dwelling houses are normally provides shielding interior blinds. This solution is significantly cheaper than, as well as developer leaves the problem of shielding the owner of the apartment. But if we want to make it an effective shielding must be shaded from the window. Shielding the interiors had flat does not prevent overheating in the summer months. Exterior blinds are controlled motor and possibly also automatically represent the highest form of protection against overheating apartment in the summer months. The Green atriums blinds can be controlled via mobile phone and smart applications. They can be opened and closed as needed, and for safety reasons e.g. to simulate the presence in the apartment during the holiday.

Measurement and Control. All energies are controlled and measured by a sophisticated system accessible via the Internet. Using Smartphone is possible to continuously accurate overview of how much energy is currently consumed for heating and hot water. Heating and cooling is managed centrally, thus avoiding the fact that someone had turned off the heating and heat their apartment through neighbouring apartments. Apartment owners have the opportunity to fine-tune the final desired temperature in the apartment via regenerative units. No monopoly energy supplier can invoice the loss of the route. Energy in Green atriums is always cheaper than from the network precisely because it is produced with high efficiency and are eliminated any losses.

Partition Walls Between Apartments. The apartments are separated by plasterboard walls, whose composition has been designed specifically for project green atrium. Supporting profiles are filled with sound insulation at a thickness of 75 mm. On the profile of each side plate is fitted Rigips which provides structural strength (this board are commonly used for planting in ATMs). It is then applied to the acoustic panel, which improves the acoustic properties of the wall, and this is equipped with a sound board Activair they absorb from the air volatiles, mainly formaldehyde, thereby improving air quality in the home. This composition of the wall thickness of 150 mm, where are used of a total 6 plates and provides protection against noise above 60 dB. The standard requires 52 db. It is also really solid partition. Noise characteristics also ensures dilation screed from the walls. The inter-residential rungs are not equipped with any sewer or water pipes that impair the properties of the walls, as is common in traditional brick technology.

4 Energy Savings and Calculation of Cost Return

According to the Isover and Rigips, annual energy savings of investing in an apartment in Green atriums compared with normal warmed byte are shown in Tables 2 and 3.

Table 2. Energy savings and calculation of cost return

Flat area m/^{2}:	90 m^2
People in flat:	4
Normally insulated apartment building	
Heating costs:	558,00 €
The cost of hot water:	416,00 €
Cooling costs:	360,00 €
Green Atrium	
Heating costs:	90,75 €
The cost of hot water:	130,00 €
Cooling costs:	54,00 €
Saving	1 059,25 €
Saving on heating:	467,25 €
Saving for hot water:	286,00 €
Saving on cooling:	306,00 €
Price of apartment with parking and cooling Green atriums (€):	124 000,00 €
Price a new apartment with parking and cooling in another house (€):	118 000,00 €
Difference	6 000,00 €
Return on investment in green atrium (years)	5,66

Source: Isover, Rigips, Glassolutions a Rehau.

Table 3. Energy savings and calculation of cost return

Structures property	Measuring unit	Requirement of standard or normal standard	Values obtained in the Green atrium
Heat demand for heating one m^2 apartment	kW/m^2/a	150	13,5
The cost of heating one m^2 apartment	€/m^2	10,2	0,97
Thermal transmittance of walls	W/m^2 K	0,32	0,13
Thermal transmittance of roof	W/m^2 K	0,2	0,1

(*Continued*)

Table 3. (*Continued*)

Structures property	Measuring unit	Requirement of standard or normal standard	Values obtained in the Green atrium
Heat transfer coefficient of windows	W/m^2 K	1,4	0,77
Infiltration leaks building	n50	8.1	0,6
The amount of water vapour condensation in the roof	$Kg/m^2/a$	0,1	0,0047
Index of air airtightness inter-flat partitions	dB	53	54

Source: Isover, Rigips, Glassolutions a Rehau.

5 Conclusion

Power management is very necessary, as well as the environment. Construction of low energy and passive houses, however, both of these requirements can be fulfilled. Most home energy is spent for heating, hot water, lighting, electrical equipment and cooling. It is the largest part used for heating [7]. Using the available technology, this energy consumption can be reduced. Low-energy construction has in comparison with classical. Many times are better thermal insulation envelope structures. In doing so, quality must be done details and technical work. Windows and large glazed areas are directed to the south, that the use of solar energy. When heating is used heat recovery unit, which heats the incoming air into the room. Construction of low-energy operating cost savings can be made up to two thirds compared to conventional house. Project Green The atrium is the first passive apartment building that meets the requirements for passive buildings. In many cases also it achieved superior results as desired. Green atriums exceptional properties have been achieved parameters: heat consumption for heating, heat transfer coefficient of walls and infiltration leaks building. When comparing energy costs and return on investment in a model example it was calculated return in six years.

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