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## ACTIVE AND PASSIVE BUILDINGS IN THE CONTEXT OF USAGE PARAMETERS (INDOOR CLIMATE)

### BUDYNKI AKTYWNE I PASYWNE W KONTEKŚCIE PARAMETRÓW UŻYTKOWANIA (KLIMATU WEWNĘTRZNEGO)

#### Abstract

In the last three decades, the issues of energy use and consumption have become one of the most important problems of the European market of real-estate development. The UE regulates it through legislation, standards and guidelines for both design and use of buildings. This paper lists the types of low-energy buildings, in the context of the requirements necessary for their design and construction. It also describes the initial experience with the use of these objects in terms of their advantages and disadvantages. Particular effort was made to compare the obtained parameters and comfort in active and passive objects. This paper provides an overview of low energy buildings, in order to introduce a series of articles presenting researches of individual authors.

*Keywords: sustainable building, low-energy buildings, passive buildings, active buildings*

#### Streszczenie

W ciągu ostatnich trzech dekad zagadnienia użycia energii i jej konsumpcji stały się jednym z najważniejszych problemów budownictwa europejskiego. W UE uregulowano je przez akty prawne, normy i wytyczne do projektowania i użytkowania obiektów budowlanych. Artykuł zestawia typy budynków niskoenergetycznych w kontekście wymagań niezbędnych przy ich projektowaniu i budowie oraz opisuje pierwsze doświadczenia z użytkowania tych obiektów z uwzględnieniem ich wad i zalet. Szczególną uwagę autorzy zwrócili na porównanie uzyskanych parametrów końcowych oraz komfortu użytkowania w obiektach pasywnych i aktywnych. Praca ta, przedstawiająca przegląd budynków niskoenergetycznych, jest wstępem do całego cyklu artykułów, w którym autorzy zaprezentują własne badania i analizy.

*Słowa kluczowe: budownictwo zrównoważone, budynki niskoenergetyczne, budynki pasywne, budynki aktywne*

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## 1. Legal regulations

The strategy of Poland's development is coherent with the European strategies, including those referring to low-energy building. In the field of properties development, the requirements and decisions of the European Commission (the Union Directives, Access Treaty, the Kyoto Protocol) are of special importance for Poland, as the attempts to implement them can be noticed. It is especially important to meet the deadline determined in the Directive 31/2010 EPBD RECAST, in which the date of introducing the standard of "Net zero energy building" is settled.

A building of net zero energy demand – according to a definition given in the Directive 31/2010 EPBD RECAST – is a building of a very high energy characteristic. Net zero or a very small amount of demanded energy should come, to a very high degree, from renewable energy sources, produced on the spot or nearby.

In the light of such demands, building in Poland and other European Union countries faces a thorough change from traditional building, to that of very much lowered energy demand. This is connected with operations in many fields, as well as the necessity to meet the new challenges.

The European Union expects its Member Countries to define the "buildings of net zero energy demand", adjusted to the regional conditions. National definitions of a "net zero energy building" are being shaped now, while the buildings with lowered energy demand are built in the European countries, according to different standards and experiences. In Europe, the idea of passive buildings is the most developed one – especially in Germany, Austria and Scandinavia (more than 15000 of the buildings meeting the Passive House standards). Recently, the idea of designing active buildings has appeared.

## 2. Passive Buildings. Designing guidelines. Examples of realisation

The idea of passive buildings originated in Germany, in the Institute of Passive Buildings. In this Institute, the parameters of such objects were determined. According to the definition, a Passive House is a building, which meets proper standards of energy-saving, provides comfort of usage and has low exploitation costs. The type of building promoted by the Institute in Darmstadt allows saving up to 90% of the energy, in comparison to the average energy consumption in the existing buildings in the central Europe and over 75% in comparison to the average for newly erected buildings. Energy saving concerns not only moderate climate zones. The passive objects localized in warm climate zones—where cooling is demanded – show much smaller energy usage than standard buildings. Passive houses use less than 1.5 l of oil or 1.5 m<sup>3</sup> of gas to heat one square meter of living area a year—considerably less than in typical "low-energy" buildings. The criteria for Passive Buildings – in comparison to the Polish standards – are very difficult to meet. According to the directives of the Institute in Darmstadt.

1. The annual heating demand may not exceed 15 kWh/(m<sup>2</sup>a).
2. *U*-values of opaque exterior components must be less than 0.15 W/(m<sup>2</sup>K).
3. *U*-values of windows must be less than 0.8 W/(m<sup>2</sup>K).
4. *G*-values must be around 50% (total solar transmittance).

5. Translucent areas oriented towards the west or east ( $\pm 50^\circ$ ), translucent areas inclined at an angle of  $75^\circ$  to the horizontal may not exceed 15% of the useful areas, or they must be equipped with temporary solar protection with a reduction factor of at least 75%.
6. Maximize passive solar gain.
7. The use of specific primary energy for all domestic applications (heating, hot water and domestic electricity) must not exceed 120 kWh/(m<sup>2</sup>a) in total.
8. Ventilation with highly efficient heat recovery – 75% of the heat from the exhaust air is transferred to the fresh air again by means of a heat exchanger.
9. Uncontrolled leakage through gaps must be smaller than 0.6 of the total house volume per hour during a pressure test at 50 Pascal (both pressurised and depressurised).
10. Thermal bridges, which cannot be avoided, must be minimised as far as possible.

Passive buildings use mainly solar energy, gained through glazing areas facing south and stored in massive walls of high thermal capacity. Thanks to high tightness and good thermal insulation of the external walls, as well as effective systems of mechanical ventilation with heat recovery, the passive houses minimize heat losses. The location of the building is of significant importance, as well as the shape of the exterior shell – relative to the geographical direction.

The first passive building in Poland – certified by the Institute of Passive Houses in Darmstadt – was built in 2006 in Solec, near Wrocław.



Fig. 1. Passive house in Solec near Wrocław

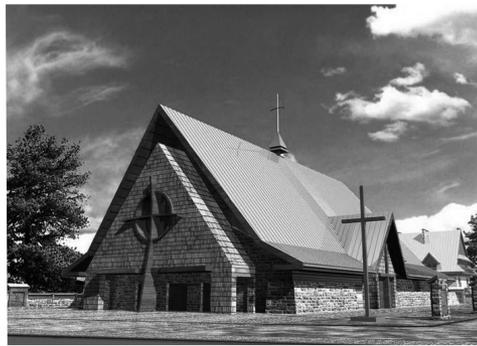


Fig. 2. Passive church in Nowy Targ, Równia Szafłarska

The first “passive” church was opened in Nowy Targ, Równia Szafłarska. It was erected according to the project of architects Tomasz Pyszczyk and Marcin Stelmach.

The object of 1740 m<sup>2</sup> was designed for a congregation of 500. The structure incorporated solutions typical for passive buildings, such as: compact building structure, high thermal insulation of the all building components of the exterior shell of the house (walls  $U = 0.1$  W/m<sup>2</sup>K, windows  $U = 0.8$  W/m<sup>2</sup>K), low-temperature underfloor heating with heat pump powered by a drilled well, as well as mechanical ventilation with a very efficient heat recovery.

Recently, a pressure test has been carried out in the church – the result of 0.59 l/h proved sufficient tightness of the casing on the passive object level.

### 3. Active Buildings. Designing guidelines. Examples of realisation

The idea of an active house originated as an alternative for energy efficient passive building, in a rigorous way forcing new directions for glazing and mechanical ventilation in the objects. It is based on similar architectural and building concepts, referring to material solutions, the object airtightness, shape of the building envelope and its optimal position, regarding the siting relative to the geographical direction – yet at the same time favoring natural light, natural ventilation and by using windows with automatically controlled opening system. At the increased glazing areas, active buildings are protected against overmuch heat gains through a system of automatically steered external roller-blinds and solar shading. The basic assumption in such types of buildings is to make use of solar energy, geothermal energy or wind energy in a most effective way, while remaining comfortable for the user.

In the designing process of an active building, it is important to analyse the possibility of limiting the negative influence of the object on the environment, starting from the phase of entering the building site, through the building process, up till the final usage of the object. Energy efficiency and saving water, the care about the quality of air, the rational choice of the building materials, technical service of the appliances – all these are priorities to be taken into account, when designing and constructing active buildings.

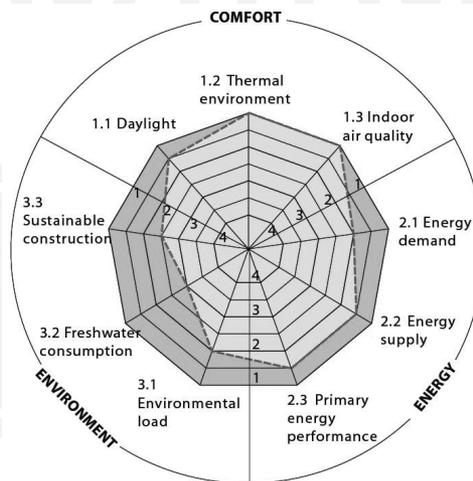


Fig. 3. Active house radar

Similarly to the passive houses, the annual energy demand of the active ones is minimized and heat transfer losses from exterior envelope of the building are limited to a minimum. Active buildings are able to “produce” electric energy or any other energy from the renewable sources, which should compensate the so-called climate payback, taken out by the house building – relative to the environment and society.

In the years 2009–2011, within the Model 2020 research project, six houses were erected in Europe, which met the criteria of active buildings. The houses were inhabited by families, which took part in the tests on users’ comfort in the objects.



Fig. 4. Solar-Activhouse, Kraig, Austria



Fig. 5. Home for Life, Lystrup, Denmark

In those buildings, a hybrid ventilation was used, which means natural ventilation in summertime and mechanical ventilation (with heat recovery) during wintertime. In the transition seasons of spring and fall, the hybrid ventilation is switched on and off under the influence of outdoor temperature changes.

#### 4. Experience gained from active and passive buildings usage

In the active Home for Life, tests were carried on the user's comfort, during the two years of usage. The results were published in REHVA – Federation of European Heating, Ventilation and Air-conditioning Associations in the article: *Using cooling ventilation system and solar shading to achieve good thermal environment in a Danish Active House*. The conclusions presented by the authors:

1. The building reaches good heat efficiency, which should be seen in connection to the high level of natural daylight.
2. Automatic control of the window openings and the solar shading elements positively influences indoor climatic conditions.
3. Cooling through window openings plays especially important role in maintaining heat comfort within the building – no significant overheating of the building was noticed in the summertime.
4. Small episodes of overcooling were observed during wintertime, keeping a favourable balance between the optimal interior temperature and usage of energy.

In Poland, the analysis was carried out on the microclimate in the passive sports hall in Słomniki. When taking measurements during high external temperatures, it was noted that:

1. In the case of a small physical activeness, the user will experience ideal conditions for his organism.
2. In the case of high physical activeness and with a bigger number of users, the increase of temperature and humidity will endanger the thermo-regulation processes of a competitor.
3. Blocking out roller blinds appeared to be necessary – in the afternoon hours, the outdoor light breakers were not able to reduce heat gains.

## 5. Conclusions

The results of both measurements are difficult to compare due to the difference in time of the carried out tests. The active house underwent measurements during a two years period, while the hall testing was carried out during just a few days of very high outdoor temperatures.

While in the passive houses an excessive heat recovery in the summertime appears to be a problem, in the active houses overcooling was noted in winter months.

Moreover, in the sports hall – at the same values of indoor climatic conditions – the competitors felt discomfort, while the audience enjoyed proper comfort.

This suggests the necessity of creating a space separation system, according to the physical activeness of the users.

Low-energy buildings demand a different way of designing than traditional buildings. The zero energy buildings create more technological problems, rather than architectural ones.

Meeting the requirements when designing the energy efficient buildings (PHPP, Active Houses Qualitative Parameters, etc.) is a necessary, yet it is not sufficient for effective functioning of the object, as a space of optimal indoor comfort.

It would be justified to introduce the necessity to carry out model analysis, as well as computer simulations at the designing stage.

Cooperation between architects, technologists, building physicists, constructors and contractors – from the very first stages of the project – is an indispensable condition when creating buildings, which would function effectively.

*The authors are in the course of research on low-energy buildings, with the comfort and quality of the internal environment, which also affects comfort, acoustics, vibration, amount of daylight and air pollution. The following publications will presented the results of this work, along with suggested steps for optimizing the design of low energy buildings. The selection of materials, installations or building integration (BMS) are the target and the main concern of this research.*

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