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# IN SITU MEASUREMENT AND SERVICE MONITORING OF LOW-ENERGY BUILDING

# POMIAR IN SITU I MONITOROWANIE DZIAŁANIA BUDYNKÓW O NISKIM ZUŻYCIU ENERGII

**Odpowiedzialność za poprawność językową ponoszą autorzy**

A b s t r a c t

This paper presents an experimental building recently completed and currently occupied. The paper contains a brief description of the building, the method and location of the measurement equipments and monitoring of the building‘s operation. Initial results show that the operation of the building meets some of the requirements for passive buildings.

*Keywords: measurement, low energy buildings*

S t r e s z c z e n i e

W artykule przedstawiono opis eksperymentalnego budynku, niedawno ukończonego, a obecnie już użytkowanego. Artykuł zawiera jego krótki opis, metodę i rozlokowanie urządzeń do pomiaru i monitorowania działania budynku. Początkowe rezultaty pokazują już, że sposób funkcjonowania budynku spełnia niektóre wymagania stawiane budynkom pasywnym.

*Słowa kluczowe: pomiary, budynki energooszczędne*

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## Denotations

$U$ – coefficient of heat transfer [W/(m$^2$·K)]
$g$ – solar factor [%]
$E$ – energy demand [kWh/(m$^2$a)]

## 1. Introduction

The development of the company at the beginning of the third millennium is immense though at the moment it is slightly subdued by the financial and economic crisis. Over time, it will gradually regain from this economic crisis (as is usually the case since history has a tendency to repeat itself) and economic development will be further advanced.

It is also during this ongoing crisis that has mainly affected the developed North American and European economies in reflection to the development of environmental quality – sensible pressure has been applied to reduce the environmental burden, as was also expressed at the Copenhagen UN summit on climate change at the end of 2009, where attention is needed to focus on the need to reduce energy intensity. This is best seen reflected in the category of design and construction of houses. This is probably due to the influence of mass media, hand in hand with the increase of fossil fuel prices and relatively low investment costs here based on a built-up area of smaller and simpler technical controls inside the building structure, and a clear and direct ownership in comparison to larger construction investment units.

The projected increase in construction in the area concerned with the design and implementation of experience and to establish good relations of firms producing building products, and to a lesser extent to carry out comprehensive research in this area for such a building, our Department of Architectural Engineering project, low-energy house "Fiamo".

## 2. Architectural and space arrangement solutions

This is about one floor detached family house floor, without a cellar and with a flat roof. The architectural design is determined by the energy concept of the building – a low energy house using the potential for solar architecture. There are large transparent areas located on the south façade which are used to keep heat the benefits from solar radiation (Fig. 1). The northern façade is minimalistic regarding to the size of the openings. The main entrance is oriented toward the north. This family house is suited for one family (with 2 or 3 family members).

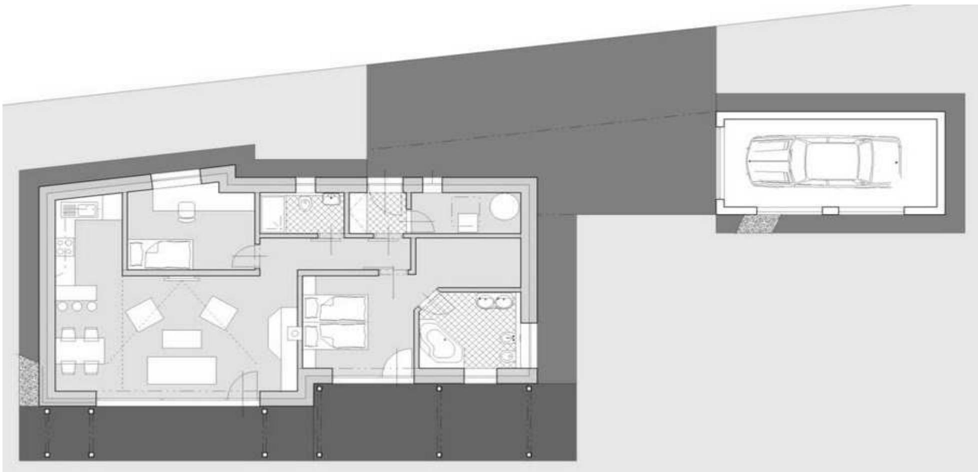

Fig. 1. Layout of house

Rys. 1. Plan budynku

### 3. Construction solution

This building is designed according to the principles and requirements for passive houses stated by PHI in Darmsatd (Feist, 1988).

External vertical load bearing structures are made of accurate autoclave concrete blocks with a thickness 250 mm. The ceiling construction of the house is installed with an autoclave concrete ceiling system of thickness 250 mm. The roof construction is designed as a single flat deck waterproof roof on a PVC base. The floor's thermal insulation is laid on the terrain designed above the foundation plate level and is made of stone wool with a thickness of 200 mm. To improve the floor's thermal insulation properties on terrain but mostly to save the homogeneity of the thermal insulation layer which is detailed in the attachment of the floor to the external wall is designed from foam glass with a height of 50 mm and a thickness 240 mm. The thermal insulation of external walls is designed from thermal insulation plates made of stone wool with a thickness 240 mm. The thermal insulation of the roof is made of thermal insulation plates with a basic thickness of 300 mm (240 + 60 mm). An additional layer of thermal insulation creates a systematic solution for slope plates with a thickness ranging from 20–180 mm to ensure the roof's slope to drain away rain water.

For the outside filling construction (windows, glass walls) frame parts are designed from plastic composite profiles with three states of sealing. Frame profiles which are used to characterize the new generation of central sealing for a more carefully provided air tightness of the window. Another characteristic and innovative element is the omission of the steel reinforcement in the window profile and its substitution with a thermal insulation filling. This solution enables designed composite profiles to used. By omitting the steel reinforcement and by adding the thermal insulating filling we can improve the thermal insulation properties of the frame profile. Triple insulated a glazing units are designed

(4-12-4-12-4) with cryptonic filling for transparent window parts and glass walls. Different types of glass in a triple glazed unit system are designed according to the orientation of the façade. There are different types depending on North or South orientation.

Setting of the filling construction was made with detailed use of sealing tape in system of wind and rain obstacles.

The whole building is ventilated and heated by a unit which has an output of 3 kW. This unit is directed to double zone circulating of hot air heating and at the same time it is directed to comfort ventilation with heat recovery. This whole system will also use solar energy from solar collectors. More detailed description of the construction, architectonical solution and technical solution is in [1–3].

Table 1

**Basic characteristics of building**

| Energy consumption | | |
|---|---|---|
| Calculation method | STN 73 0540 [4] | PHPP [5] |
| Energy | 27 (kWh/(m$^2$a)) | 24 (kWh/(m$^2$a)) |
| Thermo technical basic properties | | |
| Roof | $U$ = 0,098 (W/(m$^2$K)) | |
| Floor | $U$ = 0,12 (W/(m$^2$K)) | |
| Windows – Frame System | $U$ = 0,85 (W/(m$^2$K)) | |
| Windows – Glass System (north orientation) | $U$ = 0,44 (W/(m$^2$K)); $g$ = 36,8% | |
| Windows – Glass System (south orientation) | $U$ = 0,51 (W/(m$^2$K)); $g$ = 60,4% | |
| Peripheral wall | $U$ = 0,125 (W/(m$^2$K)) | |
| Surface properties | | |
| Footprint area | 134 m$^2$ | |
| Floor area of house | 84,2 m$^2$ | |
| Floor area of garage | 19,8 m$^2$ | |
| Hard surfaces | 96 m$^2$ | |

## 4. Measurements of the building structures and building operation monitoring

### 4.1. Measurements of the building structures

Long-term measurements of building structures are currently under preparation. Attention is given to the devices functionality, accuracy of the cyclical record and the accuracy of the instrumentation. Monitoring will take place in the period of 05/2010–12/2012. Internal environment monitoring includes monitoring of air temperature, surface temperature structure, heat flow, $CO_2$ concentration and relative humidity. In parallel, it will be monitored by the parameters of the external environment (air temperature, relative humidity, solar radiation intensity).

Table 2

**Description of measuring points**

| POSITION # | MEASUREMENT | EXPLORING ELEMENT |
|---|---|---|
| T1 | Air interior temperature | MT8736AG |
| T2 | Air interior temperature | S3120 – PT 100 |
| T3 | Air interior temperature | S3120 – PT 100 |
| T4 | Air interior temperature | S3120 – PT 100 |
| T5 | Air interior temperature | S3120 – PT 100 |
| T6 | Air interior temperature | S3120 – PT 100 |
| T7 | Air interior temperature | PT100 |
| T8 | Air interior temperature | FHAD462 |
| T9 | Air interior temperature | P Micro TX |
| T10 | Air interior temperature | PT100 |
| T11 | Air interior temperature | P Micro TH |
| T12 | Air interior temperature | P Micro TH |
| T13 | Surface temperature – glass system | FTA683 |
| T14 | Surface temperature – glass system | PT100 |
| T15 | Surface temperature – wall (east orientation) | PT100 |
| T16 | Surface temperature – wall (south orientation) | FQA018C |
| T17 | Surface temperature – wall (north orientation) | PT100 |
| T18 | Surface temperature – floor | PT100 |
| T19 | Surface temperature – slab | PT100 |
| T20 | Air temperature | P Micro TH |
| T21 | Air temperature | P Micro TH |
| F1 | Heat flow – wall (south orientation) | FQA018C |
| F2 | Heat flow – wall (east orientation) | AM |
| F3 | Heat flow – slab | AM |
| F4 | Heat flow – glass system | AM |
| F5 | Heat flow – glass system | AM |
| F6 | Heat flow – floor | AM |
| F7 | Heat flow – wall (north orientation) | AM |
| V1 | Relative humidity | S3120 – PT 100 |
| V8 | Relative humidity | FHAD462 |
| | | |
| C1 | $CO_2$ – concentration | FYA600CO2 |
| C2 | $CO_2$ – concentration | FYA600CO2 |
| C3 | $CO_2$ – concentration | FYA600CO2 |
| | | |
| 1 | Fluid temperature in the pipe | FPA4415 |
| 2 | Fluid temperature in the pipe | FPA4415 |
| 5 | Intensity of solar radiation | FLA628S |

Specific types of measurements will be a repeated single measurement for the building's airtightness and the gas concentration in the glass system. For these measurements to be verified, any loss of building construction quality (blowerdoor test) or loss of product quality (the glass system) must be considered. The overall distribution of sensors is shown in the table as well as in figure 2.

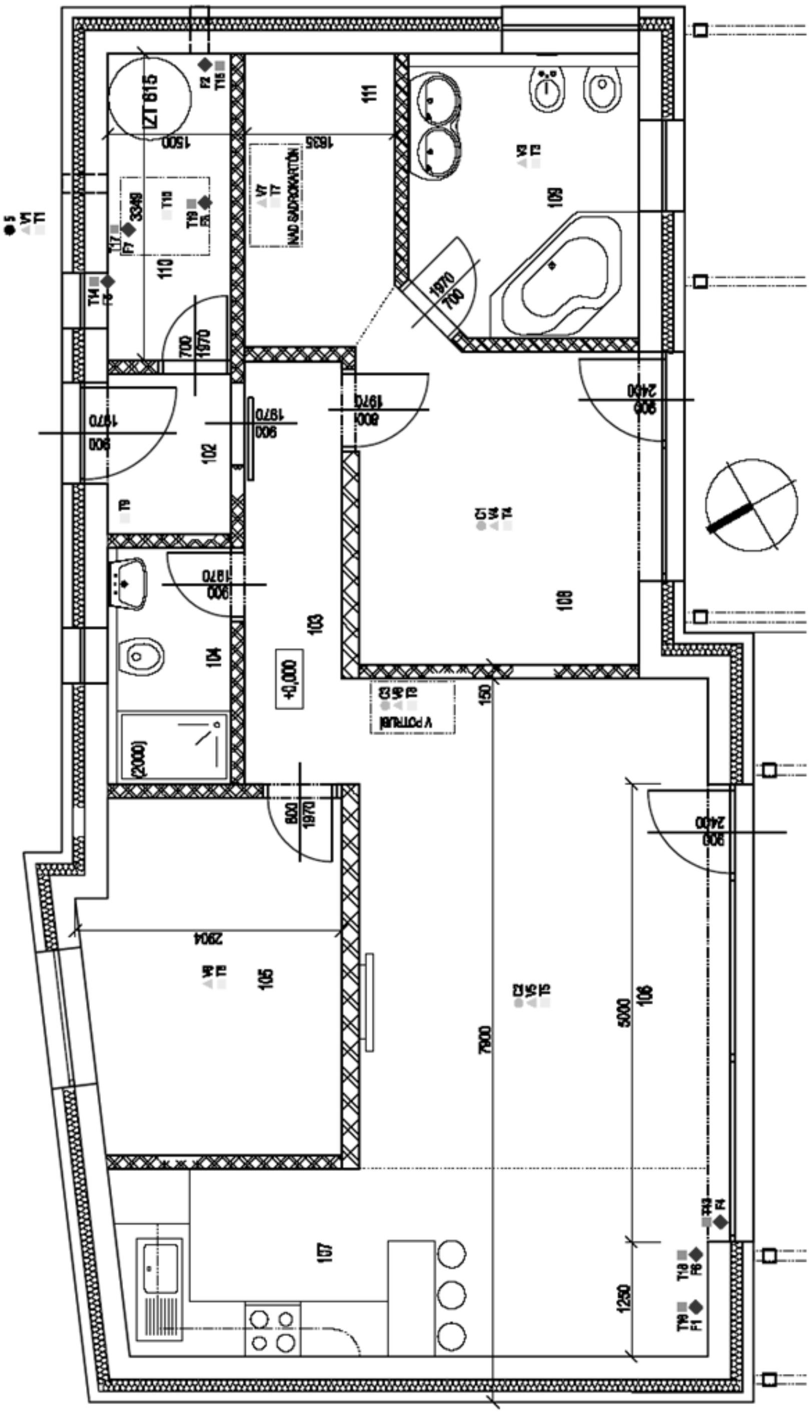


Fig. 2. Positions for measurements of building structures in house

Rys. 2. Schemat rozmieszczenia elementów pomiarowych w budynku

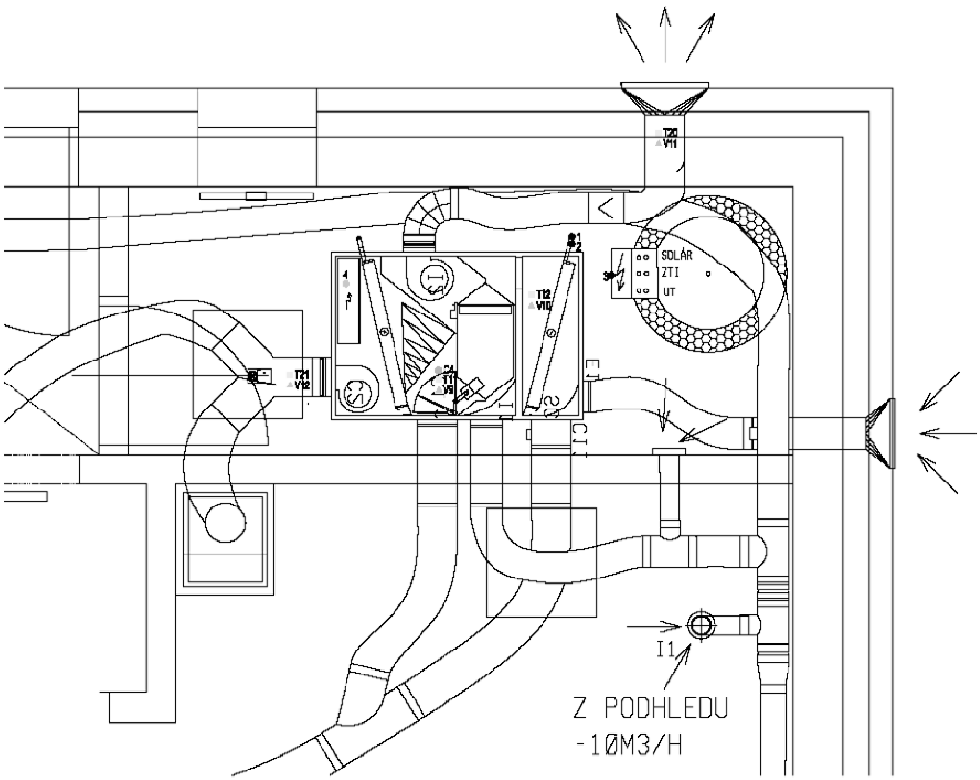


Fig. 3. Positions of exploring elements in HVAC unit

Rys. 3. Schemat elementów w jednostce ogrzewania i wentylacji

The measurement has been made using an airtight test [6] with the result $n_{50}$ = 0,58 (1/h). This result is consistent with the requirements for passive houses. Some shortcomings that were revealed by airtight test were systemic. The description of defects was published in [7].

## 4.2. Building operation monitoring

The measurement equipment operating parameters were running for five months. The measurement of the performance indicators are recorded by the temperature in the reservoir, the effectiveness and efficiency of solar panels, energy consumption across buildings, particularly a reservoir of warm water (approximately 80% of total energy consumption). Alongside different operating modes of air-heating unit are monitored. The first measurement results show that the overall primary energy demand for buildings should be in the range of 5000–6000 (kWh/(a)), i.e. 75 (kWh/(m$^2$a)). The exact value will not be known until after a year's period of measurement. The preliminary result is also consistent with the requirements for passive houses $E_{max}$ = 120 kWh/(m$^2$a).

## 5. Conclusions

The implementation of this measure should enhance the knowledge about the operation of low energy (passive) buildings. Initial results (specific primary energy demand – 75 kWh/($m^2$a)) shows that a set trend and building design are correct. Based on the information and data of the set of structure measurements and the monitoring of building operations our next task is to transfer the knowledge into wider practice in the form of increased construction of low-energy buildings in the SR conditions. The specific conditions in the construction of the SR (subsidies, energy prices, conservatism of investors, prices of construction materials, access to building products and technology, a form of construction) are barriers from the wider application of the low energy building construction. Wider transfers into practice are possible only while using affordable materials and technology, economic efficiency and craftsmanship, while respecting the requirements of sustainable development.

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