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ANNA SEDLÁKOVÁ, JAROSLAV VOJTUŠ*,
EVA KRÍDLOVÁ BURDOVÁ**

CONSUMER MODEL IN ORDER TO RESEARCH THE INTEGRATION EFFECTIVENESS OF RENEWABLE ENERGY SOURCES – DESIGN CONCEPT OF BUILDING CONSTRUCTIONS

MODEL ODBIORCZY W BADANIU INTEGRACYJNEJ WYDAJNOŚCI ODNAWIALNYCH ŹRÓDEŁ ENERGII – PROJEKTOWA KONCEPCJA KONSTRUKCJI BUDOWLANYCH

A b s t r a c t

Designing a building requires the interplay of architecture and design parameters to create an artificial material environment. Each architectural and engineering design has a direct impact on the indoor climate environment and a key determinant of operational performance of buildings throughout the life of the building. One important component of the process of reducing the operating energy performance of buildings within a designated period of their exploitation as packaging design of buildings and their physical and technical characteristics, which are intended design concept and building material solutions.

Keywords: architectural design, energy consumption , energy efficient buildings, energy efficient houses, construction and design requirements

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

Projektowanie budynku wymaga wzajemnego oddziaływania między parametrami architektonicznymi a projektowymi w celu stworzenia sztucznego środowiska materialnego. Każdy projekt architektoniczny i inżynierski wywiera bezpośredni wpływ na środowisko klimatu wnętrz i stanowi kluczowy wyznacznik użytkowej wydajności budynków w ich pełnym cyklu życiowym. Jednym z istotnych elementów procesu ograniczania użytkowej wydajności energetycznej budynków w wyznaczonym okresie eksploatacyjnym jest pakietowy projekt budynków i ich charakterystyki fizyczno-technicznej jako zamierzona koncepcja projektowa z rozwiązaniami w zakresie materiałów budowlanych.

Słowa kluczowe: projektowanie architektoniczne, zużycie energii, budynki energooszczędne

* Prof. PhD. Eng. Anna Sedláková, PhD. Eng. Jaroslav Vojtuš Institute of Architectural Engineering, Department of Building Services, Faculty of Civil Engineering, Technical University of Košice, Slovakia.

** PhD. Eng. Eva Krídlová Burdová, Institute of Environmental Engineering, Department of Building Services, Faculty of Civil Engineering, Technical University of Košice, Slovakia.

1. Description of the experimental building

1.1. General description of the building

In accordance with long-term strategic objectives of reducing emissions and improving energy efficiency, adoption of the European Parliament on May 18, 2010 and the adoption of 2010/31/EU raised the commitment by 2020 to reduce overall emissions of greenhouse gases by at least 20%. The Directive requires Member States to design all new buildings with nearly zero energy until December 31, the2020 th. Aims of the Directive can be applied in conjunction excellent thermal parameters of packaging designs energy-efficient buildings and shape solutions. Article deals with the experimental building that is part of the research faculty. Experimental building will be built in the laboratory hall, the whole building will be placed in climate chambers, where will be simulated exterier temperatures. Parameters of peripheral structures correspond to the parameters of passive house. The paper is published systems to ensure the internal environment in rooms with the help of air conditioning and heating systems using renewable energy sources.

The experimental house is designed in passive standards in terms of building structures. On the basis of calculated balances for the needs of heat, hot water demand and the need for ventilation of the building were designed variants of heating and ventilation. The paper does not deal with hot water, however the proposal distribution of hot water and the energy required for domestic hot water is also included in the research. The building is part of the research and development environment to ensure sustainable interoperability and integration of research into space of efficient use more valent systems based on renewable energy sources. The building is located in a chamber that will simulate outdoor temperature excluding the effects of sunlight. The whole technological park will use biomass technology for the efficient use of hydrogen, solar energy, geothermal sources and hydrogen batteries as alternative sources of energy. Experimental building will be incorporated into the project as one of the appliance of energy. The source of energy will be high-capacity storage tank located under the Technology Park. The following figure shows the experimental building.

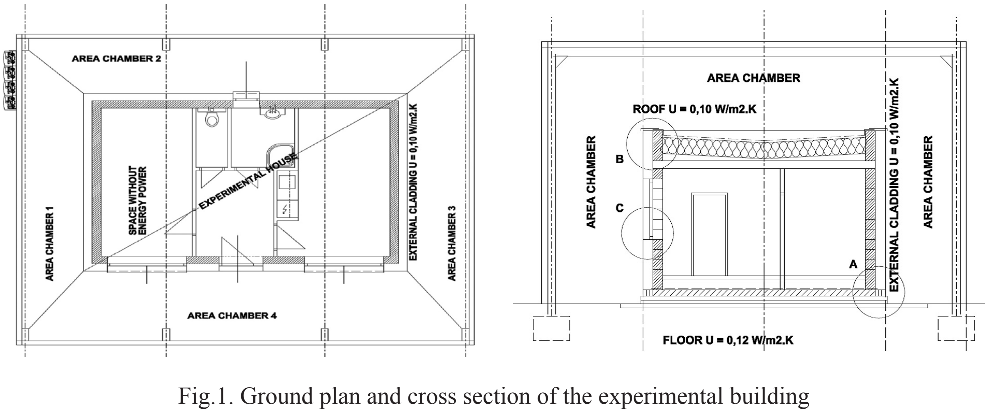

Fig.1. Ground plan and cross section of the experimental building

Rys.1. Rzut poziomy i przekrój poprzeczny budynku eksperymentalnego

2. The consumer model

The assessment of the environmental performances of construction materials and products is a complex issue which requires the use of a set of comprehensive criteria [1]. Energy and environmental impact are two major concerns of today's new building design and construction [2,4]. The aim of this paper is present concept of building structure design and environmental assessment for consumer model of research in order to force the integration of renewable energy sources. In this paper is presented an initial integration of the energy and environmental performance of consumer model. This consumer model will be confronted with measurement in situ. The consumer model is designed as a Passive House with the specific heat energy demand for heating of consumer model is less than 15 kWh/m^{2}a. The specific total final demand of consumer model is 40-60 kWh/ m^{2}a. The total amount of primary energy of consumer model is 100-120 kWh/m^{2}a. In consumer model is comfortable ventilation system with heat recuperations.

2.1. Concept of building structure design

The consumer model is a single-story building with one bedroom, one living room with kitchen and one baths and toilet. In the figure (Fig. 3) is shown view of the consumer model and in the figure (Fig. 4) shows the floor plan of the consumer model. Built-up area is 55,2 m^2.

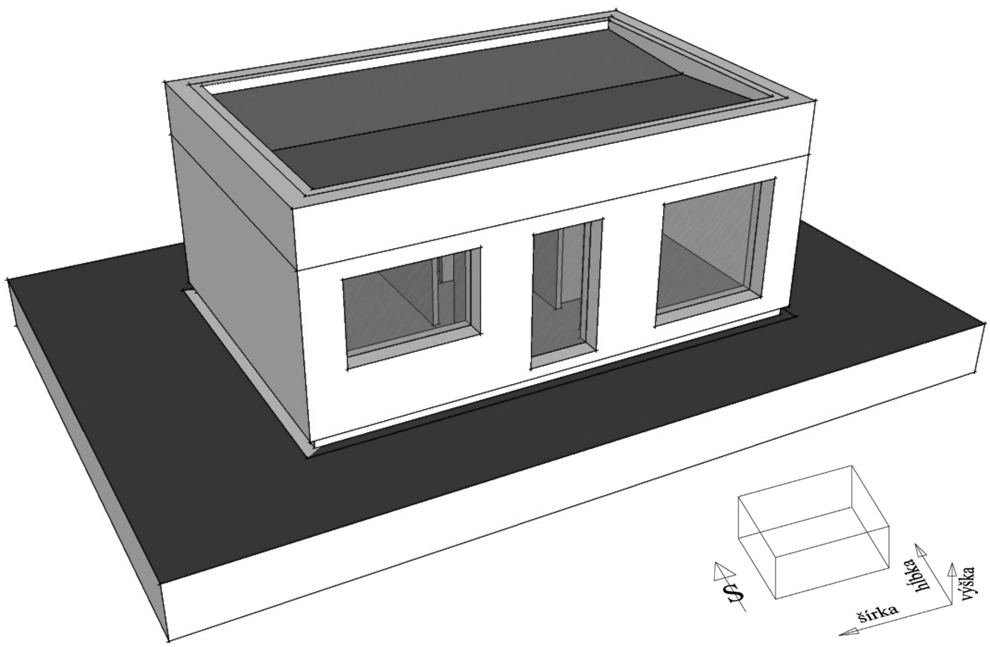

Fig.2. View of the consumer model

Rys.2. Widok modelu odbiorczego

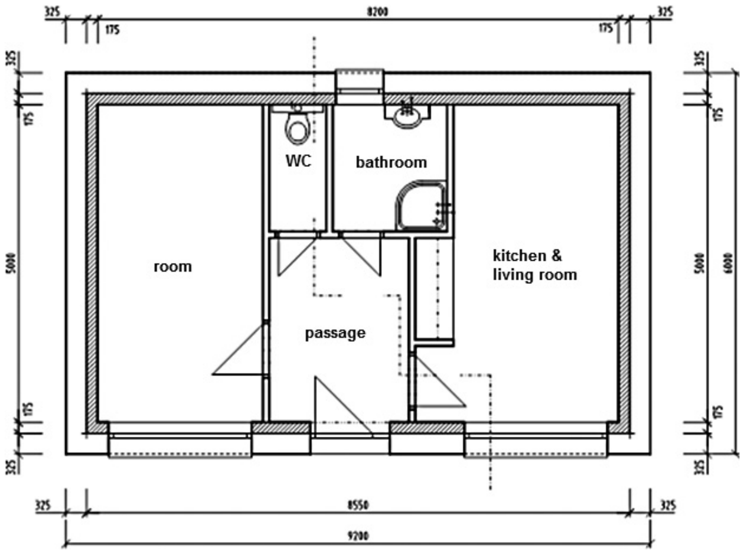

Fig. 3. The floor plan of the consumer model

Rys. 3. Plan piętra w modelu odbiorczym

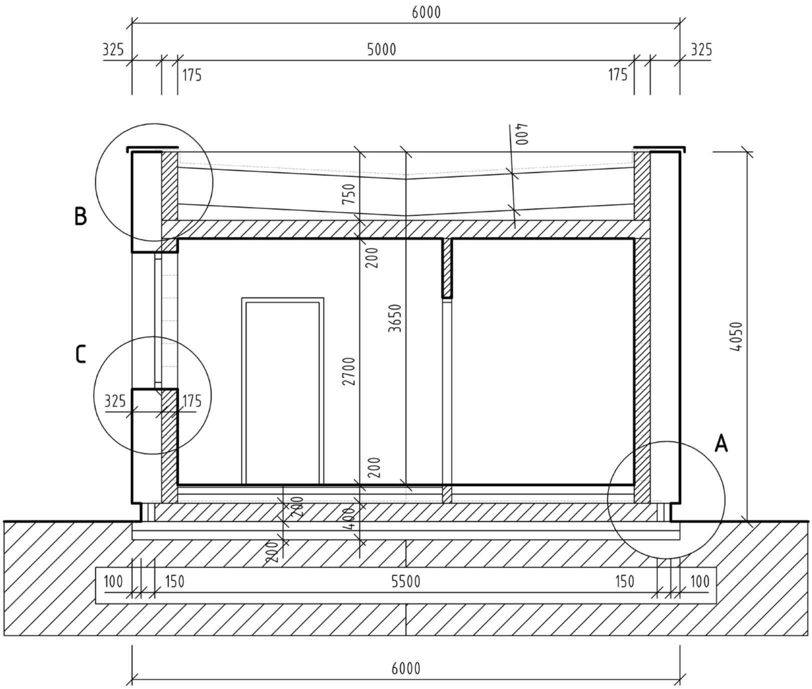

Fig. 4. The cut of the consumer model

Rys. 4. Przekrój przez model odbiorczy

2.2. Charakteristic details of packing structure of the model house

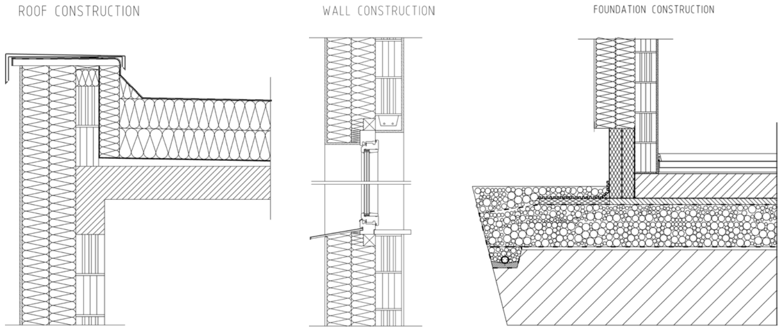

Fig. 5. Charakteristic details of packing structure of the model house

Rys. 5. Charakterystyczne detale struktury modelu

2.3. Computing method

To facilitate the calculation of different combinations of input parameters was used optimization method based on stochastic random selection of input parameters [7]. Was used application in Ms Excel [6], which was applied to the optimization method. Interval input is through the median and the mean deviation. The inputs for the optimization model are the dimension of building sides, the building envelope *U*–value, % of window to the wall, solar properties of window etc. All input parameters meet the criteria of minimum thermal properties according to STN 73 0540 [6], Table 1 and Fig.6, 7.

3. Environmental performance of consumer model

The environmental impact of the consumer modes has been computed using the information database Passivhaus Bauteilkatalog [5]. Building materials, components and constructions of consumer model was evaluated according to amount of embodied energy, amount of CO_2 and SO_2 emissions. The present knowledge allows evaluating the part of life cycle, from raw material exploitation to production of architectural elements. The values of primary energy for this part of the life cycle are determined by specialists. The selected experimental building was assessed from primary energy point of view derived from non-renewable energy (Figure 8). The value of total primary energy embodied in building materials and constructions is 198 352,94 MJ per year. The global warming potential is expressed as equivalent amount of CO_2, which significantly contributes to the greenhouse effect. The following figure shows the amount of CO_2 emissions related to building materials and constructions used in the evaluated office. The total CO_2 emissions represent the value 17 970,20 kg per year. The total area of building represents value 55,2 m^2 (area of all materials and constructions in the mentioned building). The value of CO_2 emissions related to m^2 area of the building represents a value of 325,54 kg/m^2 per year. The acidification of environment causes sulfur dioxide, nitrogen oxides, ammonia and others.

Table 1

Input parameters to calculate the heat energy of model house

parameter			min. value	med. value	max. value
index	name	unit			
U_{st}	Transmission heat loss coefficient of wall	[W/ m^2.K]	0,10	0,13	0,20
U_{pdl}	Transmission heat loss coefficient of floor	[W/ m^2.K]	0,12	0,15	0,25
U_{st}	Transmission heat loss coefficient of roof	[W/m^2.K]	0,10	0,12	0,15
U_{ok}	Transmission heat loss coefficient of window	[W/m^2.K]	0,40	0,80	1,10
% ok S	% of window to wall - N	[%]	30	50	70
% ok J	% of window to wall - S	[%]	30	50	70
% ok V	% of window to wall - E	[%]	30	50	70
% ok Z	% of window to wall - W	[%]	30	50	70
$g_{ok} - S$	Total solar energy transmittance - N	[-]	0,10	0,50	0,90
$g_{ok} - J$	Total solar energy transmittance - S	[-]	0,10	0,50	0,90
$g_{ok} - V$	Total solar energy transmittance - E	[-]	0,10	0,50	0,90
$g_{ok} - Z$	Total solar energy transmittance - W	[-]	0,10	0,50	0,90
n	Air change rate	[1/h]	0,10	0,30	0.50
ΔU	Efect of termal bridge, offset by flat [6]	[W/(m.K)]	-0,04	0,00	0,10
ΔU_A	Connection of the substructure of the circumferential wall	[W/(m.K)]	-0,04	0,00	0,10
ΔU_B	Connection of the external wall to the roof construction	[W/(m.K)]	-0,04	0,00	0,10
ΔU_C	Connection opening structures to a perimeter wall	[W/(m.K)]	-0,04	0,00	0,10
ΔU_D	The walls in the corner	[W/(m.K)]	-0,04	0,00	0,10

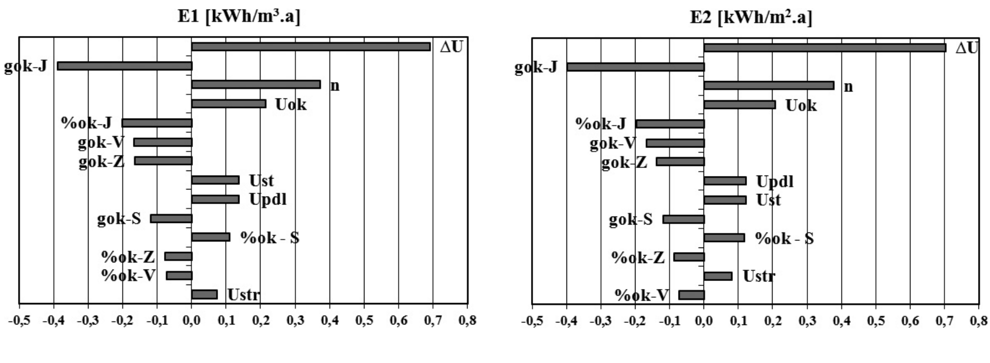

Fig. 6. The correlation coefficient of sensitivity of input parameters on the need for heating, left – E1[kWh/m^3.a], right – E2 [kWh/m^2.a], effect of termal bridge, offset by flat [6]

Rys. 6. Współczynnik korelacji czułości parametrów zapotrzebowania na energię cieplną, z lewej – E1[kWh/m3.a], z prawej – E2 [kWh/m2.a], skutek mostka cieplnego, wyrównanie [6]

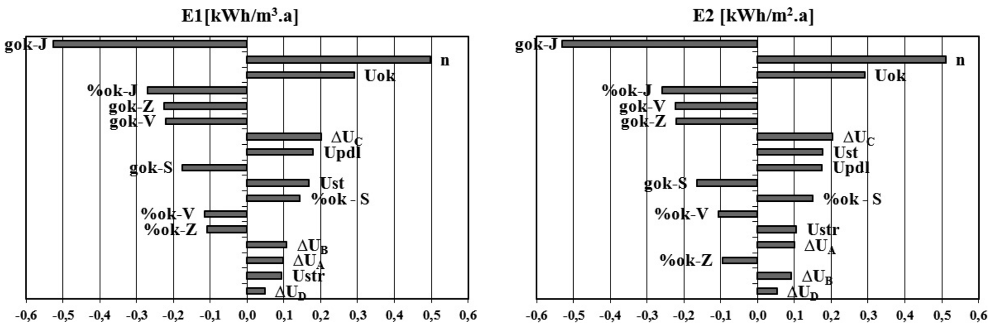

Fig. 7. The correlation coefficient of sensitivity of input parameters on the need for heating, left - E1[kWh/m^3.a], right – E2 [kWh/m^2.a], Effect of thermal bridges counted exactly

Rys. 7. Współczynnik korelacji czułości parametrów zapotrzebowania na energię cieplną, z lewej – E1[kWh/m3.a], z prawej – E2 [kWh/m2.a], dokładnie obliczony skutek mostków cieplnych

Sulfur dioxide has the most significant effect, therefore is expressed as equivalent amount. The total amount of SO_2 emissions related to building materials and constructions represents value of 65,52 kg per year. The value of SO_2 emissions related to m^2 area of the building represents value of 1,18 kg/m^2 per year.

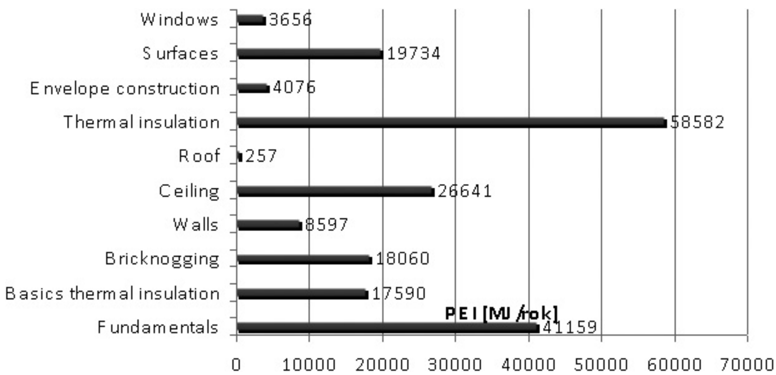

Fig. 8. PEI

Rys. 8. PEI

4. Conclusions

In order to identify savings in energy and emissions from any type of bioenergy production and use, a thorough evaluation from "cradle to grave,, must be carefully carried out [3] but our LCA analyse has been computed from „cradle to gate" (Cradle-to-gate is an assessment of a partial product life cycle from resource extraction (cradle) to the factory gate (i.e., before it is transported to the consumer). The use phase and disposal phase of the product are omitted in this case. The objective of this article was presents concept of building structure design and environmental assessment for consumer model of research in order to force the integration of renewable energy sources. LCA allowed identifying the main impacts of building materials. The study showed the concept of building structure design and environmental assessment for consumer model of research. The aim of this paper was also shown the amount of CO_2 and SO_2 emissions and the primary energy intensity of consumer model. This consumption model is designed as a low-energy with gross insulated of envelope, the ground floor and roof constructions. Therefore, CO_2 emissions, SO_2 emissions and primary energy from thermal insulation of these constructions were accounted for the largest portion of the total amount of emissions and primary energy intensity.

Energy efficiency is a basic principle of the Passive House concept, but despite its importance, efficiency of household appliances is designated as an optional Passive House solution. Therefore, the consumer model will be confronted with measurement in situ.

Based on the results of measurements and after fine-tuning simulations of the experimental building will be to obtain relevant results applicable in practice for the design of passive buildings, in compliance with basic hygienic requirements in terms of structures, internal environment and in terms of design and use of heating or ventilation systems.

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