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ENVIRONMENTAL ASSESSMENT AND MATERIAL SOLUTIONS OF A RESIDENTIAL MODEL DESIGN CONCEPT FOR RESEARCH PURPOSES

Energy effective houses increase efficiency and they are designed to decrease Negative effect on human healthy and environment during their life-cycle by means of better location, design, constructions, operation, maintenance and reconstruction performance is their main contribution which means lower energy consumption and lower operating costs. These buildings have certain thermal-technical specifications. Which consumer model will be solved by design .

Key words: architectural design, energy consumption, energy efficient buildings.

Енергоефективні будинки підвищують ефективність і вони призначені для зниження негативного впливу на здоров'я людини навколишнього середовища за допомогою кращого розміщення, проектування, спорудження, експлуатації, технічного обслуговування та реконструкції. Ефективність є основним чинником, який приводить до зниження споживання енергії і експлуатаційних витрат. Ці будівлі мають певні теплотехнічні характеристики.

Ключові слова: архітектурне проектування, енергоспоживання, енергоефективні будівлі.

Introduction

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 exterior temperatures. Parameters of peripheral structures correspond to the parameters of passive house. [10]

Description of the experimental building

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 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, Fig. 2). [6,7,8]

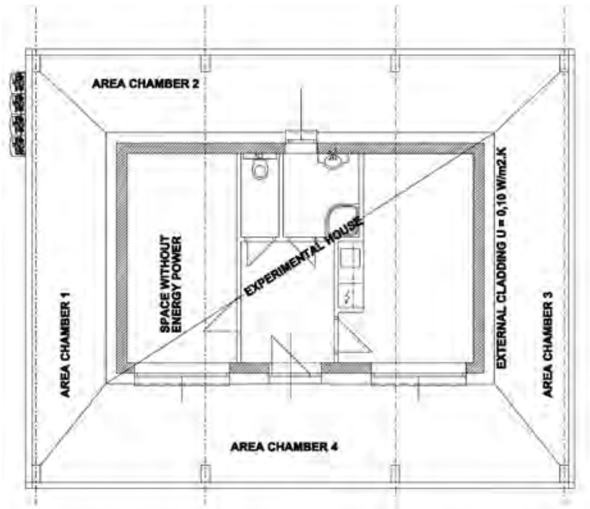

Fig. 1. Ground plan of the experimental building

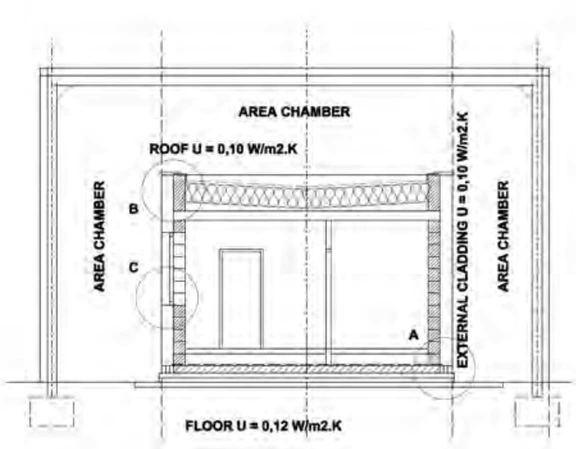

Fig. 2. Cross section of the experimental building

The consumer model

A consumer model is an experimental building that is part of the research and environmental development to ensure the sustainable interoperability and integration of research into space of efficient use of more valid systems based on renewable energy sources.

The consumer model is an experimental building that is a part of our faculty research and will be built in the laboratory hall of the faculty. The whole building will be placed in climate chambers, where will be simulated exterior temperatures. Parameters of peripheral structures correspond to the parameters of passive house.

The consumer model is designed as a Passive House with the specific heat energy demand for heating that is less than 15 kWh/m^2a. The specific total final demand of the consumer model is 40-60 kWh/m^2a. The total amount of primary energy of the consumer model is 100-120 kWh/m^2a. In the consumer model is comfortable ventilation system with the heat recuperations. The heat transmittance coefficient: envelope structures: U<0.10 – 0.13 W/m^2.K; roof structures: U<0.10 W/m^2.K; floor on the ground: U<0.10 – 0.15 W/m^2.K; windows: U<0.8 W/m^2.K. Built-up area is 55,2 m^2. The variants of heating and ventilation were designed on the basis of calculated balances for the needs of heat, hot water demand and the need for ventilation of the building. 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 consumer model 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. The consumer model 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 experimental building is shown by the following figures.

The assessment of the environmental performances of building materials and products is a complex issue which requires the use of a set of comprehensive criteria [3]. Energy and environmental impact are two major concerns of today's new building design and construction [4].

The aim of this paper is to present a concept of the building structure design and environmental assessment for the consumer model of research in order to force the integration of renewable energy sources. The paper presents an initial integration of the energy and environmental performance of the consumer model that will be confronted with measurement in situ. [5]

The paper presents systems that ensure the internal environment in rooms with the help of air conditioning and heating systems using renewable energy sources. The consumer model is a single-story building with one bedroom, one living room with kitchen and one baths and toilet. The view of the consumer model is shown in the figure (Fig. 2).

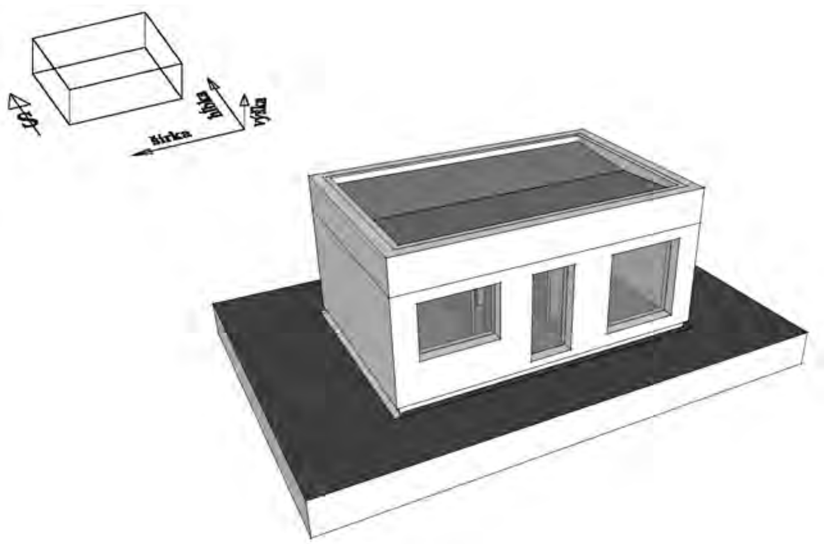

Fig. 3. View of the consumer model

Assessment of building in terms of energy need for heating

The annual energy consumption affects the amount of input parameters. When considering quantitative thermal variables of transparent and opaque building envelope design and the resulting average heat transfer coefficient U_{em} (primary variable describing the quality of the building envelope in terms of heat loss) must satisfy the conditions of the building annual energy consumption in buildings [1].

Boundary conditions for the calculation:

Outside air temperature calculated in the winter to shall designate the location of the building, depending on the geographic location according to maps of temperature fields and, depending on altitude **Košice 297 m above sea level (**2. temperature region**), θe = – 13 °C.** Calculated relative humidity of ambient air is determined by the ambient temperature as calculated: **φe = 84%**. Calculation of the internal air temperature for the residential part of the building: **θi = 20 °C**. Relative humidity of indoor air: **φi = 50%**. Surcharge for heating temperatures dipped to decrease indoor air: **to 5 K.** [1]

The heat for heating the house demonstration

Select structural system we determine the future value of the quantity of input parameters of the building envelope structures that affect heat energy demand. The design is important to know which of the input parameters are influencing the need for heat to heat up and then pay more attention to these parameters. The impact sensitivity of input parameters to the need for heat energy can be expressed by the correlation coefficient, which we determine the order of sensitivity (Fig 4, Fig. 5) In this case, the correlation coefficient determined by the combination of input parameters 20000. [9]

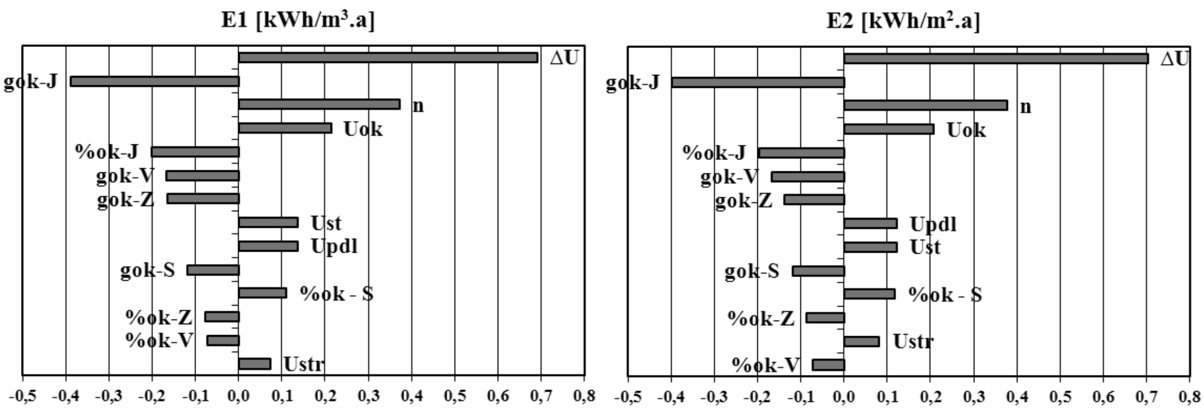

Fig. 4. The correlation coefficient of sensitivity of input parameters on the need for heating, left – E1 [kWh/m³.a], right – E2 [kWh/m².a], Effect of thermal bridges counted exactly.

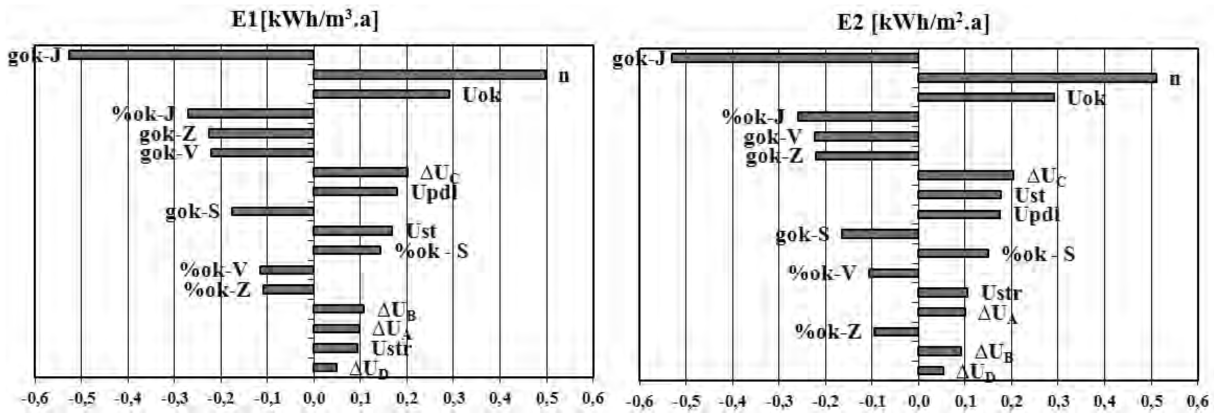

Fig. 5. The correlation coefficient of sensitivity of input parameters on the need for heating, left – E1[kWh/m^3.a], right – E2 [kWh/m^2.a], Effect of thermal bridges counted exactly.

In calculating the energy need for heating the consumer model is considered the input parameters within the ranges as shown in the table (Table 1). Annual energy consumption was calculated by the method of quasi-stationary seasonal STN 73 0540 [1] in MS Excel.

Environmental performance of consumer model

The environmental impact of the consumer modes has been computed using the information database Passivhaus Bauteilkatalog [2].

Building materials, components and structures of three alternatives of the consumer model was evaluated according to amount of embodied energy, amount of CO_2 and SO_2 emissions. The present knowledge allows us to evaluate the part of life cycle, from raw material exploitation to production of architectural elements. [2,3]

The values of primary energy for this part of the life cycle are determined by specialists. The consumer model was assessed from primary energy point of view derived from non-renewable energy. The value of total primary energy embodied in building materials and constructions is 198 352,94 MJ per year in alternative I and 295 164,81 MJ per year in alternative II and 252618,90 MJ per year in alternative III (Fig. 6).

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
ΔUA	Connection of the substructure of the circumferential wall	[W/(m.K)]	-0.04	0.00	0.10
ΔUB	Connection of the external wall to the roof construction	[W/(m.K)]	-0.04	0.00	0.10
ΔUC	Connection opening structures to a perimeter wall	[W/(m.K)]	-0.04	0.00	0.10
ΔUD	The walls in the corner	[W/(m.K)]	-0.04	0.00	0.10

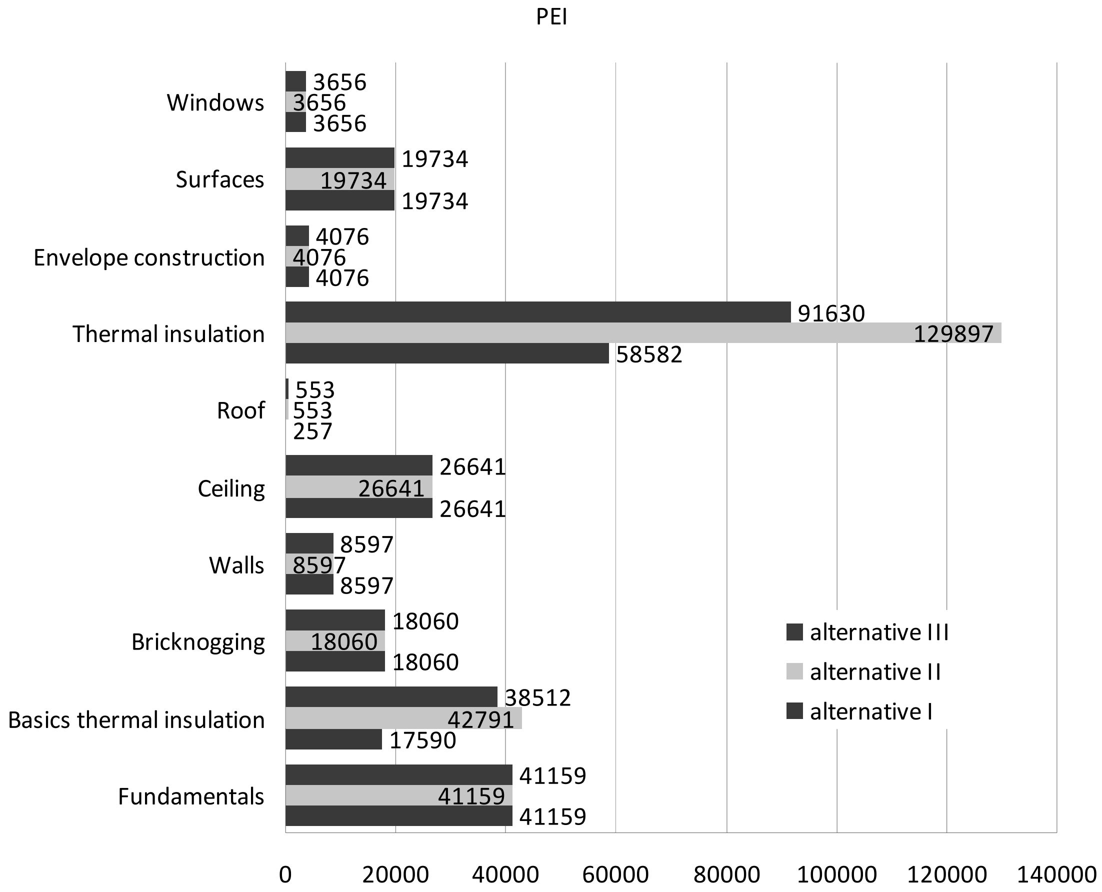

Fig. 6. PEI [MJ]

The global warming potential is expressed as equivalent amount of CO_2, which significantly contributes to the greenhouse effect. The following figure (Fig. 7) shows the amount of CO_2 emissions related to building materials and structures used in the evaluated office. The value 17 970.20 kg per year in alternative I , 97522.4 kg per year in alternative II and 95997,65 kg per year in alternative III represents the total CO_2 emissions. The total area of building is 55.2 m^2. The value of CO_2 emissions related to m^2 area of the building is 325.54 kg/m^2 per year in alternative I, 1766.7 kg/m^2 per year in alternative II and 1745,41 kg/m^2 per year in alternative III.

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The acidification of environment causes sulfur dioxide, nitrogen oxides, ammonia and others. 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 structures is 65,52 kg per year for alternative I, 217,09 kg per year for alternative II and 207,68 kg per year for alternative III. In the figure is shown the comparison of these alternatives (Fig. 8). The value of SO_2 emissions related to m^2 area of the building is 1,18 kg/m^2 SO_2eq. per year for alternative I with mineral insulation and 3,93 kg/m^2 SO_2eq. per year for alternative II with polystyrene insulation and the value of SO_2 emissions related to m^2 area of the building is 3,76 kg/m^2 SO_2eq. per year for alternative III with sheep pool.

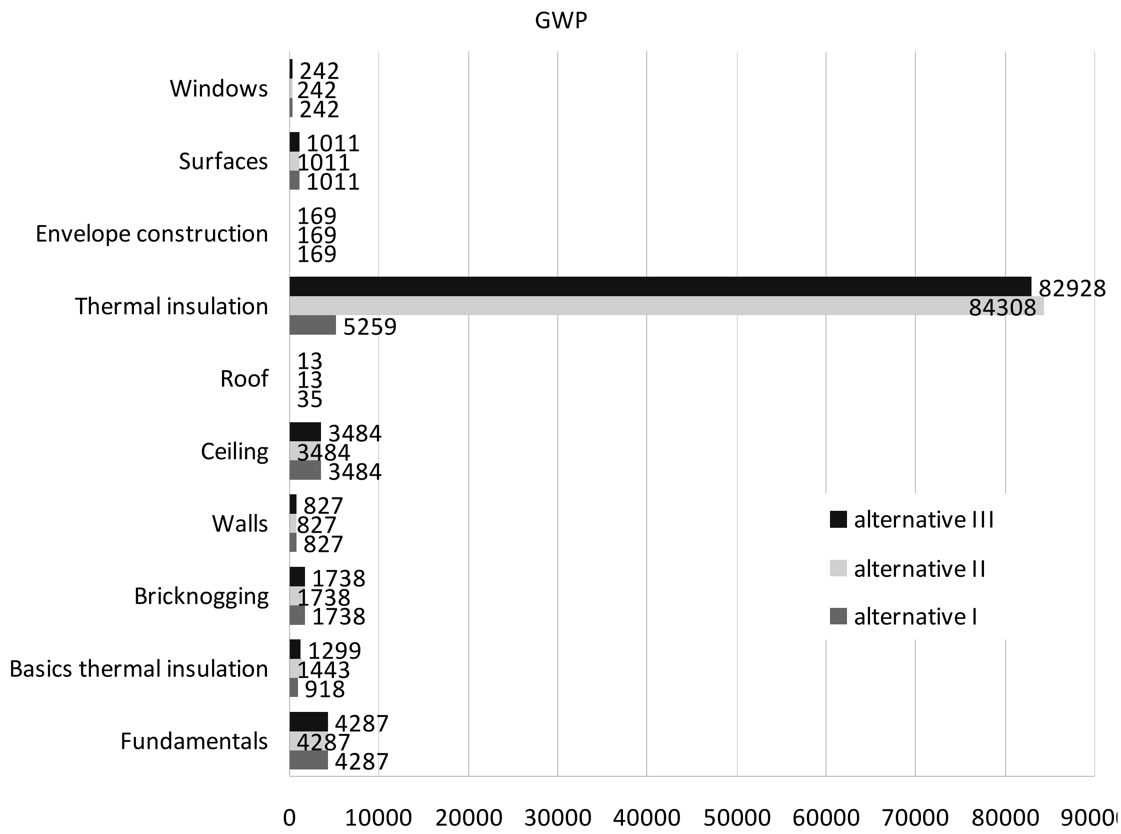

Fig..7. GWP [kgCO_2eq.]

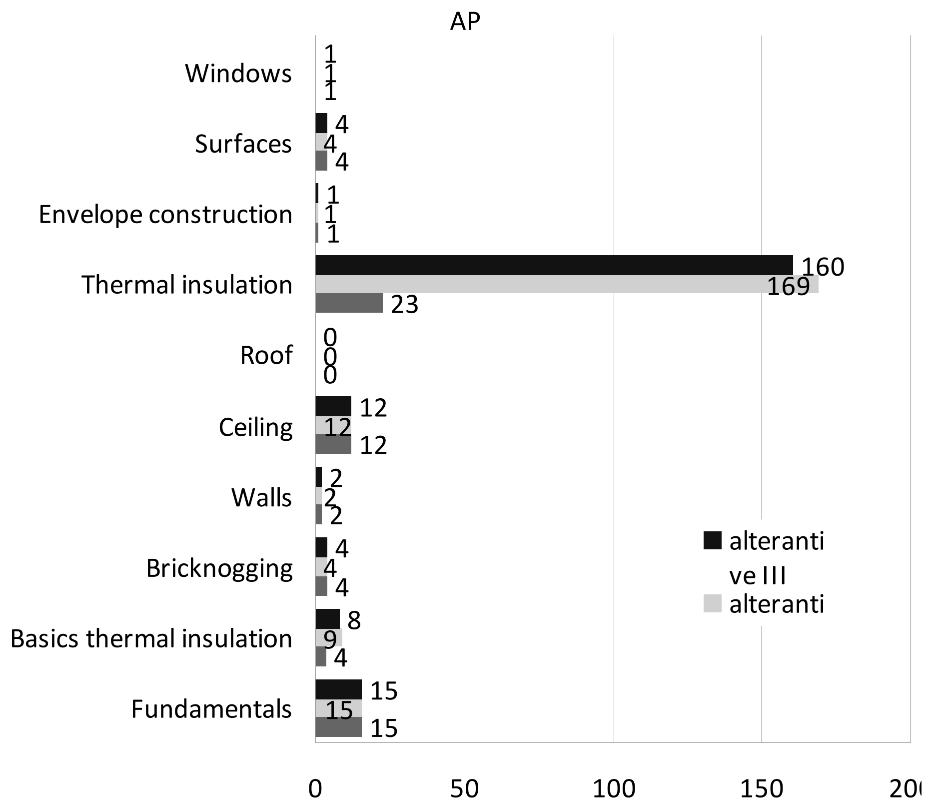

Fig. 8. AP [kgSO_2eq.]

The annual energy consumption affects the amount of input parameters. When considering quantitative thermal variables of transparent and opaque building envelope design and the resulting average heat transfer coefficient U_{em} (primary variable describing the quality of the building envelope in terms of heat loss) must satisfy the conditions of the building annual energy consumption in buildings [3].

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 [4]. 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.

Conclusion

The objective of this article was to present the concept of building structure design and environmental assessment for the consumer model of research in order to force the integration of renewable energy sources. The aim of this paper was the comparison of three alternatives of thermal insulation. Alterative I is more environmental acceptable instead of alternatives II and III.

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