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Proceeding Paper

Reducing Greenhouse Gas Emission through Energy-Saving Technologies for Heating Modular Buildings †

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Abstract: Providing housing with the possibility of rapid construction, with life support systems of the house that allow for the maintenance of comfortable living conditions for those who choose to live there.

Keywords: modular buildings; greenhouse gas emissions; module–cottage; energy consumption

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1. Introduction

The scope of the proposed design-construction is the means of providing housing with the possibility of rapid placement of the building on the territory, with life support systems of the house that allow for the maintenance of comfortable living conditions.

Modular buildings are structures that are erected in a short time with the help of ready-made modules that are installed on site without the use of large equipment. Characterized by simplicity and speed of installation [1,2], these structures are not inferior to traditional brick or concrete buildings in strength and durability. Due to the peculiarities of technology and the use of insulating materials, such structures are lightweight, allowing for their installation on almost any basis; they do not require a strong foundation. This type of building can be both temporary and permanent. Suburban buildings are becoming an ideal place for private recreation, hostels, military bases, and medical and observation complexes. One of the main advantages of modular buildings is that they take a short amount of time to construct; the necessary modules are manufactured in factories and assembled directly on site. Houses created using modular technology have the best characteristics of thermal protection [3]. The use of modern materials in the construction of modular buildings in the future will reduce the cost of insulation, while maintaining thermal comfort [4].

2. Materials and Methods

In order to reduce operating costs [5,6] and increase the comfort of the room [7], sandwich panels are used, in which a layer of insulation is attached to the load-bearing part of the structure by adhesive and mechanical means [3]. The wall sandwich panel is a three-layer construction which is made of two metal sheets and a heat-insulating filler.

Advantages of sandwich panels include environmental friendliness, hygiene, safety, ease of transportation, high heat and sound insulation, and quick installation and/or repair of buildings. Construction is also carried out at any time of the year to reduce the load on the metal structure and foundation.

The dimensions of the module-cottage are: length-7.5 m; width-5 m and consists of three rooms with an area of 12.5 m^2 each (Figure 1). The height of the module is

3 m. The module is also equipped with a technological unit with an area of 5 m^2, which houses equipment for heating, hot water supply and a ventilation system. It also includes energy-saving double-glazed windows, with an area of 1.5 m^2 (WxH = 1 × 1.5 m).

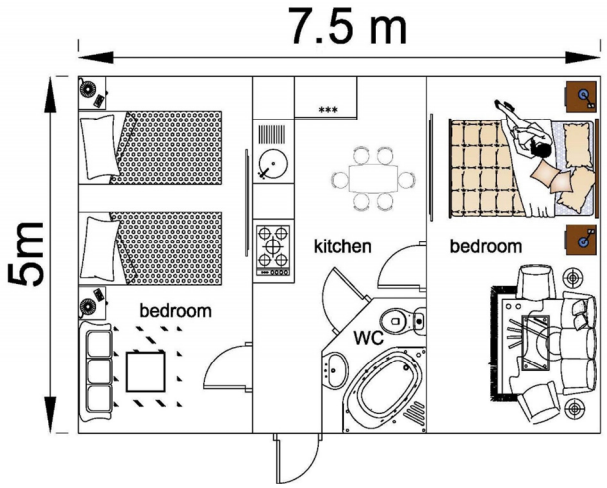

Figure 1. Construction of a modular residential building.

External protections are made of sandwich panels filled with polyurethane foam 200 mm thick [3]. The characteristics of the material are shown in Table 1.

Table 1. The parameters of used insulation material.

Thickness, mm	Weight, kg/m^2	Thermal Conductivity Resistance R (m2K/W)	Fire Resistance	λ, W/mK
200	16.9	8.51	EI-15	0.022

3. Computations and Results

This design is tested for condensation in the protection layer. Based on the obtained graphs (Figure 2), the possibility of condensation of water vapor in the protection layer of the house is excluded. For the proposed construction of the building and taking into account its overall dimensions, the thermal characteristics will be equal to Table 2. Further calculations were performed for the city of Lviv in the RETScreen Expert software package. For this region, climatological data are shown in Table 3.

The analysis of energy consumption of the offered house for two variants is carried out. In the first option (base case) heat supply of a residential building was carried out only with the help of a gas boiler. In the second option (proposed case) energy saving systems were used: solar air heating [6,7], recuperator [8,9], solar water heater and photovoltaic panels [10].

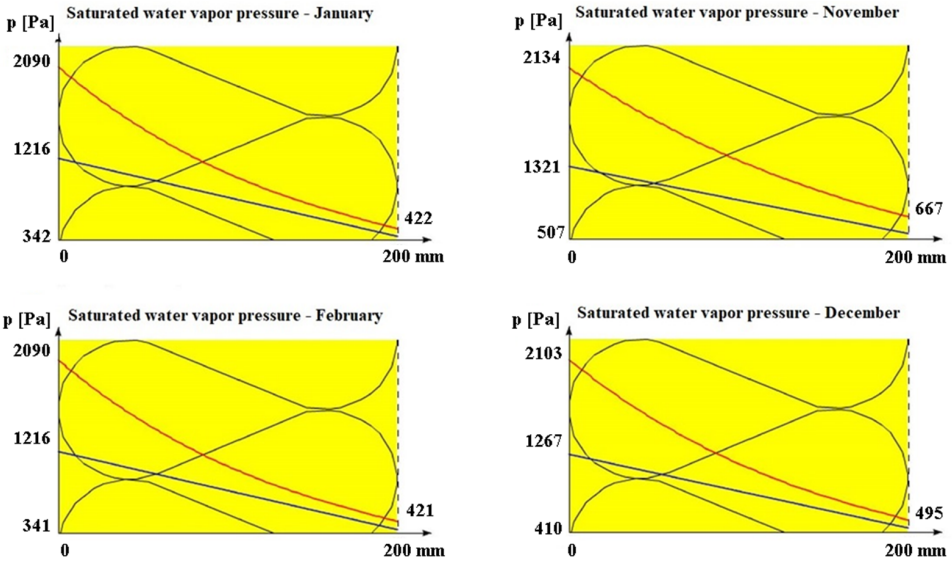

Figure 2. Monthly chart of saturated water vapor for the winter period of the year.

Table 2. The thermal characteristics the proposed construction of the building.

Estimated heat consumption—house	79.88 kWh/m^2
Maximum allowable heat consumption—Emax	242.46 kWh/m^2
Compliance with norms	Yes

Table 3. Climatological data used in computations, region of Lviv.

	Units	**Location**
Latitude		49.8
Longitude		24.0
Heaven		Cool–wet
Altitude	m	323
Estimated heating temperature	°C	−19.0

The results of the analysis and comparison of the two options are presented in Figures 3 and 4. As a result of the proposed technical solutions, a reduction in greenhouse gas emissions will be achieved. The results of the analysis are presented in Figure 5.

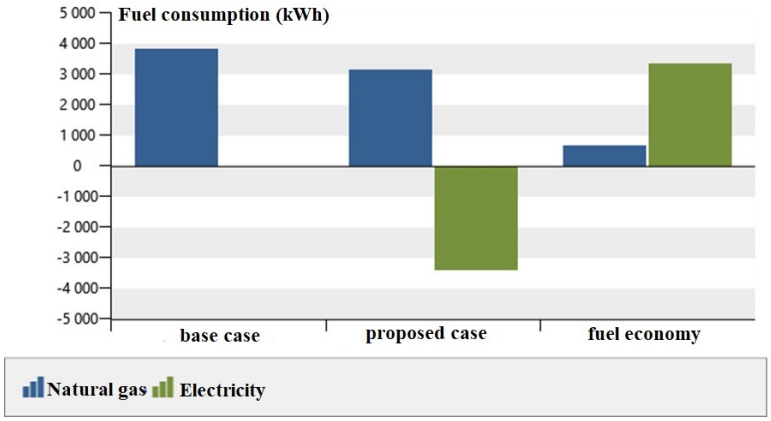

Figure 3. Fuel consumption for two comparison options: base case and proposed case.

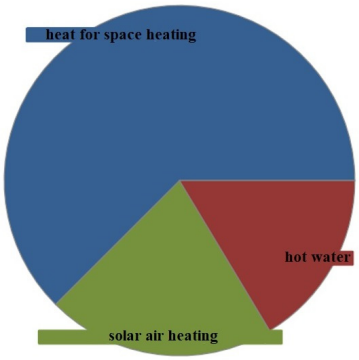

Figure 4. Energy consumption of a residential building for the proposed option.

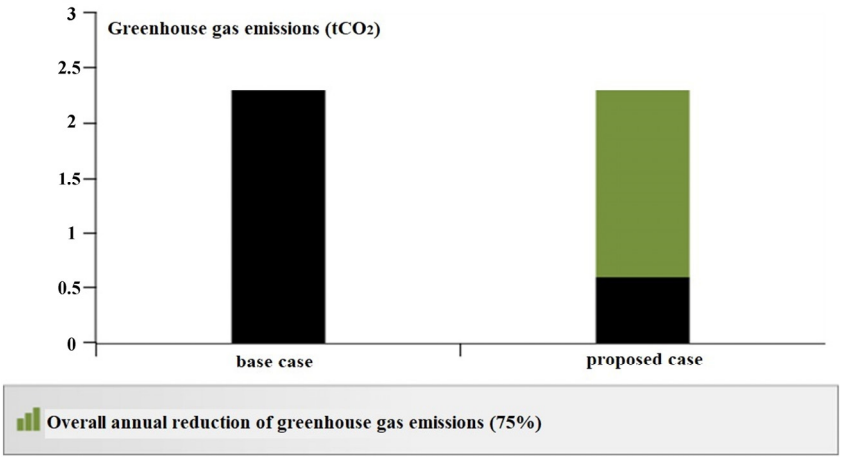

Figure 5. Comparison of greenhouse gas emissions for the baseline and the proposed option of heating a residential building.

4. Conclusions

- The possibility of using modular buildings for residential and public needs is considered. Due to the peculiarities of technology and the use of thermal insulation materials, such structures are erected in a short time with the help of ready-made modules, which are characterized by simplicity and speed of installation.
- Condensation of water vapor in the protection layer of the house was checked.
- The comparative analysis of energy consumption for two variants of heat supply of the modular house is carried out.
- The total annual reduction of greenhouse gas emissions is obtained, taking into account the proposed method of heat supply of the building.

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