FINAL ENERGY CONSUMPTION FOR HEATING A PASSIVE HOUSE (CASE OF KRAGUJEVAC)

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1. Introduction

The basic idea of a passive house is the heat recovery of a ventilation air. The supply air entering the conditioned area is heated by the exhaust air living the same, in order to minimize the required amount of energy for heating the object.

According to the Passivhaus Institut, it has to meet the following criteria:

- final energy consumption for heating during the heating season does not exceed 15 kWh/m^2 of net residential space;
- the total energy consumption must not exceed 120 kWh per square meter per year;
- a maximum of 0.6 air changes per hour at 50 Pa pressure, as verified with a blower door test;
- not more than 10% of the hours in a given year over 25˚C.

To achieve Passive House criteria, building designers must consider as mandatory the following principles: thermal bridge free design, superior windows, ventilation with heat recovery, quality insulation and airtight construction.

2. Description of the analyzed building

The passive house (Fig. 2.1) has two floors (ground floor and first floor). On each floor there is one apartment with identical arrangement of rooms (Fig. 2.2). The entrance doors are oriented towards the west. Each apartment accomodates a four-member family. Total useful (net) area of the passive house is 198.39 m^2 (99.195 m^2 per apartment).

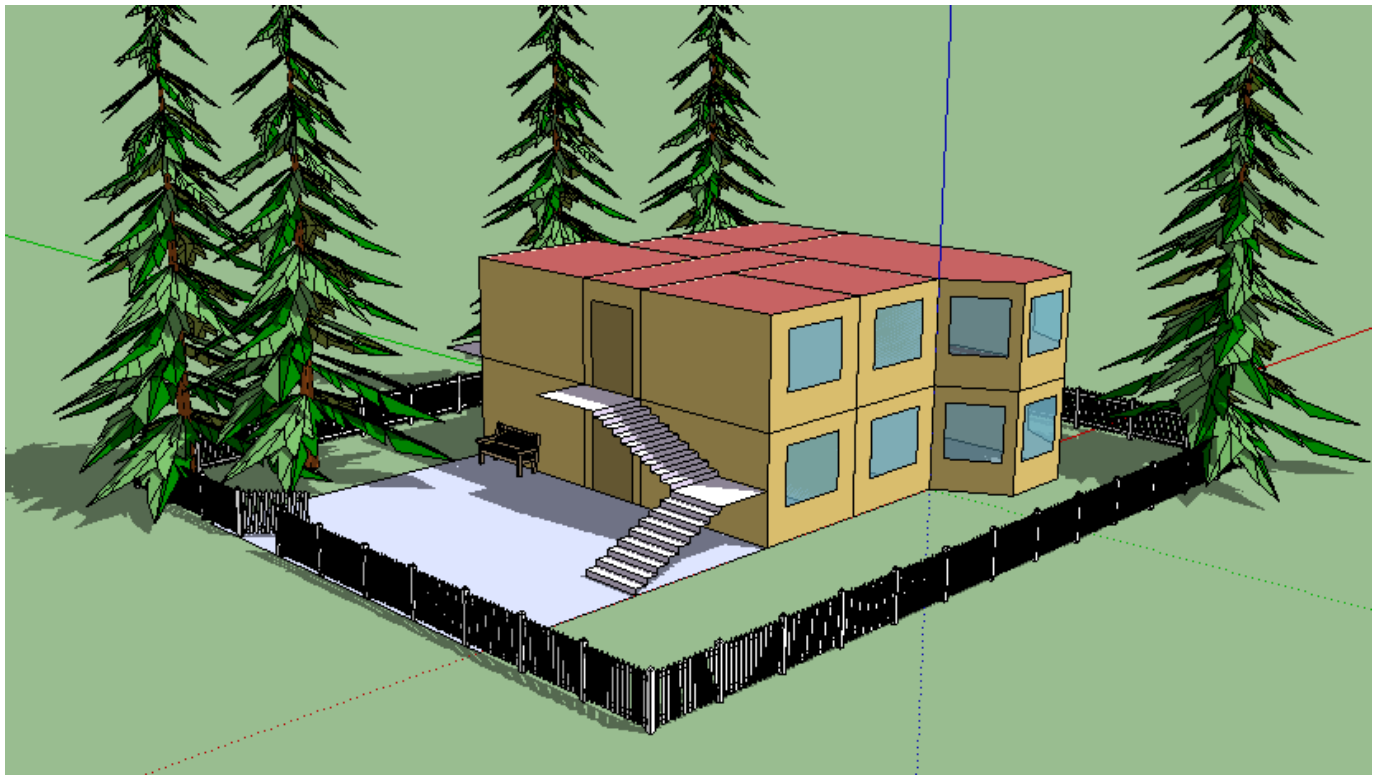

Fig. 2.1 – Analyzed building

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Table 2.1 – Thermal characteristics of the building constructions

Construction	U [W/m^{2}K]
Ground floor	0.203
Interior ceiling	0.226
Roof	0.312
Exterior wall	0.172
Exterior door	4
Window	1.574

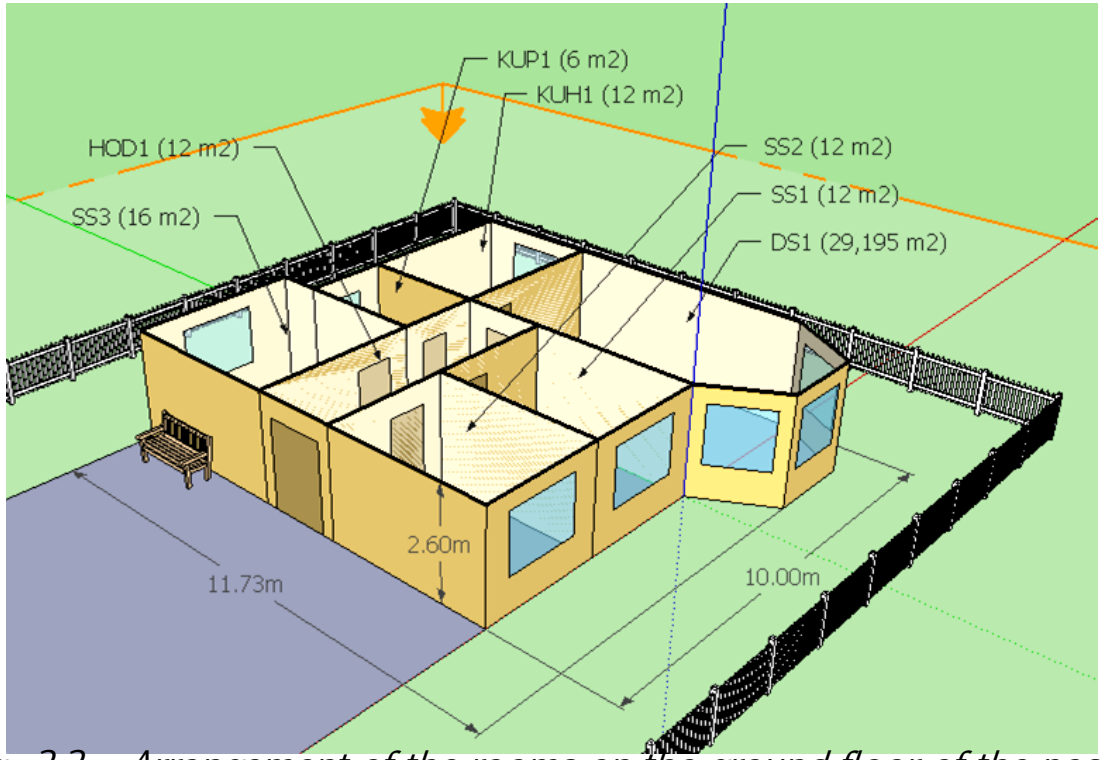

Fig. 2.2 – Arrangement of the rooms on the ground floor of the passive house

3. Description of the heating system

3.1 Energy Recovery Ventilator

In order to control the quality of air in the building, each room is equipped with an ERV. The basic elements of ERV are:

- supply air fan (fan 1, Fig. 3.1);
- exhaust air fan (fan 2, Fig. 3.1);
- air to air plate heat exchanger;
- controller.

$$\dot{Q}_{sens} = \dot{m}_1 \cdot (h_{1b} - h_{2a})_{sens} \quad (3.1)$$

$$\dot{Q}_{tot} = \dot{m}_1 \cdot (h_{1b} - h_{2a}) \quad (3.2)$$

$$\dot{Q}_{lat} = \dot{Q}_{tot} - \dot{Q}_{sens} \quad (3.3)$$

$$\dot{Q}_{systot} = \dot{Q}_{tot} \cdot TimeStepSys \cdot 3600 \quad (3.4)$$

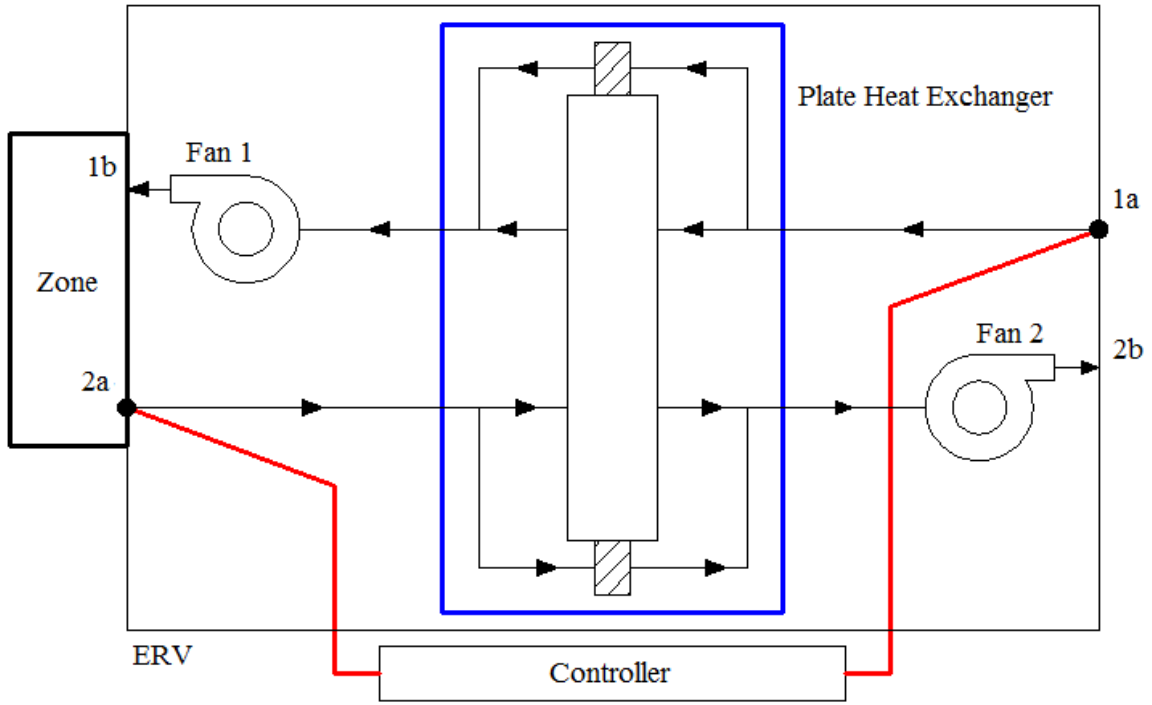

Fig. 3.1 – Schematic of the ERV

3. Description of the heating system

3.2 Geothermal heat pump

Table 3.1– Technical characteristics of the heat pump (REHAU GEO 7)

Parameter	Unit	Value
Rated heating capacity	[W]	7300
COP	[-]	4.1
Rated heating power consumption	[W]	1600
Minimum water flow rate (heating)	[l/h]	1100
Minimum brine flow rate	[kg/h]	1300
Number of bore holes	[-]	2
Bore hole lenght	[m]	73.2

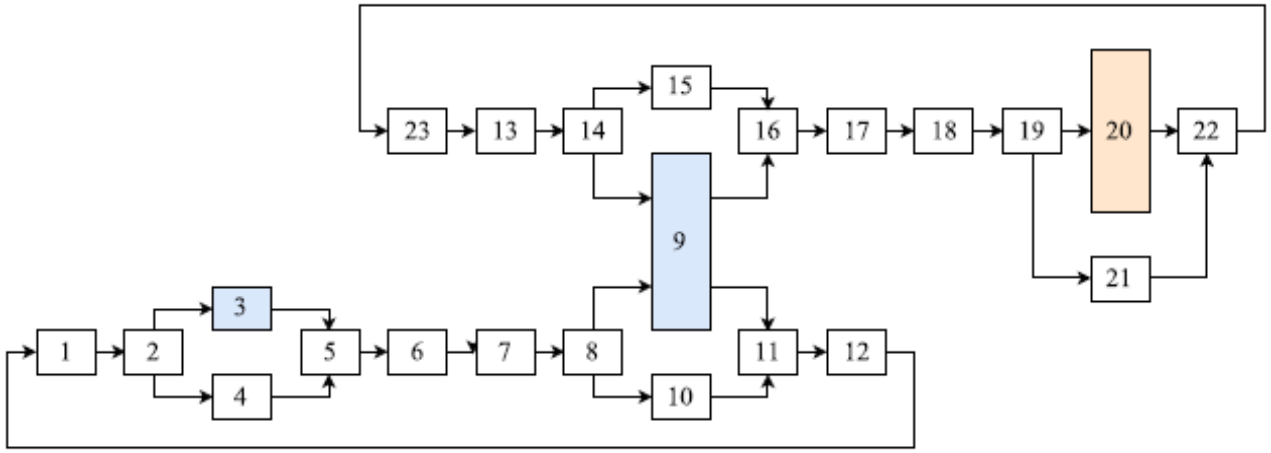

Fig. 3.2 - Analyzed heating system:
1, 13 – circulation pump; 2, 8, 14, 19 – splitter;
3 – ground heat exchanger; 4, 10, 15, 21 – bypass branch;
5, 11, 16, 22 – mixer; 6, 12, 17, 23 – outlet pipe; 7, 18 – inlet pipe;
9 – heat pump; 20 – conditioned zones

4. Results

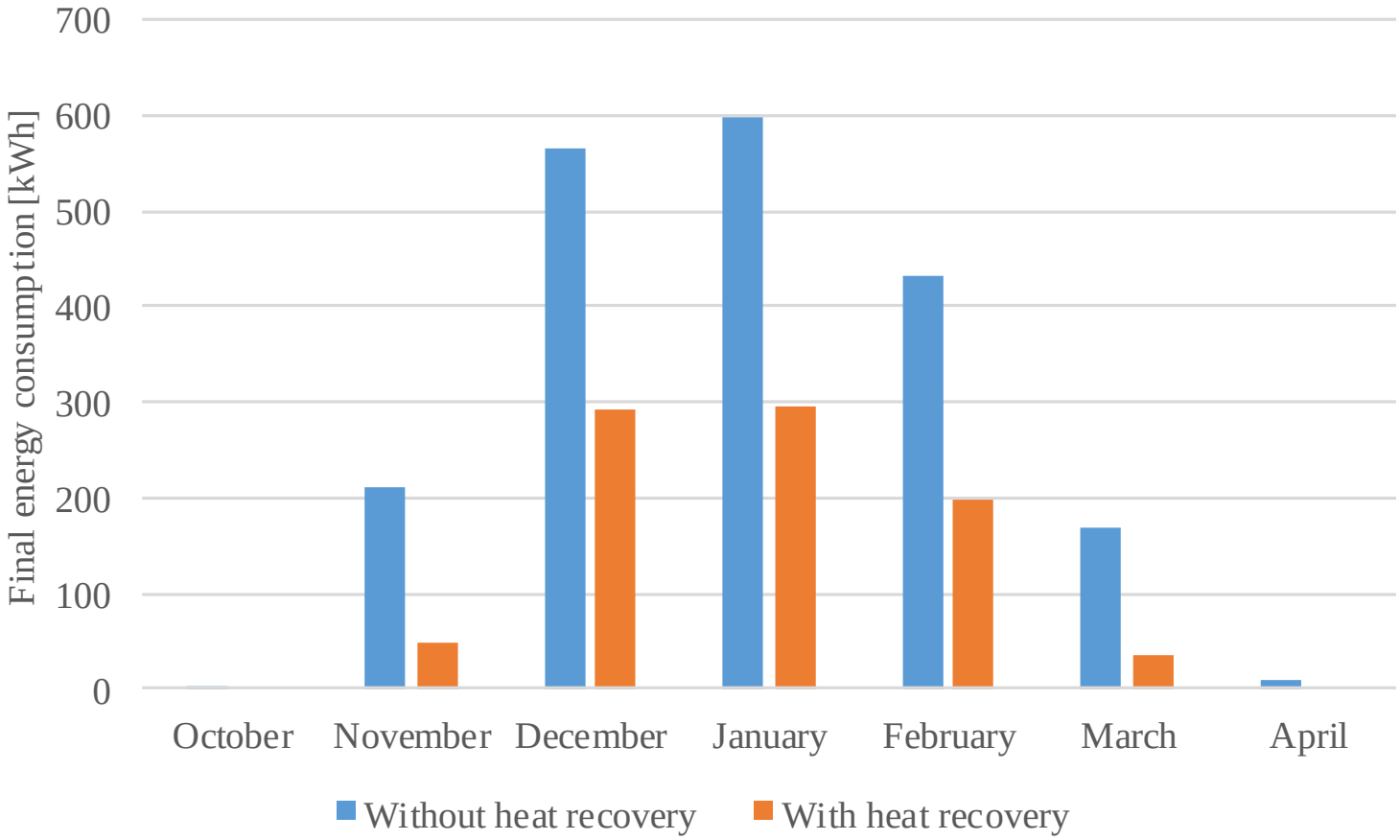

Fig. 4.1 – Final energy consumption for heating the passive house

4. Results

The average energy savings for entire heating season amounts 56.41%.

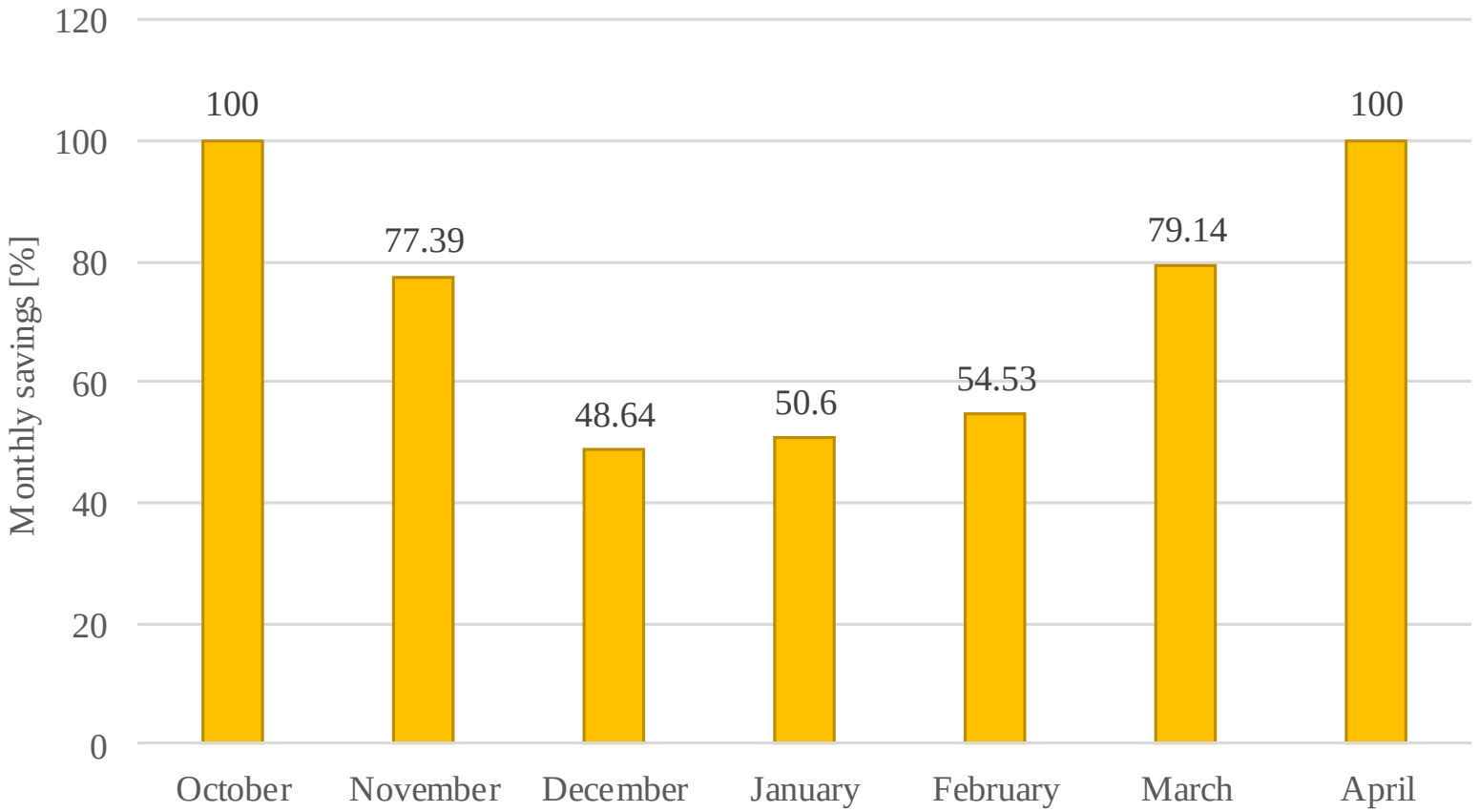

Fig. 4.2 – Monthly percentage savings for heating the passive house

5. Conclusions

In order to meet passive house criteria, building designers must consider the following: thermal bridge free design, superior windows, ventilation with heat recovery, quality insulation and airtight construction.

The simulation results show that a passive house consumes 1987.6 kWh (10.01 kWh/m^2 of the heated area) during the heating season if there is no heat recovery. On the other side, when the ERV operates, the final energy consumption during the heating season is 866.38 kWh (4.37 kWh/m^2 of the heated area).

The lowest energy savings are achieved in December (48.64%). The average energy savings for entire heating season amounts 56.41%.