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ENERGY RENOVATION OF AN OLDER HOUSE

ENERGETSKA PRENOVA STAREJŠE HIŠE

Zdravko Praunseis[ℜ], Jurij Avsec, Simon Marčič, Renato Strojko

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Abstract

This paper presents an energy renovation of an older house, according to state regulations for efficient energy use. There are many ways to design successful energy efficient homes, because they can be built from many different types of material. Becoming a successful builder of energy-efficient homes does not merely require proficient knowledge of theory in new building techniques, but also skills in implementing innovative designs and high-quality construction practises. The energy performance of the building is evaluated and then an energy performance certificate is granted; these certificates are obligatory for all public buildings and also for all buildings that are rented or sold.

Povzetek

Članek predstavlja energetsko sanacijo starejših hiš glede na veljavni državni Pravilnik o učinkoviti rabi energije. Obstaja mnogo različnih možnosti kako uspešno izvesti in doseči energetsko učinkovitost zgradb glede na uporabo različnih konstrukcijskih materialov. Uspešen projektant energetsko varčnih hiš mora poleg sodobne gradnje stavb poznati tudi možnosti praktične uporabe inovativnih konstrukcijskih idej in obstoječih praks v svetu. Prikazani so energetski kazalci, ki jih podaja Energetska izkaznica in številčno ovrednotijo stavbo glede na

[ℜ] Corresponding author: Zdravko Praunseis, PhD, Faculty of Energy Techology, University of Maribor, Tel.:+386 31 743 753, Fax: +386 7 620 2222, Mailing address : Hočevarjev trg 1, 8270 Krško, Slovenia

E-mail address: zdravko.praunseis@uni-mb-si

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porabo energije. Energetska izkaznica je po novi zakonodaji obvezna za vse javne objekte in tudi za vse objekte, ki so predmet nepremičninskih poslov.

1 INTRODUCTION

In the Republic of Slovenia, buildings are mostly energy inefficient. For example, almost two-thirds of multi-dwelling buildings are energy inefficient with regard to the thickness of the insulation of the external walls. Moreover, only 16% of all windows have energy efficient glass. Energy efficient renovation is defined as that which accomplishes at least a 30% reduction of energy use and, of course, fulfils all requirements set by law. Such goals can be reached by carefully planning a renovation; specifically, the following steps should be followed, Praunseis, [1]:

- Constructing a so-called building envelope with additional heat insulation made without heat-bridges and (as much as possible) airless,
- Installing new efficiency equipment for heating and air-conditioning with recuperative functions and low electricity consumption,
- Installing low-emissivity window glazing to control solar heat gain and loss in hot climates,
- Making use of solar energy for hot water preparation can reduce energy consumption by at least 50%,
- Installing a photovoltaic system (PV system) for generating electric power influences the energy balance of the building,
- Selecting appropriate energy carriers, i.e. choosing renewable energy and systems where possible,
- Building a passive cooling system.

With the practical case of the Jozlinova house, some renovation possibilities shall be demonstrated with the main goal of making an energy efficient house. Materials and construction types for the walls, ensuring the presence of excellent heat envelope of the building as well as some renewable sources of energy, shall be presented.

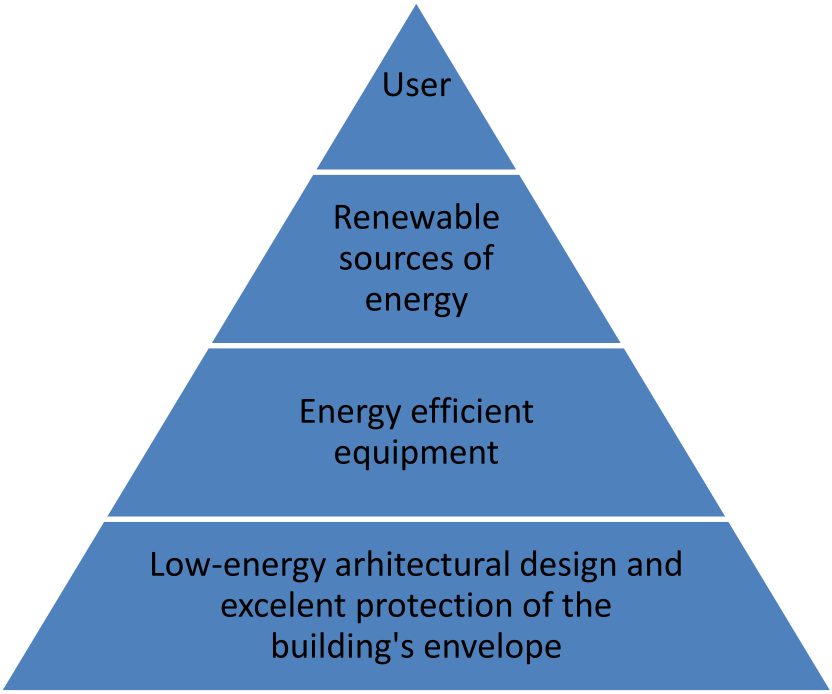

Figure 1: *Dominant factors for energy efficiency building*

2 ENERGY EFFICIENT BUILDINGS – LAW REQUIREMENTS

As a member of the EU, the Republic of Slovenia has adopted EU Directive EU-EPBD Recast 2010/31/EU (previously, Directive EU-EPBD 2002/91/EU). Both directives are related to the energy efficiency of buildings. Some other EU directives have also been adopted for the purposes of energy reduction, e.g. Directive 2006/32/EC on end-use efficiency and energy services and Directive 2009/28/EC on renewable energy, according to which Slovenia has to achieve a goal of 25% renewable energy sources in end use.

On the basis of the above-mentioned EU directives, Slovenia has adopted new proposals and requirements in its legislation, UL RS, [2,3]; the law covering civil engineering has prescribed new regulations:

- Statute of efficient energy use in buildings (PURES 2010).
- Technical guide TSG-1-004:2010-Efficient energy use.

When preparing project documentation for obtaining building permission, a document of energy performance for the building must be prepared as a standard part of the civil engineering requirements.

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3 RENOVATION

Renovation typically entails two phases: civil works for improving the building envelope and installing new equipment, Praunseis et al., [4].

3.1 Renovation for improving building envelope- civil works

The building envelope is the border between the building and its surroundings; these are primarily the external walls, roof and ground-floor.

External wall – A decision was made that the outside wall be built from modular bricks, which are excellent insulators and a well-known material. Recently developed bricks have thicker walls to provide better thermal insulation; the latest versions use internal fillers instead of air.

Requirements for much lower thermal transmittance for walls can be attained with the use of **insulating material,** such as glass wool (fiberglass), mineral wool (stone wool), EPS (expanded polystyrene); where water is present, XEPS (extruded polystyrene) shall be used. All these insulating materials have low thermal conductivity (λ; W/mK), i.e. they retain heat. All the above-mentioned insulating materials can be used with ease as they are light, inexpensive and easily handled. Recently, cellulose insulation has been used in wooden panel buildings; it is placed in the space between wooden panels with a blower. Cellulose is considered to be an ecologically sound material and has lower temperature conductivity ($a=\lambda/\rho \times c$; m^2/h) than mineral wool. It also has a longer phase delay, which means that more time is needed to warm or cool the place, which is especially useful in summer when the building is being cooled at night.

For insulation against water and moisture (waterproofing), a **hydro-isolation** material shall be used. This **waterproofing membrane** (Fig.2) is made from different types of reinforcement (glass fleece, geotextile) coated on both sides with oxidized bitumen. This shall be built as the first ground-layer insulation on the concrete floor. Special requirements for waterproofing are necessary for basement rooms.

Special attention must be dedicated to the physics of the building and for water and water vapour transfer through different types of walls or other construction elements. For this purpose, **protective membranes** made from extremely thin PVC or PE (Fig.3) are used. They are classified according to their function: to stop water and let vapour pass, or to stop both vapour and water. As a rule, the outer side of the external wall shall be guaranteed waterproof, and there must be a membrane that lets vapour through on the inner side of the external wall.

Figure 2: *Waterproofing membrane*

Figure 3: *PE protective membrane*

Roof – For the roof, a typical style with ventilation (Fig.4) was built with two layers of mineral wool insulation so that all thicknesses of insulation are greater than 20 cm; mineral wool was fixed in rolls between wooden beams (pos. 8); wool was additionally fixed in slabs (pos. 9) to wooden beams. An aluminium vapour-stop membrane was tightly fixed to the isolation from inside (pos.10). Finally, a layer of Knauf gypsum board (pos.11) was added; this material is excellent for cladding walls and ceilings constructed on metal grids and wooden frames: for backing surfaces, partitions and ceilings.

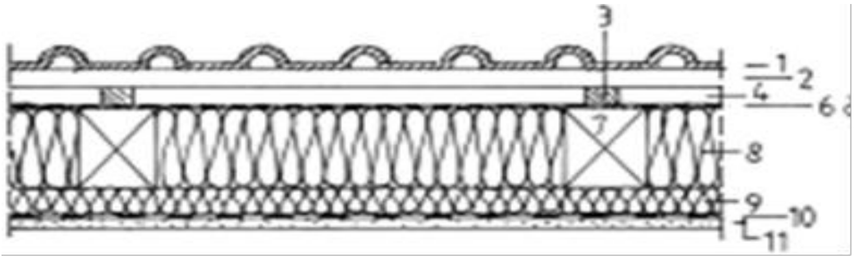

Figure 4: *Roof details*

Basement – Renovation of the basement of an old house requires considerable attention; it cannot be assumed that that earth is a good isolator. The floor in the basement (Fig.5) must be insulated (insulation under concrete baseplate) and simultaneously protected against water (hydro-insulation). On the concrete baseplate, the first layer of insulation of XPES (extruded polystyrene) was fixed (Fig 6.), then a layer of concrete (slab concrete) and finally ceramic tile. The layer of concrete was used for levelling and serves as a solid basis for the final layer.

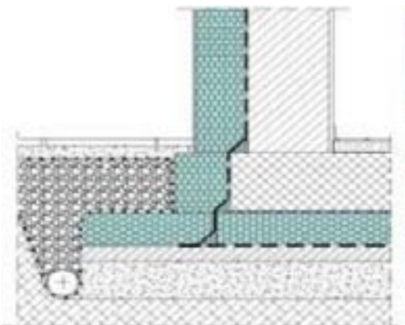

Figure 5: *Basement waterproofing detail*   ***Figure 6:*** *Placing of XEPS isolation*

Doors and windows (building furniture) – Wooden windows of the brand Ekolight were chosen. These windows are double-glazed (U_w= 1.2 W/m²K). Spruce wooden doors of the brand Klasik were also chosen (U_d < 1.6 W/m²K) (Fig.7).

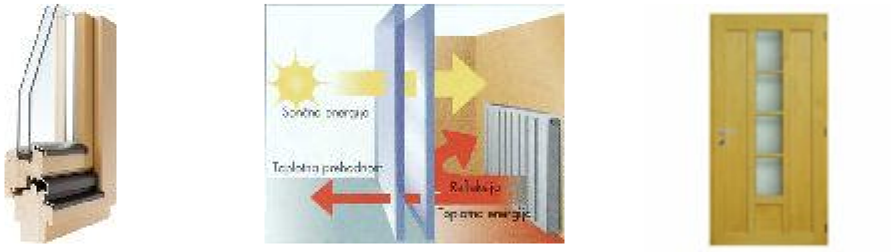

Figure 7: *Windows and doors*

3.2 Placing new equipment based on renewable energy

State regulations prescribe that at least 20% of all needed building energy must be provided by renewable sources of energy.

Renewable sources of energy are:

1. Sunlight (solar thermal collection system for hot water and photovoltaic system, or PV system for converting sunlight into electricity)
2. Wind (bulk movement of air)
3. Hydro-electric (rivers, rain, tides, waves)
4. Biomass biological material)
5. Geothermal (thermal energy generated and stored in the ground)

For our building, the following steps were taken:

- Placing solar thermal collectors (evacuated tube type) (Fig.8) for hot water and supporting heating in winter

Figure 8: *Fixed solar collectors*

Figure 9: *Evacuated tube collectors*

For hot water, evacuated tube collectors (Fig.9) are based on the latest technology and achieve greater efficiency than previous flat-plate collectors, especially in colder conditions. A vacuum between the two glass layers insulates against heat loss.

- Placing an air-source heat pump for heating

Air-source heat pumps (ASHPs) (Fig. 10) are used to provide interior space heating and cooling even in colder climates, and can be used efficiently for water heating in milder climates (Fig. 11). A major advantage of some ASHPs is that the same system may be used for heating in

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winter and cooling in summer, though it is not true air conditioning without a facility to adjust the humidity of the inside air. Though the cost of installation is generally high, it is less than the cost of a ground source heat pump because the latter requires excavation to install its ground loop.

Figure 10: *Air source-heat pump*

Figure 11: *Function of air source heat pump*

- Installing heat recovery ventilation

Heat recovery ventilation (HRV) is an energy recovery ventilation system using equipment known as a heat recovery ventilator, heat exchanger, air exchanger, or air-to-air heat exchanger (Fig. 12), which employs a counter-flow heat exchanger (counter current heat exchange) between the inbound and outbound air flows. HRV provides fresh air and improved climate control, while also saving energy by reducing heating (and cooling) requirements.

Figure 12: *Main unit of heat recovery ventilation*

- Placing underfloor heating

Underfloor heating (Fig.13) was selected due to its low temperature level of heating (35 degrees Celsius) which is very comfortable, heating rooms and their occupants from the bottom-up. The low temperature level of this heating is more economical than other methods requiring middle

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or high temperatures, i.e. the energy needed for heating can be attained with less power. One alternative is a wall heating system (Fig. 14).

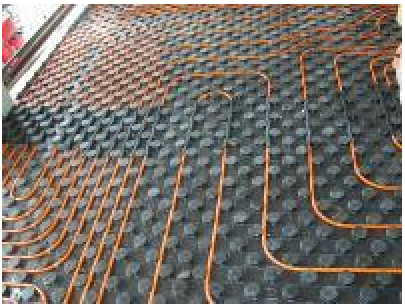


Figure 13: *Underfloor heating system*

Figure 14: *Wall heating system*

4 RESULTS OF THE ENERGY RENOVATION

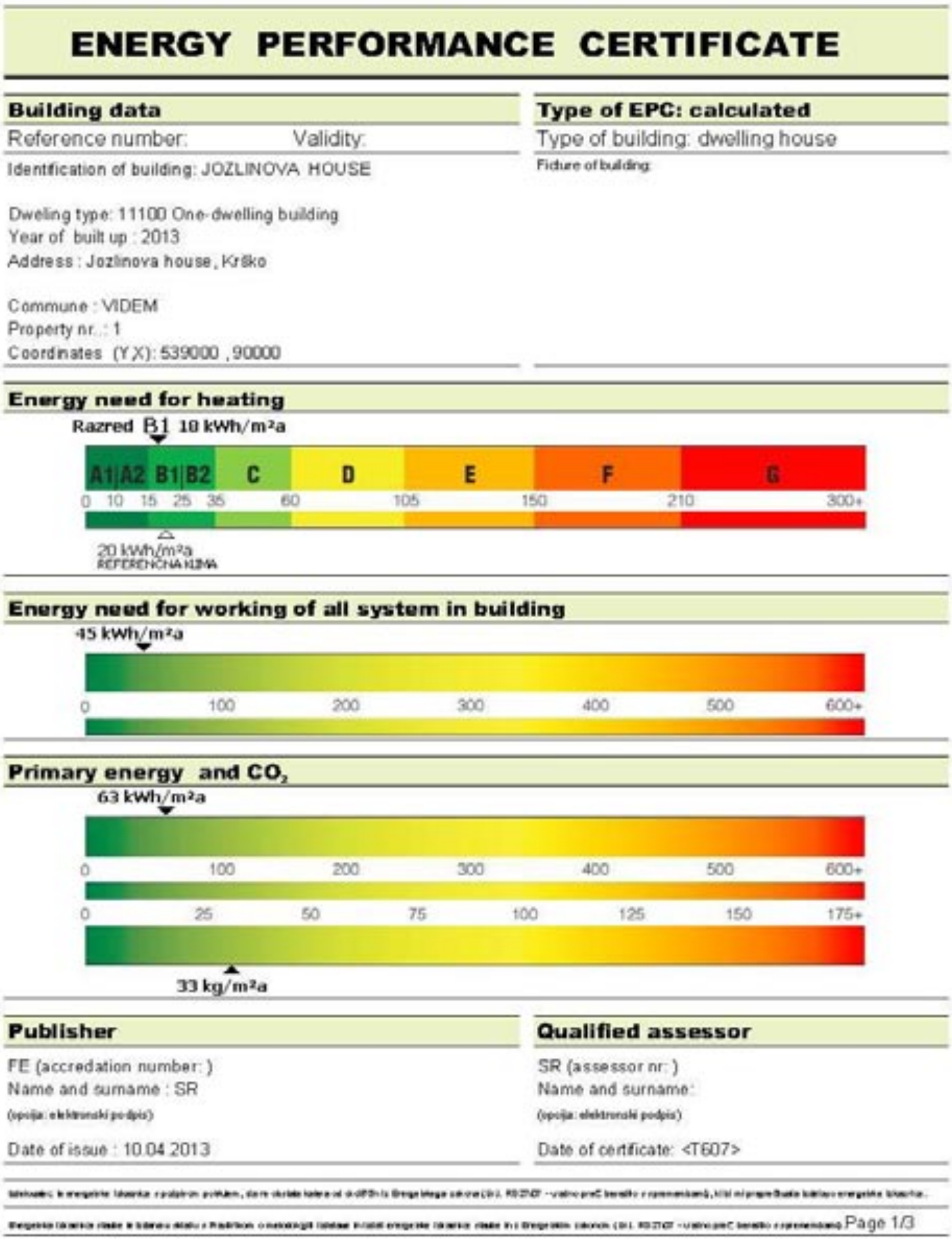
All the activities done for an energy renovation of an older house becoming can be measured. Approval for energy efficient building is given by numeric (energy level) indicators. For this purpose, an energy performance certificate, UL RS, [5], has been adopted; this is a public document accompanied by recommendations for the cost-effective improvement of the energy performance. An energy performance certificate can be calculated according to the type of building. For our building, the calculated energy performance certificate was issued using the Knauf-energy software programme and can be seen below.

1. Coefficient of heat loss due to transmission through the building envelope area $H_t`(T) = H_{(t)}/A$

$$H_t` < 0.28 + T_L/300 + 0.04/f_o + z/4 \tag{4.1}$$

Where f_o means no number between the window area (*z* means civil engineering frame) and the building envelope area

$$Ht' = 0.295\ W/m^2K < Ht'_{max} = 0.396\ W/m^2K$$



ENERGY PERFORMANCE CERTIFICATE

Building data

Reference number: Validity:

Identification of building: JOZLINOVA HOUSE

Dweling type: 11100 One-dwelling building
Year of built up : 2013
Address : Jozlinova house, Krško

Commune : VIDEM
Property nr.: 1
Coordinates (Y,X): 539000 ,90000

Type of EPC: calculated

Type of building: dwelling house

Fidure of building:

Energy need for heating

Razred B1 10 kWh/m²a

A1|A2 B1|B2 C D E F G
0 10 15 25 35 60 105 150 210 300+

20 kWh/m²a
REFERENČNA KLIMA

Energy need for working of all system in building

45 kWh/m²a

0 100 200 300 400 500 600+

Primary energy and CO_2

63 kWh/m²a

0 100 200 300 400 500 600+

0 25 50 75 100 125 150 175+

33 kg/m²a

Publisher

FE (accredation number:)
Name and surname : SR
(opcija: elektronski podpis)

Date of issue : 10.04.2013

Qualified assessor

SR (assessor nr:)
Name and surname:
(opcija: elektronski podpis)

Date of certificate: <T607>

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KNAUF INSULATION

Figure 15: *Energy performance certificate*

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2. The allowed yearly energy need for heating of building, $Q_{(NH)}$, calculated to condition area $A_{(k)}$ or volume of the building $V_{(e)}$ shall not be exceeded:

$$Q_{(NH)}/ V_{(e)} < 45 + 60\ f(0) - 4.4\ T_{(L)}\ (kWh/m^2a)\ \text{(for residential buildings)} \tag{4.2}$$

$$Q_{(NH)}/A_{(k)} = 17.9\ KWh/m^2a < (Q_{(NH)}/A_{(k)})_{max} = 43.1\ kWh/m^2a$$

As can be seen in energy performance certificate (see above), our building is classified as B1.

3. The allowed yearly energy need for cooling, $Q_{(NC)}$, of building, calculated to condition area $A_{(k)}$ shall not be exceeded.

$$Q_{(NC)}/A_{(k)} < 50\ kWh/m^2a\ \text{(for residential buildings)} \tag{4.3}$$

$$Q_{(NC)}/A_{(k)} = 18.6\ kWh/m^2a < (Q_{(NC)}/A_{(k)})_{max} = 70\ kWh/m^2a$$

4. The allowed yearly energy need for working all systems in building $Q_{(p)}$, calculated to condition area $A_{(k)}$ shall not be exceeded :

$$Q_{(p)}/A_{(k)} = 200 + 1.1\ (60\ f(0) - 4{,}4\ T_{(L)})\ kWh/m^2a \tag{4.4}$$

$$Q_{(p)}/A_{(k)} = 62.5\ kWh/m^2a < (Q_{(p)}/A_{(k)})max = 187\ kwh/m^2a$$

5. The calculated yearly CO_2 emission is 33 kg/m²a

6. The percentage ratio of renewable sources of energy is 44%, which confirms that the prescribed demand has been reached.

7. The calculated thermal conductivities of the building envelope are below the prescribed values in the TSG-1-004:2010 book.

5 CONCLUSIONS

The scope of the task was to illustrate improving a building's energy efficiency according to the requirements of the latest state regulations. The main materials and technologies are demonstrated as sample model for the construction of building envelopes in order to achieve all prescribed requirements. Renewable sources of energy are classified, as are the technical solutions that have been chosen for our building.

The energy performance certificate was calculated and created; all proposed and executed tasks for energy efficient of the house were evaluated by the PC program. The result is the calculation and a certificate showing that all required parameters have been fulfilled. It has definitively been confirmed that our renovated building, the Jozlinova House, is an energy-efficient building, which will result in much lower energy costs.

Our building has a B1 energy performance certificate, which means that it has exceptionally high energy efficiency and can be classified as a "low-energy house".

Energy efficiency is becoming increasingly important, and its role in the future will be even more significant in geo-politics. This requires controlling and managing energy consumption,

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which shall be limited due to new regulation. Managing energy shall become increasingly economical due to regulations and new technical solutions.

References

[1] **Z. Praunseis, R. Strojko:** *Energy efficient Jozlinova house*, Project work, University of Maribor, Faculty of Energy Technology, April 2013

[2] **UL RS:** *Statute of efficient energy use in buildings* (PURES 2010) (Pravilnik o učinkoviti rabi energije v stavbah - UL RS št. 52/30.6.2010)

[3] **UL RS:** *Technical guide TSG-1-004:2010-Efficient energy use*; (Tehnična smernica za graditev TSG-1-004- Učinkovita raba energije - UL RS št. 52/30.6.2010)

[4] **Z. Praunseis:** *Energy efficient house*, EOO, lectures, University of Maribor, Faculty of Energy Technology, February 2012

[5] **UL RS:** *Statute of methodology making and issuing of energy performance certificates for buildings* (Pravilnik o metodologiji izdelave in izdaji energetski izkaznic stavb – UL RS št. 77/2009 z dne 02.10.2009 in Pravilnik o spremembah in dopolnitvah Pravilnika o metodologiji izdelave in izdaji energetskih izkaznic stavb – UL RS št. 93/2012 z dne 07.12.2012)

Nomenclature

(Symbols)	(Symbol meaning)
λ	thermal conductivity
a	temperature conductivity
U	heat transfer coefficient