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Energy renovation of an older house

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Abstract: This paper presents an energy renovation of an older house, following the state regulations for efficient energy use. There are many ways to design successful energy efficient homes, because that they can be constructed from many different types of construction material. Becoming a successful builder of energy efficient homes does not merely require a good knowledge of theory in new building techniques, but also skills in implementing innovative designs and high-quality construction practices. The energy performance of 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.

Keywords: Energy, Energy Performance Certificate, Renovation, Renewable Sources

1. Introduction

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

- Constructing a so-called buildings envelope with additional heat insulation made without heat-bridges and airless,
- Installing new efficiency equipment for heating and air-conditioning with recuperative functions and low electricity consumption,
- Installing low-emissivity window glazing can control solar heat gain and lose in hot climates,
- Making use of solar energy for hot water preparation can reduced 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 possibilities of renovation of the old house shall be demonstrated with main goal making an energy efficient house. Materials and construction types for walls, ensuring the presence of excellent heat envelope of the building as well as some renewable sources of energy shall be presented.

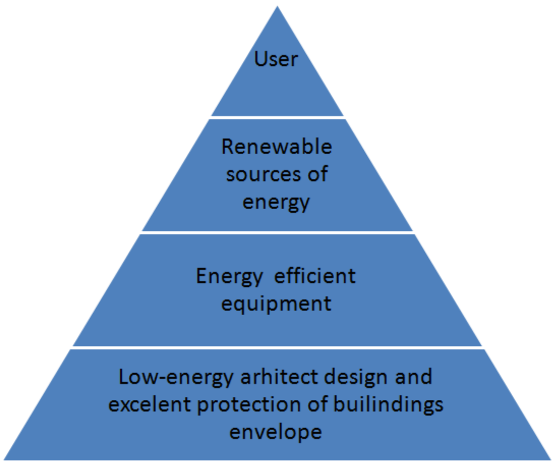


Figure 1. *Dominant factors for energy efficiency building*

2. Energy Efficient Buildings – Law Requirements

As the member o 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:

- Statue 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 building must be prepared as a standard part of physic of the civil engineering requirements.

3. Renovation

Renovation typically entails two phases; civil works for improving the building envelope and installing new equipment, *Praunseis and others, [4]*:

3.1. Renovation for Improving Building Envelope-Civil Works

The building envelope represents the border between the building and its surroundings; mostly the external walls, roof and ground-floor.

External wall - A decision was made that outside wall shall be built from modular bricks, which are good insulators and are a well-known material. Recently development bricks thicker walls to provide better thermal insulation; the latest type 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 are glass wool (fiberglass), mineral wool (stone wool), EPS (expanded polystyrene) and 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 built with easy as they are light, inexpensive and easily handed. Recently cellulose insulation has been used in wooden panel building; it is placed in the space between wooden panels with the blower. Cellulose is considered an ecologically sound material and has lower temperature conductivity ($a=\lambda/\rho \times c$; m^2/h) than mineral wool. It also has lower phase delay, which means that more time is needed to warm or cool the place, which is especially 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 attendance must be dedicated to physic of building and for water and water vapour transferring trough different walls or construction system. For this purpose *protective membranes* made very thin from PVC or PE (Fig.3) are used. They are classified according to their function: to stop water and let trough vapour, to stop vapour and to stop water. It is a rule that on the outside shall be guaranteed waterproof and on the inside must be membrane which lets vapour trough.

Figure 2. *Waterproofing membrane*

Figure 3. *PE protective membrane*

Roof – for roof a typical type of roof with ventilation (Fig.4) shall be built with two layers of isolation mineral wool that all thickness of isolation is more than 20 cm ; between wooden beams shall be fixed wool in rolls (pos. 8) and then additionally shall be fixed wool in slabs (pos. 9) to wooden beams. On the isolation from inside of space was put vapour-stop membrane from Aluminium (pos.10) which has been tightened well. At the end as final layer “knauf” gypsum board (pos.11) which are technically excellent for cladding walls and ceilings constructed on metal grids and wooden frames : for furring, partitions and ceilings.

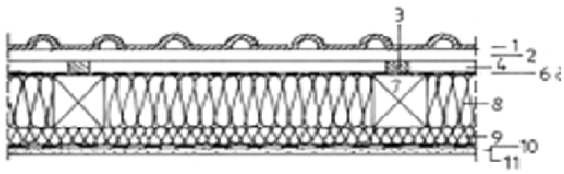


Figure 4. *Roof details*

Basement – renovation of the basement of the old house requires high attention while thinking that earth is a good isolator is wrong. Floor in basemen (Fig.5) must be isolated (isolation under concrete baseplate) and at same time protected against water (hydro-isolation). On the concrete baseplate first isolation from XPS (extruded polystyrene) shall be fixed (Fig 6.), than layer of concrete (slab concrete) and finally ceramic. Layer of concrete shall be used for levelling and served as hard ground for final layer.

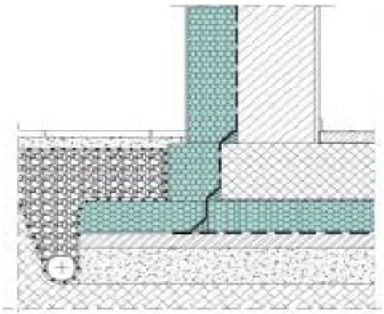


Figure 5. *Basement waterproofing detail*

Figure 6. *Placing of XPS isolation*

Doors and windows (building furniture) – for windows have been chosen wooden windows type Ekolight. These windows are double-glazed with U_w= 1,2 W/m2K. Also wooden doors has been chosen from wood of spruce type Klasik U_d < 1,6 W/m2K (Fig.7).

Figure 7. *Windows and Doors*

3.2. Placing New Equipment Based on Renewable Energy

State regulation prescribes that a least 25 % all needed for building energy must be full-filled by *renewable sources of energy.*

Renewable sources of energy are:

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

For our object following steps have been made

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

Figure 8. *Fixated solar collectors*

Figure 9. *Evacuated tube collectors*

For hot water evacuated tube collectors (Fig.9) have been fixated while they are based on the latest technology and also achieving greater efficiency as previous flat-plate collectors, especially in colder conditions. Vacuum between the two glass layers insulates against heat loss.

- Placing an *air-source heat pump for heating*

Air source heat pumps (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 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 a ground source heat pump requires excavation to install its ground loop.

Figure 10. *Air source-heat pump*

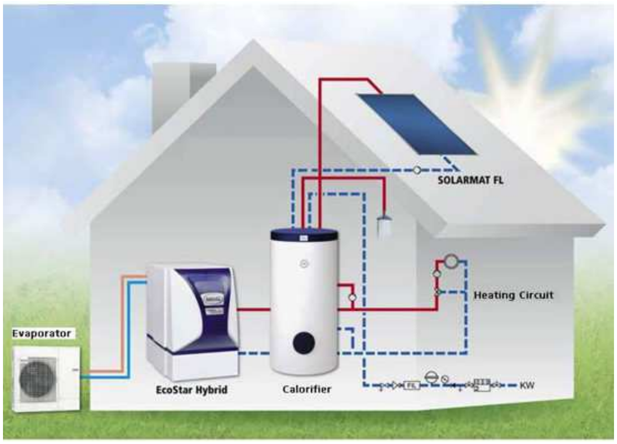


Figure 11. *Function of air source heat pump*

- Placing *heat recovery ventilation*

Heat recovery ventilation, also known as *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 flow. 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 for warmer due to its low temperature level of heating (35 degrees Celsius) which it is for human most comfortable while heat must be placed on feet not on head. Low temperature level of heating is more economical as middle or high temperature while energy needed for building can be reached with less power. Alternative is also wall heating system (Fig. 14)

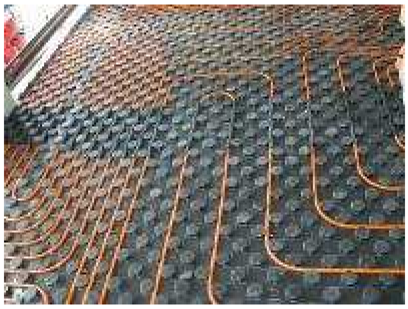


Figure 13. *Underfloor heating system*

Figure 14. *Wall heating system*

4. Results of Energetic Renovation

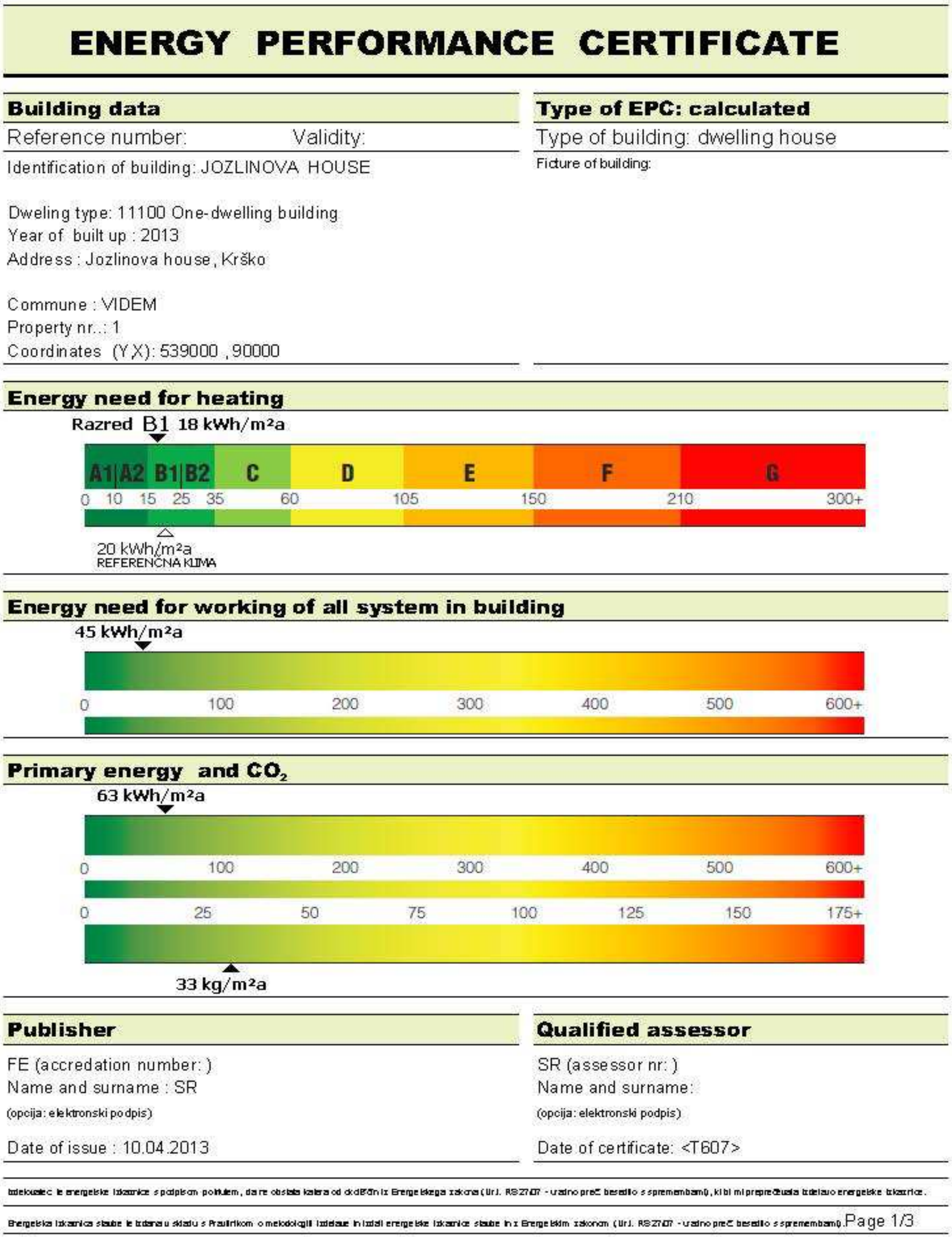
All activities done for energetic renovation of older house becoming energy efficient building can be measured by calculating. Approval for energy efficient building is given by numeric (energetic) indicators. For this purpose *energy performance certificate*, *UL RS, [5]*, has been adopted which is public document with accompanied by recommendations for cost-effective improvement of the energy performance. Energy performance certificate can be measured or calculated depending on type of buildings. For our object calculated energy performance certificate was made and issued by software program Knauf-energy and can be seen on next page.

1. Coefficient of heat loss due to transmission trough building envelope area Ht`(T) = H(t)/A

$$H_t` < 0,28 + T_L/300 + 0,04/f_o + z/4 \qquad (4.1)$$

Where means f_o number between window area (z- civil engineering frame) and building envelope area

$$Ht' = 0,295 \text{ W/m2K} \quad < \quad Ht'_{max} = 0,396 \text{ W/m2K}$$


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

Picture of building:

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

2. 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:

$$Q_{(NH)}/ V_{(e)} < 45 + 60\ f(0) - 4{,}4\ T_{(L)} \text{ (kWh/m2a) (for residential buildings)} \quad (4.2)$$

$$Q_{(NH)}/A_{(k)} = 17{,}9 \text{ KWh/m2a} < (Q_{(NH)}/A_{(k)})_{max} = 43{,}1 \text{ kWh/m2a}$$

As can be seen in energy performance certificate (figure on the previous page) our object is classified into B1 class.

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

$$Q_{(NC)}/A_{(k)} < 50 \text{ kWh/m2a (for residential buildings)} \quad (4.3)$$

$$Q_{(NC)}/A_{(k)} = 18{,}6 \text{ kWh/m2a} < (Q_{(NC)}/A_{(k)})_{max} = 70 \text{ kWh/m2a}$$

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

$$Q_{(p)}/A_{(k)}= 200 + 1,1 (60 f(0) – 4,4 T_{(L)}) kWh/m2a \quad (4.4)$$

$$Q_{(p)}/A_{(k)} = 62,5 kWh/m2a < (Q_{(p)}/A_{(k)})max= 187 kwh/m2a$$

5. Calculated yearly CO2 emission is 33 kg/m2a
6. The percentage ratio of renewable sources of energy is 44 % what confirms that prescribed demand has been reached.
7. Calculated thermal conductivities of the building envelope are below prescribed values in book TSG-1-004:2010

5. Conclusions

The scope of the task was to illustrate integrity of solving building energy efficiency which is provided by the latest state regulation. Main materials and technologies are demonstrated as sample model for construction type of building envelope in purpose to achieving all prescribed requirements. Renewable sources of energy are classified and technical solutions which have been chosen for our object.

By making and issuing energy performance certificate on the basic of program Knauf-energy was confirmed, due all done activities in building, that calculated energy indicators are below as prescribed. Definitively it has been confirmed that our renovated object “Jozlinova house” is energy efficiency building which should be served to the owner with low-cost operating of the house.

Our object is classified according to energy performance certificate into B1 class what means that object has very high energy efficiency and it belongs to the group of “low-energy houses”.

Energy becomes more and more important and its role in the future will be great also in geo-political field. Part of energetic plan is also controlling and managing over need consumption of energy, which shall be limited due to new state regulation. Managing with the energy shall become more and more economically due to regulations and new technical solutions.

Nomenclature

(Symbols): (Symbol meaning); λ: thermal conductivity, *a:* temperature conductivity, *U:* heat transfer coefficient

References

[1] Z. Praunseis, R.Strojko: *Energy efficient Jozlinova house*, Seminar work, Faculty of Energy Krško, April 2013

[2] UL RS: *Statue 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 and others: *Energy efficient house*, EOO-Seminar work, Faculty of Energy Krško, February 2012

[5] UL RS: *Statue 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)