Journal of Energy Technology

JET Volume 9 (2016) p.p. 27-37
Issue 3, October 2016
Typology of article 1.01
www.fe.um.si/en/jet.html

ENERGY RENOVATION OF THE LETUŠ CULTURAL CENTRE

ENERGETSKA PRENOVA KULTURNEGA DOMA LETUŠ

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Keywords: efficient use of energy, energy renovation of building, energy indicators, required heat for heating, thermal conductivity

Abstract

This paper describes the energy status of the Letuš Cultural Centre, which is an older and energy-wasteful building. The paper also describes the guidelines and regulations concerning the efficient use of energy in buildings, both for Europe and Slovenia. With the help of KI Energy software, energy indicators for the building were calculated, and it was placed in energy class G. Actions for energy renovation of the building are proposed and described. In order to determine the effectiveness of the proposed measures, recalculation of energy indicators was performed. Economic analysis of the efficiency of the actions proposed is also presented.

Povzetek

V predstavljenem delu smo opisali energetsko stanje stavbe – Kulturni dom Letuš. Stavba je starejše izdelave in je energijsko potratna. Opisane so smernice in podlage v zakonodaji, tako v evropski kakor slovenski, za učinkovito rabo energije v stavbah.

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Za stavbo smo z računalniškim programom KI Energija izračunali energijske kazalnike, kateri uvrščajo stavbo v energijski razred G. Predlagali in opisali smo ukrepe energetske prenove stavbe. Za ugotovitev učinkovitosti predlaganih ukrepov smo izvedli ponoven izračun energijskih kazalnikov. Na koncu je predstavljena še analiza ekonomske učinkovitosti ukrepov. Naloga ima uporabno vrednost, saj se bo lahko lastnik na podlagi izsledkov naloge lažje odločil za nujno potrebne ukrepe prenove. V sklopu naloge je izdelana tudi Energetska izkaznica.

1 INTRODUCTION

Energy renovation of buildings is one of the key challenges and opportunities for economic recovery in our country. The Republic of Slovenia is a member of the European Union and thus is committed to the implementation of European legislation into its national legal systems. The key interconnected objectives are pursued within the regulatory framework: efficient use of energy, protecting the environment and saving money in energy use.

A long-term strategy to promote investment in the energy renovation of buildings was made for Slovenia. The strategic objective of this document is carbon-free energy use in buildings by the year 2050, *[1]*.

The current housing fund has the greatest potential to generate savings in energy use in buildings. If the Republic of Slovenia's objectives are to be achieved, a quarter of all buildings must be renovated by 2020, which represents over 20 million square metres of building space. With this, the energy use in buildings will be decreased by about 10%. These measures will revive economic growth as they create opportunities for new investments of approximately €500 million in one year. These investments show the possibility of significant savings in energy consumption. By reducing energy imports and lower prices, the contribution may also be in an estimated 10,000 new jobs, *[3].*

The energy performance certificate was designed under the "Energy Performance of Buildings Directive", *[2].* Its primary purpose is to give information about the energy consumption of the building; it includes proposals for recommended energy efficient measures.

The purpose of this research is to present the possibilities for the energy renovation of a public building: the Letuš Cultural Centre. The research will show the current status of energy supply of the building, its shortcomings, the possibility of implementing the measures and economic efficiency of the investment in renovation. Energy indicators of the building before and after renovation will be calculated. The owner and manager of the building will be presented with the findings and suggestions about the measures (organizational and investment) that need to be taken.

This work does not include a complete renovation of the building; the emphasis is solely on measures to improve the building shell. The matter of renewable energy sources remains open; this must be resolved in accordance with the relevant legislation regarding the energy supply of the building. The building has great energy potential because it is situated along the Savinja River. Decades ago, a part of this building was used for a hydroelectric power plant, which is currently being renovated.

2 GENERAL FACILITY INFORMATION

The Letuš Cultural Centre is located in the village of Letuš by the Savinja River. The building was erected in 1927, and renovated and upgraded in the present form in 1976. It is owned by the Municipality of Braslovče and managed by a local committee. In addition to the implementation of cultural activities and events, the purpose of the cultural centre is socializing villagers and youth, and it serves for different associations' activities of local communities and the municipality.

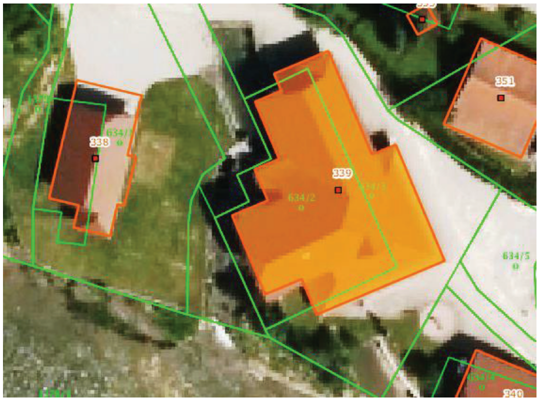

Figure 1: *Object location – ARSO [12]*

The building was built in an L-shape with external layout dimensions of 22.25 m × 25.30 m and a ridge height of 10.3 m (Figure 1). In the NW-SE direction of the ridge, the building contains the main room, which is a one-floor hall. In the direction of the NE-SW ridge in the second part of the building is a two-floor hall. The ground floor contains an office, meeting room, handy kitchen, wardrobe, utility cleaning room, an archive and a hallway that connects all of these areas. On the first floor of this building, there are a museum and cultural society rooms. On the ground floor, there is a large glass-enclosed hall, which is not heated. Figure 2 shows the building from the front to show the architectural diversity of the building.

Figure 2: *Front side of the Letuš Cultural Centre*

2.1 Building envelope

The building envelope consists of outer walls, building elements (windows, doors, floor, and roof). External walls throughout the house differ in thickness, from 24 cm to 65 cm. The walls are of solid red brick, on the outside treated with a conventional plaster, which is worn out in many places to such an extent that it falls off the building. In addition to the exterior walls not having any thermal insulation, there is also a significant problem with moisture. This is especially seen on the walls near the floor.

Windows are wooden with single or double glazing. Window frames are rotten and worn out, window sashes are twisted, without gaskets and leaking very badly. Because of this, there are large heat losses accompanied by significantly increased convection or ventilation losses. Like the windows, the entry gates are wooden and 6 cm thick; due to age and twisted closing mechanisms, many leaks are present.

The floors of the ground floor are partly restored due to a partial renovation in 2010. Weathered and worn wooden parquet floors were completely removed. A floor with a new concrete screed was built and waterproofed, and Thermodur thermal insulation was laid. The rest of the ground floor is not repaired and remains with clinker ceramic plates without any thermal insulation. The roof of the building was restored in 2005 but is not a part of the thermal envelope of the heating zone. Both in the hall and on the first floor, the zone is concluded by the ceiling against the unheated attic. In the hall, the ceiling is made up of panels and foil, between the rafters (from the upper side) thermal insulation had been placed, but it is damaged and destroyed to the extent that it does not function as intended. Insulation from the upper side is not protected by wooden planks; before it was repaired, it was repeatedly soaked, and mechanically damaged during the roof replacement. Ceilings in another part of the building have a thickness of 28 cm; the structure consists of lime plaster and wooden boards. In some places, the ceiling is lowered and treated with wood panelling, with the presence of an air gap.

2.2 Technical system of the building

For heating the ground floor and the halls of the Letuš Cultural Centre, a heating system with an ELFO (Extra Light Fuel Oil) 85,000 kcal/h boiler is used (shown in Figure 3), and the heat transfer is conducted via an air-air heat exchanger. Blowing of the heated air is carried out with ducts (80 cm × 20 cm), which are routed into the hall and hallway. The water system is designed with a central air duct, which runs from the boiler room to the multipurpose hall. Air duct distribution pipes were originally not built for heating auxiliary rooms, but later an additional channel for heating of the meeting room was constructed. Control of the volume of blowing air is not carried out; in addition, steering hatches to make a selection of the heated rooms have not been installed. Hall temperature control is two-point, conducted by a room thermostat that is placed on the wall in the hall. The temperature mode of functioning is set. Other rooms have no temperature control. The ELFO system heats the hall and the ground floor. First floor rooms are not heated with this system; portable radiators are used for heating. The temperature is set manually with thermostats on eight different radiators.

Figure 3: *Boiler room with ELFO boiler*

3 BUILDING'S ENERGY SITUATION BEFORE AND AFTER THE RENOVATION

After the calculation of the energy indicators, the building was placed in the high energy class G, which is the highest grade on the colour strip. This class is determined by the energy indicator QNH/Ak, "the annual heat required for heating the building on one unit of heated area of the building", *[7].* Within one year of measurements, the Letuš Cultural Centre needs QNH = 226 kWh of thermal energy per square metre of heated surface. The total energy supplied to the building is Q = 302 kWh of energy per year per square meter. Together, this amounts to Qp = 428 kWh/m²a of primary energy for which the calculated emissions are CO_2 = 102 kg/m²a. Figure 4 shows the indicators of the energy characteristics of the building on the colour strip, which is an integral part of EPC (energy performance certificate).

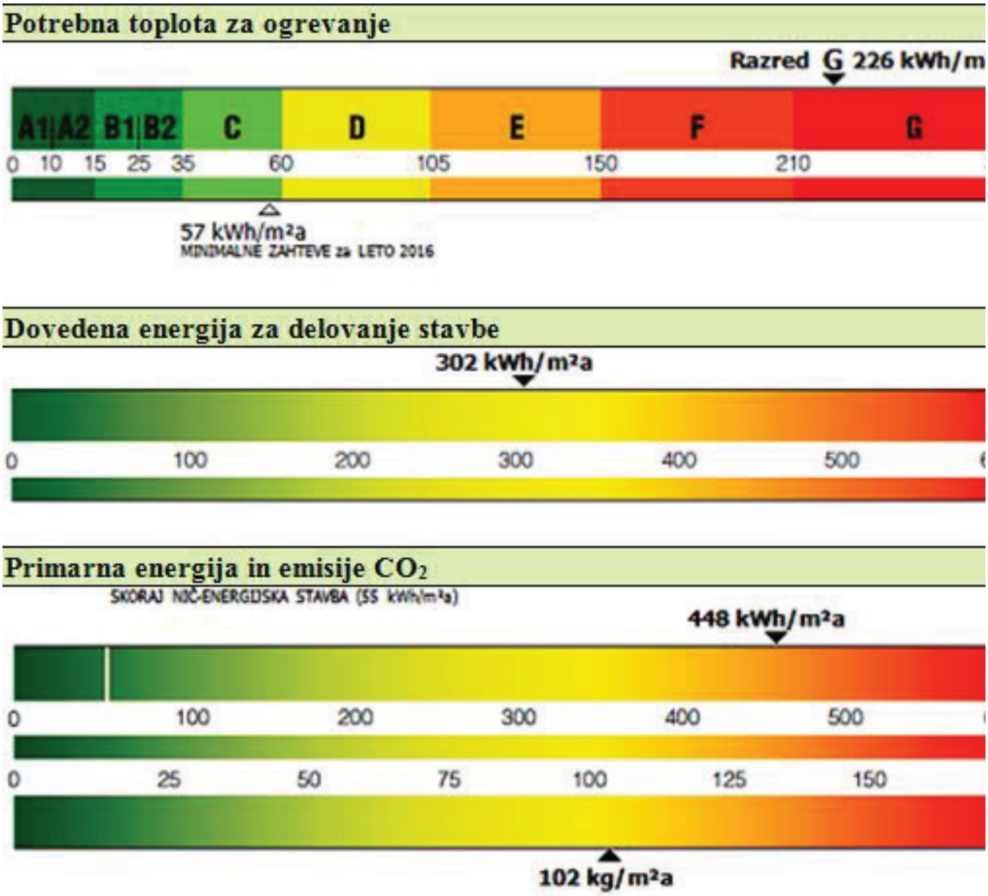

Figure 4: *Energy indicators before renovation*

The program in which the energy indicators were calculated also includes an analysis of the entry structures of individual zones and the building as a whole. From the calculated indicators, we find that the building is energy inefficient. There are high energy losses due to the envelope of the building. Based on the collected data which describe the energy consumption and on the basis of current energy prices, we calculated the annual energy costs for the building. Energy input of the building in one year is 131,909 kWh, of which 36,252 kWh of electricity and energy from ELFO at 95,657 kWh. An infrared camera was used for further analysis of the transmission and convection losses from the building shell. With thermal imaging, we found that windows and doors sealed very poorly. Ventilation losses are significant and may determine that it is necessary to replace the windows (Figure 5).

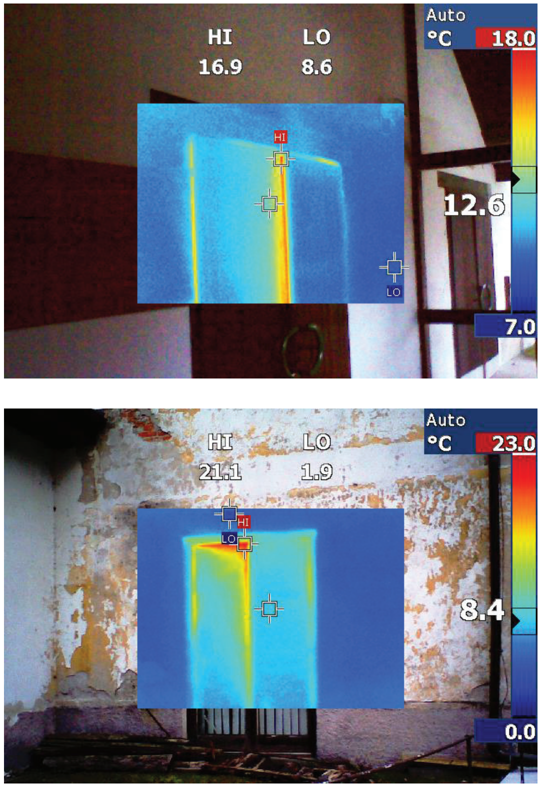

Figure 5: *Sealing of the side doors*

The balance of energy indicators for the building after the renovation is shown in Figure 6.

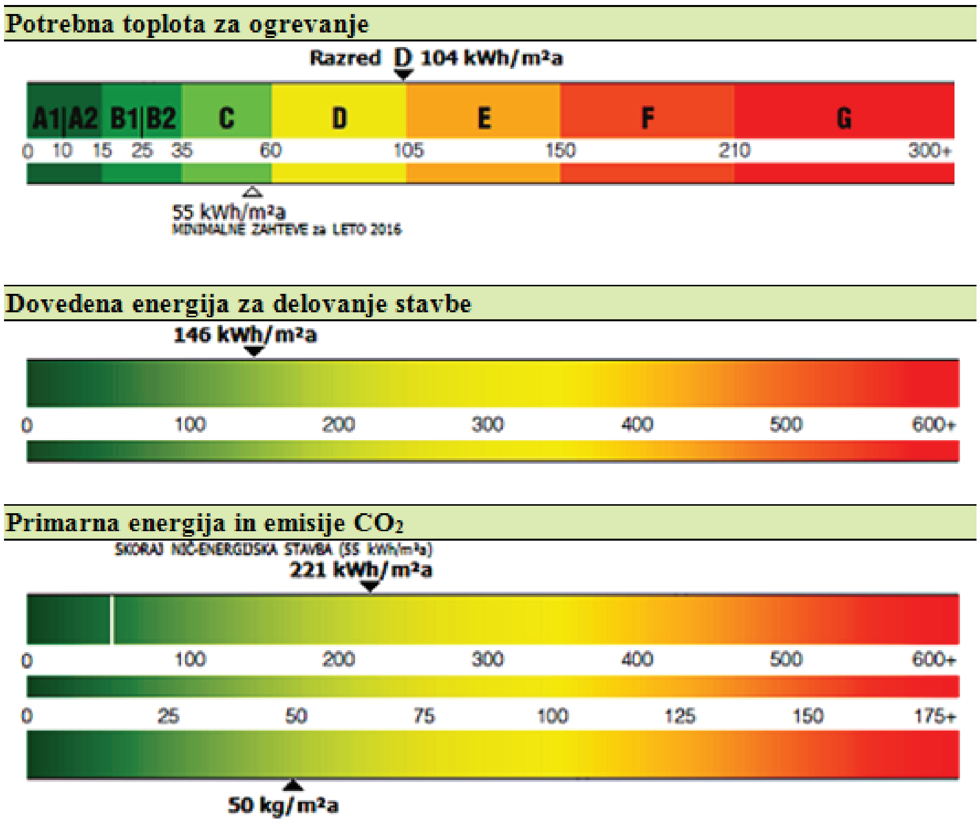

Figure 6: *Primary energy and CO2 emissions after implementation of the measures*

Figure 7 shows energy indicators before and after the renovation of the Letuš Cultural Centre. It was found that the consumption of the energy by the building was reduced by more than one half after the proposed measures were implemented. On closer examination, the smallest contribution to the reduction of used energy is contributed by Measure A: replacement of the external building materials. This is due to a very low "z" factor of windows and doors against the surface of the entire building envelope. The proposed Measure B represents a greater contribution to reducing energy consumption via the additional insulation of ceiling structures. The maximum reduction of the energy consumption can be achieved with Measure C: the renovation of the facade with the installation of thermal insulation materials.

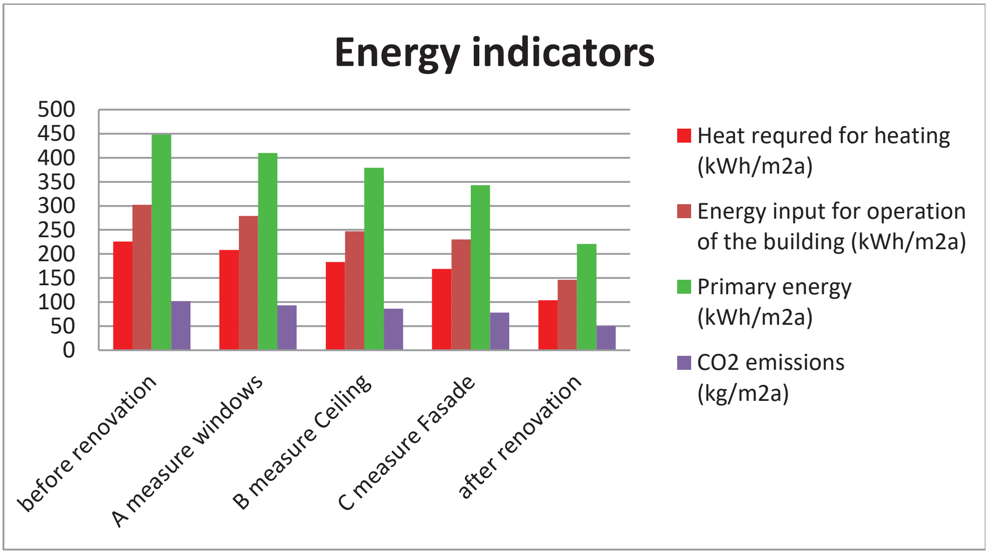

Figure 7: *Energy indicators*

The ratio between the energy products is about the same before the renovation of a building; more precisely, the proportion of ELFO decreased by 4% after the renovation (Figure 8).

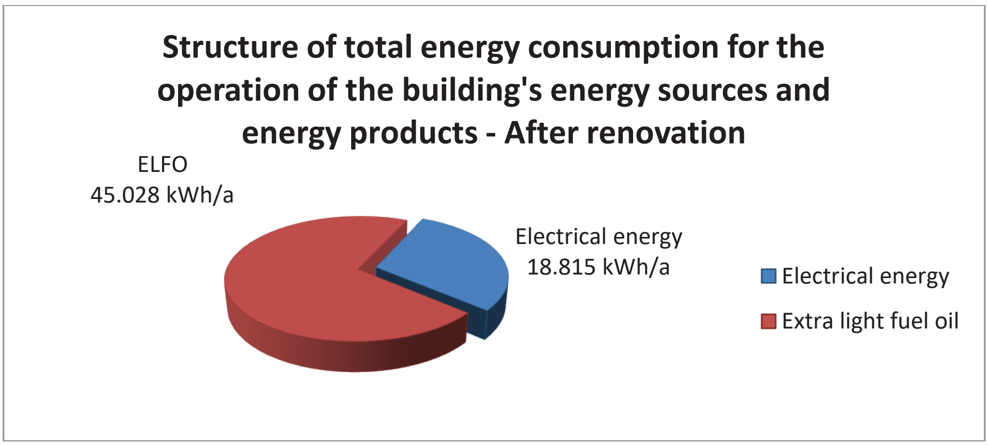

Figure 8: *Energy for the building after renovation*

Energy renovation of a building is an investment. We have calculated the economic viability of the project over the life cycle of the building envelope (i.e. 20 years). This economic analysis was performed in accordance with the LCC (Life Cycle Cost) analysis.

Economic analysis was performed using the following financial ratios:

- Payback period of the investment,
- Net present value (NPV),
- The internal rate of return (IRR).

To assess the cost effectiveness of the measures in the renovation of a building, it is advisable to use the payback period. The payback period is both a static method and a very simple method that defines the rationality of the investment. The payback period is calculated by dividing the value of an investment (the cost of renovation) by the annual return; in our case, this is an annual saving on energy costs for the building. If the annual income or savings are the same, then this method is quite acceptable. The disadvantage of the payback period is ignorance of the time component (i.e. the loss of money at the time). In most cases, the unit for the payback period is expressed in years.

4 CONCLUSION

Energy is an asset of extraordinary proportions and the foundation and driving force for economic development. The supply of cost-effective and environmentally acceptable energy is the foundation for a good and efficient economy. The global trend is to reduce energy consumption with the emphasis on maximizing the use of renewable energy sources. About 40% of all consumed energy is used for the normal operation of buildings. This area is most certainly a major challenge for savings. With the right approach and awareness, we can make great strides in reducing negative impacts on the environment, while providing a great opportunity for the recovery and growth of the economy. The Letuš Cultural Centre is a public building; consequently, it must be a particularly good example of a correct approach to energy management. The building is old and is placed in the energy class G, which is a very bad grade.

After a thorough analysis and applied calculations, we proposed a variety of measures. In addition to organizational measures, there are also three proposed investments: window replacement, renovation of the ceiling with additional thermal insulation, and facade renovation with the installation of thermal insulation. With these renovation measures, the energy needed for the building will be reduced by half, and so the operating costs will be lower. The payback period of the investment costs has been calculated, according to the static method, as a little over eight years, which is a good indicator for this type of investment. With the dynamic method, the calculated time to restore the investment is a little longer, just slightly above 13 years. Energy savings from these actions are subject to the conditions of continuous heating and other reference conditions. If the building is to function with interrupted operation, the annual energy savings is reduced, and the will also relatively prolong the period of reparability. The measures do not represent a comprehensive energy reform: such renovation should also include solutions and measures for the installed technical systems, such as the heating system. The current system is most definitely in need of a renovation, but there are many alternative solutions. It should also be noted that the use of renewable energy sources remains under consideration since the location of the building of the Letuš Cultural Centre is suitable for exploitation of the hydro-electricity, due to its location by the Savinja River.

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