Application of principles of energy efficiency in the renewal of towns and cities with preserved historical and cultural complexes – a case study of Trebinje

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ABSTRACT

Historical complexes in towns and cities, as most prominent witnesses of the past, are important elements of culture. Building heritage is a non-renewable resourse and the best way to preserve it is through urban renewal. The principal goals of urban renewal imply the improvement of living and working conditions in towns and cities, while optimizing the exploitation of all available resources, from man-made physical structures to energy.

This research focuses on the town of Trebinje as an urban complex with a preserved urban matrix dating back to the 17th century and contains the analysis of a typical local structure, for the purpose of identifying those principles of improvement of energy efficiency applicable in Mediterranean climate zones.

The case study focuses on the building of the Museum of Herzegovina in Trebinje, which should also serve as a pilot project for the Trebinje town administration and the Ministry of Education and Culture of Republika Srpska, but also as a project that can be multiplied in the future.

KEYWORDS

Building heritage, urban renewal, energy efficiency, renewable energy sources.

1. INTRODUCTION

Urban renewal is a special planning strategy employed in many European countries. For many countries worldwide it has become a priority issue in the final decades of the 20th century. Renewal is a natural process; towns and cities regenerate, primarily because their physical tissue ages and degenerates, but also due to the impact of natural and social factors.

This paper presents a case study focusing on the building of the Museum of Herzegovina in Trebinje. The building is located in the Old Town, which is a listed cultural and historical complex. Initially Austrian-Hungarian barracks, the building later changed its use and became a secondary school (Gymnasium); currently, it is used as a museum. The building was listed by both the Preservation Department of the Republic Institute for the Protection of Cultural, Historical and National Heritage of Republika Srpska and the Bosnia and Herzegovina Commission to Preserve National Monuments.

2. PRINCIPAL DOCUMENTS AND CHARTERS ON ENERGY EFFICIENCY AND URBAN RENEWAL

In the last decades of the 20th century, urban renewal became more important than urban development. Many towns and cities have been very successful in regenerating quarters and neighbourhoods; many of those cases were presented and pushed as positive, only to prove to have been negative later on.

The idea of urban renewal has been promoted internationally by a number of documents. The first important charter was adopted in Vancouver (1975), followed by the Agenda 21 (Rio de Janeiro, 1992), European Urban Charter (1992), Aalborg Charter (Denmark,1994), and Habitat II Agenda (Istanbul, 1996).[1] Over the last few years, various conferences met to look at ways to harmonize a common planning policy of urban renewal and reconstruction.

What is needed to implement urban renewal policies is time, educating the local populations and good relations and communication between local and state institutions. Each region is special in its own way, and urban renewal must take account of that.

Bosnia and Herzegovina has not signed any of the international planning-related documents adopted in the last twenty years. Some local planning documents adhere to the international ones, but implementing them only partially and at a minimum.

All activities of urban renewal should go hand in hand with efforts to enhance the energy performance of both buildings and urban complexes. Energy efficiency in the building sector has been the subject of numerous action plans and directives adopted by the EU,[2] following the adoption of major international documents related to the necessity of climate protection, of which the most important one is the Kyoto Protocol (1997).

The most important of these documents is the Directive on the energy performance of buildings – the old and new versions (2002 and 2010).[3] This directive requires that any more extensive project of building renovation should also improve its energy efficiency. Its implementation is not statutory for listed buildings or houses of worship. This does not mean that the energy performance of such buildings should not be upgraded, where possible.

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[1]Stojkov, Borislav, *Obnova gradova u Srbiji u novim uslovima razvoja*, *Obnova gradova u Srbiji – temeljne odrednice*, IAUS, Beograd, 1996, p. 10

[2]Action Plan for Energy Efficiency: Realising the Potential, of Commission of the European Communities (COM 2006) 545, 2020 by 2020 Europe's climate change opportunity (COM 2008) 30, Energy efficiency: delivering the 20% target (COM 2008)772, Renewable Energy Road Map: Renewable energies in the 21st century: building a more sustainable future, COM (2006) 848

[3]European Directive 2002/91/EC of the European Parliaments and of the Council of 16 December 2002 on the energy performance of buildings

European Directive 2010/31/EU of the European Parliament and of the Council of May 2010 on the energy performance of buildings (recast)

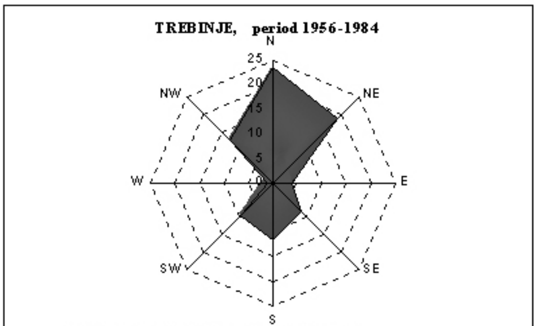
Bosnia and Herzegovina ratified the Kyoto Protocol in 2007, and in 2009 it adopted the Initial Report on Climate Change. The procedure to adopt the Directive on the Energy Performance of Buildings is under way, and after it has been incorporated in the legislation, improvements can be expected in terms of improvement of energy performance of buildings.

3. TREBINJE'S DEVELOPMENT THROUGH HISTORY

Trebinje is a regional center in southernmost Herzegovina. It is situated in the valley of the River Trebišnjica, in the tri-border area between BiH, Montenegro and Croatia. Its geostrategic position at the intersection of three regions, Herzegovina, Montenegro and the Adriatic seaboard, has been a crucial factor in the town's history.

The most important routes passing through the town are those between Belgrade and Dubrovnik, and between Mostar and Podgorica. The Trebišnjica, the river running through the town, is one of the world's longest losing streams.

Trebinje is situated in a Mediterranean climate zone, or more specifically, in the Adriatic climate, owing to the proximity of the Adriatic Sea and its relatively low altitude on the one hand, and the high mountain ranges in the hinterland on the other. The mean annual temperature in Trebinje is 14.2^0 C; the mean temperature in January is 5.5^0 C, and in August it rises to 23.5^0 C. With an average of over 270 sunny days per year, Trebinje is one of the region's sunniest towns.



Godišnja ruza vetrova, Trebinje, 1956-1984.

Pravac	N	NE	E	SE	S	SW	W	NW	C
Cestina (%)	23.7	18.5	3.9	8.1	11.4	9.5	0.9	12.2	11.6
Sr.brzina (m/s)	2.8	3.6	2.4	3.5	3.3	3.0	2.1	3.5	

Figure 1. The annual wind rose for Trebinje[4]

The town of Trebinje as it is today was founded in the early 18th century. In a time of war, from 1683 to 1699, circumstances forced the Turks to settle and set up households in Herzegovina. As a result, the new town of Trebinje was born on the right bank of the Trebišnjica. The Turkish town was erected in 1706. Settlements grew around the fortification raised by the Turks, which then developed at a slower or faster pace.

Trebinje was not only a military stronghold and the regional administrative center, but also the central place of a larger military region, which got its shape, characterised by remparts and a ditch, in the first four decades of the 18th century.

[4]Documentation of the Institute for Urbanism of Republic of Srpska, Urban plan 'Trebinje 2015', Banjaluka, 2002, p. 24

The local climate was the one factor that strongly affected the formation of Trebinje's urban space. The modern town quarters developed under the influence of Austrian-Mediterranean architecture. In some of its elements the main street is reminiscent of Dubrovnik, and the way of life in the town, the people's customs, the residential architecture, etc. were also strongly influenced by the Mediterranean seaboard way of living.

Trebinje is an old town that developed at the intersection of various influences and interests; it is a town with a long and eventful history, which did not only change the appearance and content of its core, but also its relevance for the broader region. Trebinje's urban structure, specificities, values and potential give it the qualities that set it apart from other Herzegovinian towns, which has proved an advantage in terms of development.

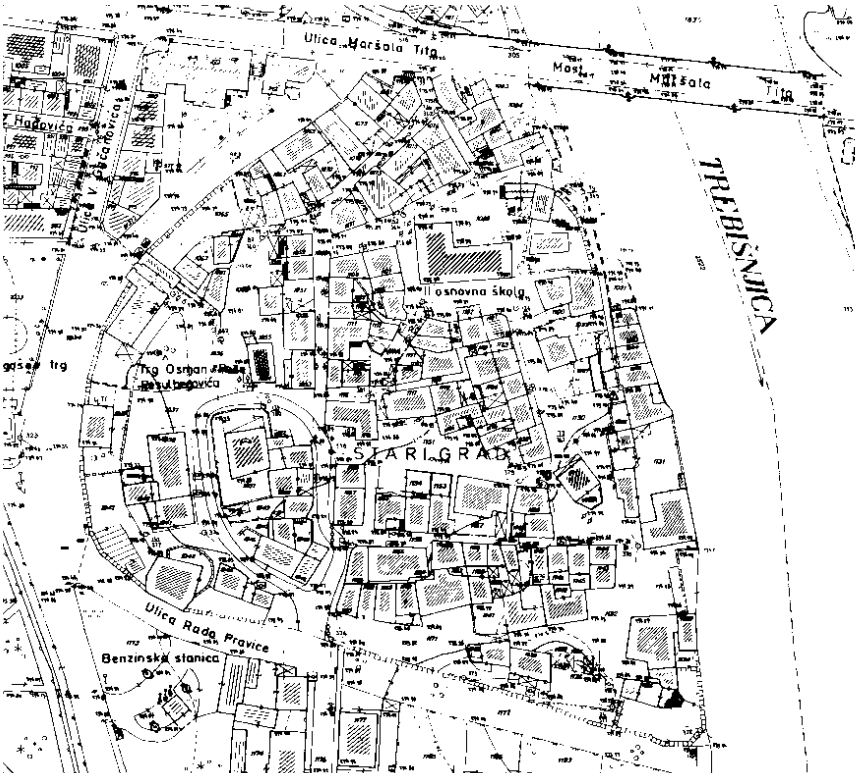


Figure 2. The structure of the Old Town

4. THE BUILDING OF THE MUSEUM OF HERZEGOVINA – A CASE STUDY

As the Austrian-Hungarian authorities stationed a considerable number of troops in the town, its physiognomy began to change. Barracks were constructed in the fine-grained urban tissue within the Old Town, at the site of the old Ban-Vir fortification. It is a three-storeyed building (ground level + two storeys), and a military dove cote was erected next to the barracks.

The building of the Museum of Herzegovina in Trebinje was selected for the case study because of its significance as a public building, as well as because of the construction material it is made from (stone), which is the material used in the construction of many buildings in Herzegovina.

Figure 3. A sketch of the barracks site in the Old Town[5]

Figure 4. Part of the original design, dated 1900[6]

The building was constructed at the very beginning of the 20th century based on a blueprint whose original parts were discovered in the Archives of Bosnia and Herzegovina (Figures 3-5).

The inspection of the building and of the examination of the documents found in the Archive confirm the building was constructed to the 1901 design. Before the Museum was placed in the building, its condition was inspected (the floor structures) and a renovation project was made for the second floor ceiling. In 2010, a project was prepared to adapt the attic into usable space, and these works are under way.

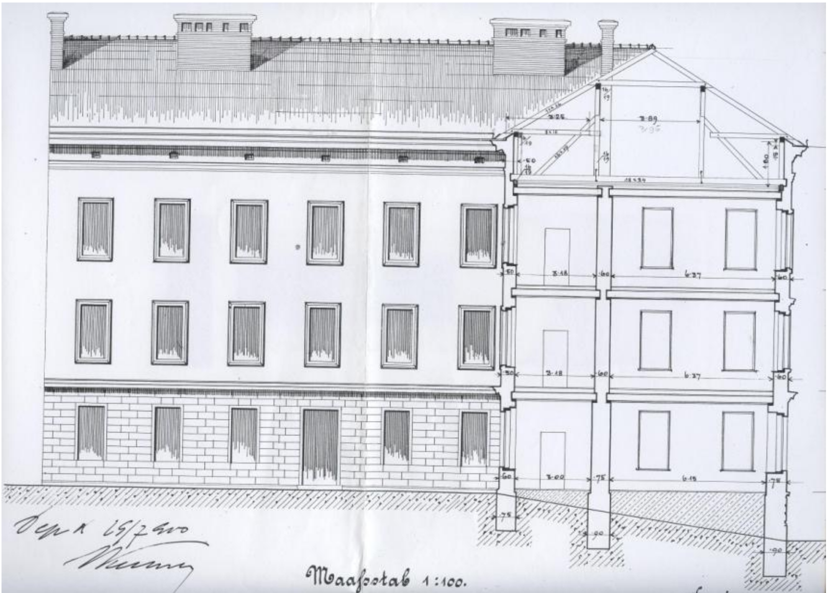


Figure 5. Part of the original design, dated 1900[7]

The examination of all the available design documents and the inspection of the current condition of the building confirm there have been no major changes to the building. Some of the ground rooms have been partly connected to facilitate seeing exhibits on display.

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[5]BiH Archives, National Government, Construction Department 1878-1918
[6]BiH Archives, National Government, Construction Department 1878-1918
[7]BiH Archives, National Government, Construction Department 1878-1918

The building is made of stone and it is assumed it was constructed in the stead of an ancient church dating back to the 4th century, which may have been the location of the old settlement of Trebinje.

The Museum complex comprises a few more stone structures – a building for storing bequests, an accessory building housing the museum depot, a clock tower, and a building used as a station or dove cote for carrier pigeons, one of its kind in this region.

The Museum building houses the following collections:
- archaeological collection
- collection of stone sculpture
- ethnological collection
- Trebinje 19th/20th c. town house collection
- natural science collection (under preparation)
- historical collection (under preparation)
- a library with over 8000 books.

Figure 6. The northwestern facade

Figure 7. A museum window

Figure 8. The south facade

Figure 9. The Museum building with the clock tower’

The building has been inscribed on the Temporary List of National Monuments of Bosnia and Herzegovina (as the Gymnasium building). The procedure to list it as a national monument of Bosnia and Herzegovina is under way.

4. 1. The energy audit of the building

An energy audit is a set of strictly defined procedures in order to identify the most efficient possible approach to enhance the energy performance of the building under consideration, while maintaining (or upgrading) the existing level of comfort.
There are two types of building energy auditing: the first one involves using simplified tools, whereas the second is detailed and entails the actual auditing on the spot, along with the visual inspection of the building.

In this particular case, the method of simplified energy auditing was employed, including all the constituent elements:
A. Data collection
B. Data evaluation and processing
C. Measures intended to enhance the energy performance of the building

Stage one involved collecting archival documents and information about the local climate, as well as inspecting the building, which also entailed gathering information about how the building is used, the number of staff, electrical devices and equipment, heating and cooling systems, lighting, and the information about energy consumption over the last three years.

The inspection findings are as follows:
Both the outside and inside walls of the building are load-carrying walls made of stone; they are in good condition, with no visible cracks or signs of dampness (heat transfer coefficient U=1.395 W/m²K)

The roof structure, i.e. the attic, is currently being adapted into exhibition space, and these calculations are valid for the condition as it was prior to the commencement of adaptation works.

The floor frames of the building were renovated before the Museum was placed in it. Additional reinforced concrete slabs were built; new reinforced concrete joists were laid, and the space between them was insulated with 6-cm mineral wool (heat transfer coefficient between joists U = 0.515 W/m²K; at reinforced concrete joists U= 4.27 W/m²K).

Due to the sloping terrain, the ground floor was laid on an unlevel fill. There is no thermal insulation and the heat transfer coefficient U = 3.3 W/m²K.
The exterior windows and doors are in very bad condition (the windows in most of the rooms are not opened for fear they might come off or fall apart). They are single-glazed, double casement windows, set in broad box frameworks.

The building is heated independently, i.e. seven air conditioners are used to heat the exhibition rooms, and the rest is heated with eight storage heaters. In summer, air conditioning is used to cool the building using minimum energy.

The lighting system in the building combines different kinds of light units. Standard fluorescent light bulbs are mainly used in the offices; there are flood lights in the exhibition rooms, and common or energy-saving bulbs are used for the display cases. The total power capacity of the installed lighting system is 41.2 KW (common incandescent light bulbs = 6.34 KW; standard fluorescent lamps = 6.06 KW; halogen flood lights = 26.40 KW; energy-saving bulbs = 2.4 KW). According to the people working in the building, the wiring is in bad condition.

The total number of staff equals 11 people, including a night guard. The Museum is open five days a week. The opening hours are from 8 AM to 4 PM, except on exhibition opening days, when it is open longer. The figures/data typical of this type of building were used in the calculations: 5 weekdays, with 11 working hours a day.

After the inspection of the building, the existing heating, ventilation and lighting systems, heating and cooling operation and the actual consumption of energy, it was possible to conclude that both the level of user comfort and storage and exhibiting conditions are unsatisfactory (in terms of temperature and humidity constancy). Energy consumption is not very high, as saving measures are employed to the maximum, which means that the exhibition rooms are essentially not heated, i.e. they are heated as needed.

Given the existing data and the properties of the available software, two applications were considered for calculation: URSA Građevinska Fizika 5 (www.ursa.com.hr) and ENSI Software (www.emsi.no). What hinders the application of this software is the lack of information about the climate in Trebinje, which is why information pertaining to towns with similar climates was used: Knin (Ursa) i Mostar (Ensi).

The calculations were done with regards to using the whole building, i.e. heating and cooling the whole building, in line with the outlined use schedule – 11 hours a day, five days a week. The calculation results indicate excessive consumption of energy used for heating and cooling, meaning that it does not only exceed the limits as defined by EU norms, but also the currently applied JUS standards, amounting to 250 kWh/m^2a.

4. 2. Measures intended to enhance the energy performance of the building

Taking into consideration the results obtained specifying the amount of energy needed to heat and cool the rather large building, as well as its importance and use (storage and display of museum exhibits, some of which require strictly controlled, constant temperature and humidity), and bearing in mind the current condition of the building, it is proposed to try and make the interior temperature and humidity as constant as possible, primarily by means of architectural and engineering works. This is achievable by means of additional insulation of the building envelope, replacement of windows and installation of overheating protection.

A single central system of heating and cooling should be installed, which would use renewable energy sources (ground, water, aun).

As museum exhibits are sensitive to light, which is, nontheless, needed in order to see them, it is necessary to negotiate the right kind of choice in terms of the system of lighting, while also bearing in mind energy efficiency (Vokić: 2002).

3.3.1. Architectural and engineeering works

Based on the data obtained in the construction physics calculations, the condition of the building and the fact it is a listed building, measures were selected to enhance the energy performance of the building envelope, which would result in a considerable reduction in energy consumption.

Exterior walls: Since this is a listed building, it is impossible to insulate the walls on the outside. Therefore, the plan proposes to install thermal insulation on the inside. Given the fact the plaster is already in fairly bad condition, it is planned to remove the current interior layer of plaster, install mineral wool as thermal insulation, including a vapour control layer, and cover the walls with plasterboards. Also, it is necessary to rewire the building and install ventilation ducts. The minimum 10-cm thermal insulation planned for installation will help secure the required heat transfer coefficient U = 0.273 W/m²K, while 15 cm of thermal insulation would help have as much as U = 0.197 W/m²K.

Since the attic will be used as exhibition space, it needs to be insulated additionally. A total layer of 22 cm of thermal insulation needs to be installed between and under the rafters, which would ensure the heat transfer coefficient U= 0.154 W/m²K,.

As the ground level floor is not insulated, it is planned to lay additional thermal insulation on top of the existing flooring, which should not be removed (in case interior windows and doors are replaced) for the purpose of easier installation. This would help ensure a floor heat transfer coefficient U = 0.577 W/m²K, whereas the installation of a 10-cm layer would achieve as much as 0.316 W/m²K.

Despite all the proposed works on the building, it will still have thermal bridges, because the wall frame cannot be separated from the floor frame.

It is planned to replace all exterior windows and doors with new ones having better insulation properties. As the building is listed, it is not possible to install superwindows, as triple glazing would change their appearance. The most acceptable solution would be to replace them with double-pane insulted glazing, which would considerably upgrade their performance. In case this solution is impossible, the exterior panes should be single glazed and the interior ones double glazed; outdoor blinds should also be installed as protection against overheating.

3.3.2. The system of heating and ventilation / HVAC

It is proposed to replace the heating system using storage heaters and air conditioners with a central air conditioning system (heating, cooling, ventilation) What remains to be considered is the selection of the most adequate renewable energy source:

- installation of thermal pump (ground-air, water-air)
- installation of photovoltaic panels to generate electric power to be used for the air conditioning system.

As the building is made of stone, this will make the installation of air conditioning somewhat complicated. These works should be carried out together with rewiring and the additional insulation of the interior side of the façade walls.

3.3.3. The lighting system

The current interior lighting system capacity is 41.2 KW (common incandescent bulbs = 6.34 KW, standard fluorescent bulbs = 6.06 KW, halogen flood lights = 26.40 KW, energy-saving bulbs = 2.4 KW).

Since changing the current interior lighting system can help to reduce considerably the consumption of power, it is proposed to replace all the units with LED lamps, which can be done in stages. The units consuming the most power can be replaced first, and the rest can follow. After the complete system has been replaced with LED lights, the electric power needed to illuminate the interior of the building and the exhibits will be reduced by more than 50%.

It is planned to install outdoor lighting, and solar power should be used to that purpose. This would allow using renewable resources to the maximum, without imposing an additional load on the city electrical grid.

4. 3. The achievements anticipated following the improvement of the energy performance of the building

The employment of all the proposed measures would considerably reduce power consumption, while improving the level of comfort, both for the building users and the items stored and exhibited in it. The amount of energy needed to provide a sufficient level of comfort prior to and following the completion of the proposed works would be reduced a lot, from 235 to 64 KWh/m²a. Using renewable kinds of energy would not only curb power consumption, but also make the building energy independent.

5. CONCLUSION

The above case study allows us to conclude there is great potential in Trebinje for improving the energy efficiency of listed buildings. Unfortunately, it remains unexploited, just as the possibility to use renewable kinds of energy, especially the sun, given the climatic conditions in Herzegovina.

There is a range of measures that can be adopted for listed buildings, from those simplest ones requiring very little funding (better sealing, changing user habits) to more complex works involving the renovation of the building envelope and the heating and ventilation system, which require comparably more funding.

Since these buildings are generally old and are in need of both maintenance and renovation, for reasons of either usability or aesthetics, incorporating efforts to enhance energy efficiency in dealing with these issues is highly important, which is also an opportunity to carry out these works simultaneously.

Most of all, it is necessary to raise the awareness of both building owners and users of the possibility and necessity to save power, change their behaviour, and resort to all other instruments that can be used to upgrade energy efficiency.

The above case study of the building of the Museum of Herzegovina shows the potential and ways to improve energy efficiency.

Given the specific structure of the building, its use and current condition, it may be concluded it has great potential for saving energy, which should also come from renewable sources. Using renewable kinds of energy may help make the building energy independent and thus contribute to efforts to curb the emission of green house gases and mitigate climate change.

A public building such as this may serve as a pilot project for the town administration and the Ministry of Education and Culture of RS, stimulating them to launch similar projects with other buildings they either manage or own.

The life span of listed buildings can be maximized by improving their energy efficiency and microclimatic conditions, which helps preserve and use building heritage.

REFERENCES

1. Agenda 21 ,Rio be Janeiro, 1992. .pdf,
2. Vokić, D., Mišljenje o poboljšanjima uvjeta čuvanja muzejske zbirke Dominikanskog samostana u Dubrovniku,http//www.k-r.hr/dominikanski%20samostan%20-%201.pdf
3. European Directive 2002/91/EC of the European Parliaments and of the Council of 16 December 2002 on the energy performance of buildings, *http://eur-ex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0065:EN:PDF*
4. European Directive 2010/31/EU of the European Parliament and of the Council of May 2010 on the energy performance of buildings (recast), *http://eur-x.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF*
5. COM(2008) 30, 20 20 by 2020 Europe's climate change opportunity, Communication from the Commission to the European Parliament, the Council, the European economic and social Committee and the Committee of the Regions, of 23.1.2008. *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0030:FIN:EN:PDF,*
6. COM (2006) 545, Action Plan for Energy Efficiency: Realising the Potential, of Commission of the European Communities of 19.10.2006. *http://ec.europa.eu/energy/action_plan_energy_efficiency/doc/com_2006_0545_en.pdf*
7. COM(2008) 772, Energy efficiency: delivering the 20% target, Communication from the Commission,of 13.11.2008, *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0772:FIN:EN:PDF,*
8. COM(2008) 30, 20 20 by 2020 Europe's climate change opportunity, Communication from the Commission to the European Parliament, the Council, the European economic and social Committee and the Committee of the Regions, of 23.1.2008, *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0030:FIN:EN:PDF.*
9. COM (2006) 848, Renewable Energy Road Map: Renewable energies in the 21st century: buildings a more sustainable futue, Commission of the European Communities, of 10. January 2006, *http://ec.europa.eu/energy/energy_policy/doc/03_renewable_energy_roadmap_en.pdf,*
10. Урбанистички план „Требиње 2015.“, Урбанистички завод Републике Српске, 2002.
11. Evropska gradska povelja CLRE www.expeditio.cg.yu, decembar, 2009
12. Istambulska agenda, Habitat II, Istambul,1996.
13. Korać, J. V., *Trebinje − istorijski pregled II, Period od dolaska Turaka do 1878. god.,* drugi dio, Zavičajni muzej Trebinje, Trebinje, 1971.
14. Korać, J. V., *Trebinje − istorijski pregled, Period do dolaska Turaka,* Zavičajni muzej Trebinje, Trebinje, 1971.