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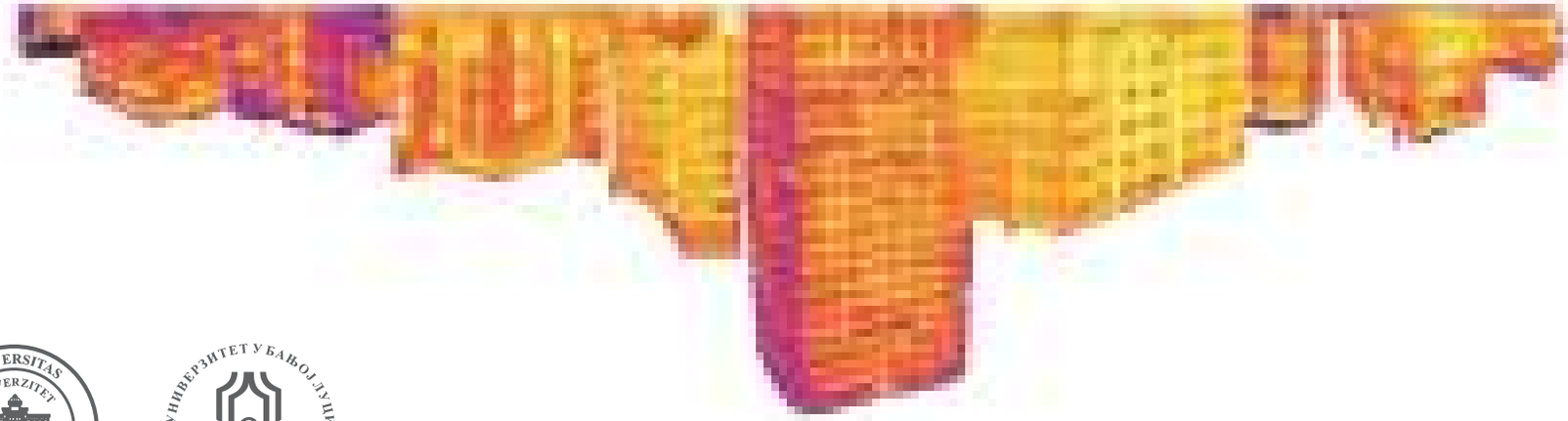
TIPOLOGIJA STAMBENIH ZGRADA BOSNE I HERCEGOVINE
TYPOLOGY OF RESIDENTIAL BUILDINGS IN BOSNIA AND HERZEGOVINA

Dragica Arnautović-Aksić | Mladen Burazor | Nijaz Delalić | Darija Gajić | Petar Gvero
Džana Kadrić | Milovan Kotur | Erdin Salihović | Darko Todorović | Nermina Zagora



Energetska Efikasnost
VRIJEME ZA BOLJA RJEŠENJA

UNIVERSITAS UNIVERZITET USARAJEVU STUDIORUM SARAJEVOENSIS

УНИВЕРЗИТЕТ У БАЊОЈ ЛУЦИ · UNIVERSITY OF BANJA LUKA · 1975

SARAJEVO, 2016.

IZVOD IZ RECENZIJA

Prof. dr. Milica Jovanović-Popović, dipl. ing. arh. (Univerzitet u Beogradu)

Pred nama je kapitalno delo grupe autora, "Tipologija stambenih zgrada Bosne i Hercegovine", knjiga koja svojom temom i postignutim rezultatima zavređuje izuzetnu pažnju. Nastala na principima metodologije projekta Tabula, koji je okupio predstavnike većeg broja evropskih zemalja, kao i na metodologiji i iskustvima istraživačkog tima Arhitektonskog fakulteta Univerziteta u Beogradu, autorima "Nacionalne tipologije stambenih zgrada Srbije", ovo delo predstavlja jedinstveno istraživanje rađeno po prvi put na ovaj način u Bosni i Hercegovini. Popisan je veliki broj stambenih objekata, jednoporodičnog i kolektivnog stanovanja, sagledana njihova tipološka prostorna distribucija, njihove strukturne i energetske performanse i formirana matrica karakterističnih tipova koja u potpunosti reprezentuje Bosnu i Hercegovinu. Za sve karakteristične reprezente predloženi su modaliteti unapređenja s ciljem da se smanji potreba za energijom, čime je omogućeno dalje utvrđivanje mogućnosti ušteda na različitim nivoima, od lokalnog, regionalnog, do nivoa BiH. Dobijeni rezultati ukazuju da stambeni fond BiH može da se tretira kao veliki energetski resurs, odnosno da obnovom ovog fonda mogu da se postignu velike energetske uštede uz istovremeno pokretanje industrijskih procesa u građevinarstvu. Dobijeni rezultati, takođe, predstavljaju osnov za formiranje akcionih planova za energetsku efikasnost na svim postojećim nivoima, a samo istraživanje predstavlja značajan korak ka harmonizaciji propisa s propisima EU.

Doc. dr. Amira Salihbegović, dipl. ing. arh. (Univerzitet u Sarajevu)

"Tipologija stambenih zgrada Bosne i Hercegovine" predstavlja veoma značajnu naučnoistraživačku publikaciju, rađenu u skladu s metodologijom evropskog projekta Tabula, namijenjenog za kreiranje jedinstvenog tipološkog modela za klasifikaciju stambenih objekata, uz mogućost modifikovanja univerzalne matrice, te praćenje i evaluiranje mjera energetske efikasnosti. Usklađenost tipoloških principa primijenjenih u zemljama okruženja i drugim evropskim zemljama pruža mogućnost komparativnih analiza, razmjenu iskustava i inicijativa za poboljšanje karakteristika izgrađenog stambenog fonda.

Publikacija je jedinstvena baza podataka o tipološkim specifičnostima postojećih stambenih zgrada na prostoru Bosne i Hercegovine, hronološki distribuiranih po periodima izgradnje, energetskim svojstvima, prijedlozima za unapređenje i rezultatima, koji mogu poslužiti kao osnov za buduće naučnoistraživačke i stručne projekte. Takođe, ova publikacija je dobra podloga za pripremu strategija i implementaciju mjera EE, unapređenje komfora u stambenim zgradama, kao i racionalizaciju potrošnje energije i energenata na nivou države, te smanjenje emisije CO_2.

Uzimajući u obzir navedeno, sa zadovoljstvom predlažem da se naučnoistraživačka publikacija "Tipologija stambenih zgrada Bosne i Hercegovine" objavi kao naučna knjiga u izdanju Arhitektonskog fakulteta Univerziteta u Sarajevu.

EXCERPT FROM REVIEWS

Prof. dr. Milica Jovanović-Popović, dipl. ing. arh. (University of Belgrade)

What we have here is a major work of a group of authors, "Typology of Residential Buildings in Bosnia and Herzegovina", a book with a topic and results that deserve special attention. It is based on methodology principles of the Tabula project, a project that gathered representatives of a number of European countries, as well as on methodology and experiences of the research team from the Faculty of Architecture of the University of Belgrade, and authors of the National Typology of Residential Buildings of Serbia. This work is a first research of its kind in Bosnia and Herzegovina. A large number of residential buildings, single-family houses and apartment buildings, have been processed; their typical distribution of rooms and areas as well as structural and energy performance have been taken into account and used to produce a matrix that truly depicts the situation in Bosnia and Herzegovina. Improvement measures aimed at reducing energy consumption are presented for each representative type, all for the purpose of defining possibilities for savings on various levels – local, regional and national. The results indicate that the housing stock of BiH can be treated as an energy resource, that is, that reconstruction thereof could results in major energy savings while initiating construction industry processes at the same time. The results can also serve as a basis for energy efficiency action plans on all of the existing levels, while the research itself represents an important step in harmonising national legislation with EU regulations.

Doc. dr. Amira Salihbegović, dipl. ing. arh. (University of Sarajevo)

"The Typology of Residential Buildings in Bosnia and Herzegovina" is an important scientific research publication produced in line with the European TABULA project designed for creation of a unique typological model for classification of residential buildings, with a possibility of modification of its universal matrix, and monitoring and evaluation of energy efficiency measures. The fact that it is harmonised with principles used in the neighbouring countries as well as other countries of Europe enables comparative analyses, exchange of experiences and initiatives for improving characteristics of the existing housing stock.

This publication is a unique database with typological specificities of the existing residential buildings in Bosnia and Herzegovina, chronologically distributed according to the year of construction, energy performance, suggested improvement measures and results, which can be used as a basis for future scientific research and similar projects. In addition, this publication is a good basis for drafting strategies and implementation of energy efficiency measures, comfort improvement in residential buildings, as well as rationalisation of consumption of energy and fuel on the national level, including reduction of CO_2 emissions.

Having in mind the above stated, it is my pleasure to suggest that scientific research publication – "Typology of Residential Buildings in Bosnia and Herzegovina" – is published as a scientific read by the Faculty of Architecture of the University of Sarajevo.

Doc. dr. Dušan Ignjatović, dipl. ing. arh. (Univerzitet u Beogradu)

Knjiga "Tipologija stambenih zgrada Bosne i Hercegovine" predstavlja izuzetno značajan rezultat obimnog istraživanja u oblasti zgradarstva, sprovedenog s ciljem identifikacije i klasifikacije kuća i zgrada s aspekta njihovih materijalno-tehničkih i energetskih karakteristika.

Grupa autora je, polazeći od generativnih principa definisanih evropskim projektom Tabula, a koje je detaljnije razradio i prilagodio lokalnim uslovima istraživački tim s Arhitektonskog fakulteta u Beogradu, sprovela istraživanje na celokupnoj teritoriji Bosne i Hercegovine identifikujući relevantne pojavne oblike stambenih kuća i zgrada, kao i njihove osnovne karakteristike. Osnovni rezultat istraživanja formulisan u vidu tipologije predstavlja jedinstveni pregled stambenog fonda koji može da posluži kao osnov za donošenje strateških odluka i formulisanje planova na različitim prostornim nivoima.

Osim identifikacije postojećeg stanja autori su, u svom radu, analizirali i mogućnosti unapređenja materijalno-tehničkih karakteristika zgrada, odnosno potencijala uštede energije u procesu njihove rekonstrukcije predlažući jasna i primenljiva tehnička rešenja. Ostvarujući lokalnu prepoznatljivost identifikovanih modelskih zgrada i istovremeno univerzalnost primenjenih principa rezultati postaju dostupni, kako pojedinačnim korisnicima, vlasnicima odnosno upraviteljima zgrada, tako i državnim organima različitih nivoa koji istraživanje mogu da koriste za definisanje akcionih planova u oblasti energetske efikasnosti odnosno planiranje budućih investicija i drugih aktivnosti u oblasti građevinarstva.

Doc. dr. Dušan Ignjatović, dipl. ing. arh. (University of Belgrade)

"The Typology of Residential Buildings in Bosnia and Herzegovina" is a very important result of a comprehensive research in the field of building design and construction conducted for the purpose of identifying and classification of houses and buildings in terms of their technical and energy characteristics.

The group of authors based their work on the generic principles defined in the European TABULA project and further developed and adapted to local conditions by the research team of the Faculty of Architecture in Belgrade, and conducted a research on the entire territory of Bosnia and Herzegovina identifying relevant types of houses and residential buildings and their basic characteristics. The main result of the research formulated as a typology represents a unique overview of the housing stock that can be used for strategic decision-making and formulation of plans on different spatial levels.

In addition to identifying the current situation, the authors analysed potentials for improvement of material and technical characteristics of buildings, that is, potentials for energy savings in the process of their reconstruction, by proposing clear and applicable technical solutions. Having in mind that identified building types are easily recognisable and universality of the principles used, results can be achieved by anyone from house owners, building managers, to state institutions of different levels that can use this research in defining their energy efficiency action plans, planning of future investments, and other activities in the field of construction and civil engineering.

Prof. dr. Veljko Đuričković, dipl. ing. maš. (Univerzitet u Banjoj Luci)

Usklađivanje bosanskohercegovačkog zakonodavstva s evropskim pravnim nasljedstvom je uslov za pristupanje Bosne i Hercegovine Evropskoj uniji. Jedna od veoma važnih aktivnosti u vezi s tim jeste prijenos Direktive o energetskim svojstvima zgrada (Directive 2002/91/EC on Energy Performance of Buildings). Posljednjih desetak godina Evropske inicijative, sadržane u paketu mjera za poticanje korištenja energije iz obnovljivih izvora kao i prerađenoj Direktivi o energetskim svojstvima zgrade (Directive 2010/31/EU on the Energy Performance of Buildings - recast), postavljaju sektor graditeljstva u ključnu ulogu energetske politike i politike zaštite okoline. Knjiga "Tipologija stambenih zgrada Bosne i Hercegovine" urađena je u skladu s navedenim Direktivama i predstavlja prvi dio velikog posla koji u Bosni i Hercegovini treba uraditi u domenu termoenergetike. Da bi se rezultati ove veoma važne studije mogli praktično koristiti u inženjerskoj praksi, potrebno je što prije uraditi sljedeću studiju: "Projektni uslovi za definisanje toplotnog bilansa građevinskih objekata u Bosni i Hercegovini", pa u vezi s tim izložiti i kritički osvrt na postojeću podjelu područja Bosne i Hercegovine na klimatske zone.

Predočena dokumentacija predstavlja originalnu naučnu studiju, zasnovanu na uvidima u dostignuća savremene nauke i tehnologije. Urađena je u skladu sa bh. zakonodavstvom, evropskim pravnim nasljedstvom i evropskom Direktivom o energetskim svojstvima zgrada 2002/91/EC. Na osnovu toga se može zaključiti da sadržajem i metodski u potpunosti odgovara oblasti za koju je namijenjena.

Studiji je priložen popis stručne i naučne literature novijeg datuma, na osnovu čega se može zaključiti da su autorima poznati rezultati novijih istraživanja iz ove oblasti, kao i savremene metode istraživanja, podržane novim računarskim pristupima i programima. Stručna terminologija je izložena korektno, kao i mjerne jedinice. Rezultati istraživanja su izloženi pregledno, u odgovarajućim tabelama i grafičkim prikazima.

Prof. dr. Veljko Đuričković, dipl. ing. maš. (University of Banja Luka)

Harmonisation of national legislation with EU *acquis communautaire* is one of the conditions for accession of Bosnia and Herzegovina to the Union. A very important activity thereof is transposition of the Directive 2002/91/EC on Energy Performance of Buildings. Over the last decade or so, European initiatives contained in the series of measures supporting the use of renewable energy sources and the recast Directive 2010/31/EU on the Energy Performance of Buildings, have been positioning civil engineering in the focus of the energy policy and the environment policy. The book titled "Typology of Residential Buildings in Bosnia and Herzegovina" has been prepared in line with the above mentioned Directives and represents the first stage of a comprehensive task Bosnia and Herzegovina needs to perform in the field of thermal energetics. For the results of this important study to be useful in engineering practice, the following study needs to be conducted as soon as possible: Design conditions for defining thermal balance of buildings in Bosnia and Herzegovina", which would also result in a critical overview of the existing distribution of climate zones of Bosnia and Herzegovina.

Provided documents represent the original scientific study based on insights regarding achievements of modern science and technology. They have been prepared in line with national legislation, the *acquis communautaire*, and the EU Directive 2002/91/EC on Energy Performance of Buildings. Therefore, it can be concluded that both their content and methodology are fully compliant with the field they are designed to serve.

The Study is accompanied by a list of contemporary professional and scientific literature, indicating that the authors are well informed on relevant recent research, as well as with modern research methods supported by modern computer-based approaches and software. Specific terminology and measuring units are presented properly. Research results are provided in a convenient layout, with appropriate tables and diagrams.

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SARAJEVO, 2016.

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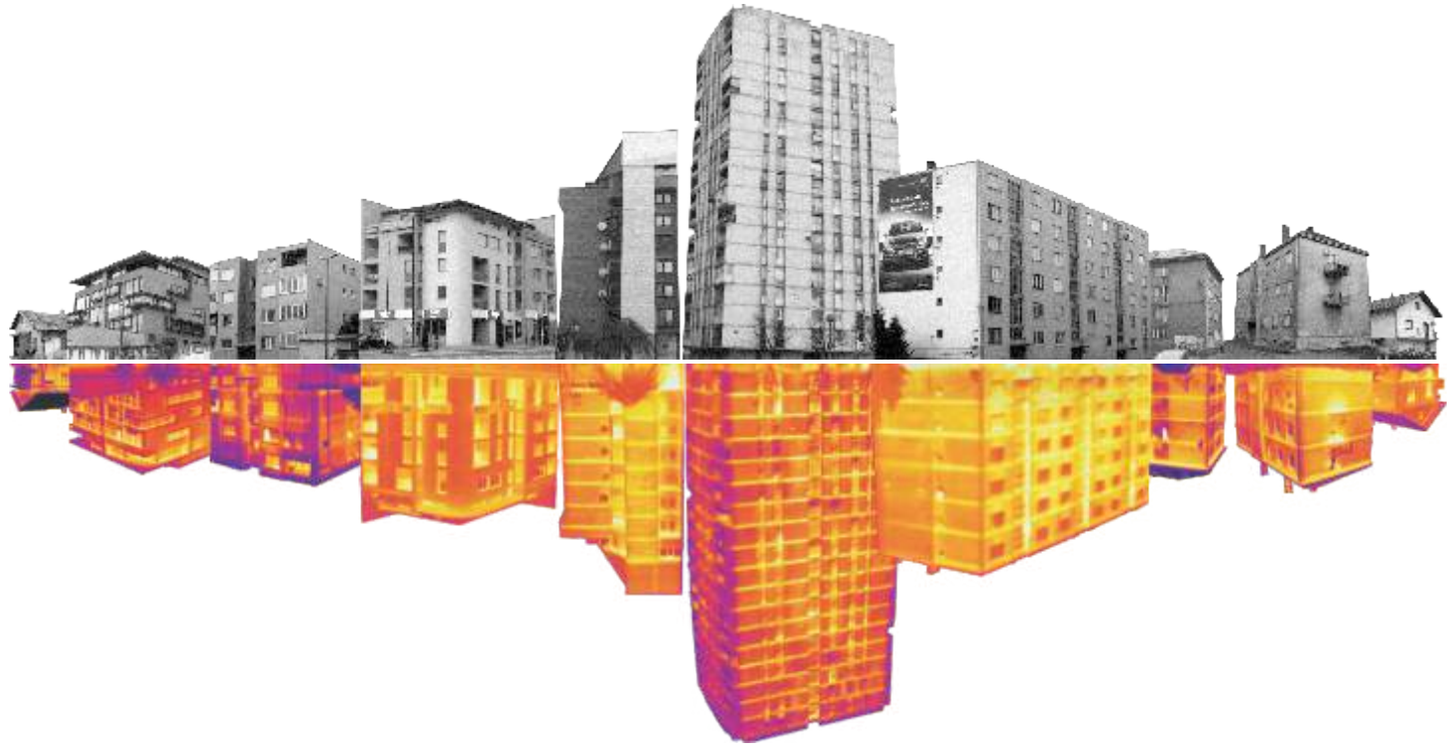

PREDGOVOR

Poštovani čitaoci,

U rukama držite knjigu u kojoj se nalazi jedno od najznačajnijih istraživanja na temu energetske efikasnosti i fonda stambenih objekata u Bosni i Hercegovini. Tijekom posljednje dvije godine tim posvećenih stručnjaka s arhitektonskih i mašinskih fakulteta u zemlji ulagao je velike napore kako bi izradio dosad prvu bazu podataka o energetskim karakteristikama i modelima eventualnih unapređenja za cjelokupan fond stambenih zgrada - Tipologiju stambenih zgrada Bosne i Hercegovine.

Rukovodeći se poznatom i priznatom evropskom TABULA metodologijom (*Typology Approach of Building Stock for Energy Efficiency Assessment* – Tipološki pristup stambenom fondu za procjenu energetske efikasnosti) za potrebe ovog istraživanja, Bosna i Hercegovina je sada članica grupe 14 EU zemalja i Srbije koje koriste ovakav pristup prikupljanju klaster podataka za primjenu u strateškoj analizi i donošenju odluka u sektoru energetske efikasnosti.

U ovoj publikaciji je predstavljena iscrpna analiza stambenog fonda u zemlji, njegova klasifikacija, trenutno stanje energetskih karakteristika u 29 različitih reprezentativnih tipova zgrada, te modeli sanacije u dva nivoa za svaki pojedinačni tip. Uz prilog u vidu detaljnih statističkih informacija o stambenom fondu, kao što je broj zgrada određenog tipa, ova jedinstvena baza podataka će poslužiti u različite svrhe:

- Ministarstva, fondovi za okoliš i energetsku efikasnost, kao i druge državne institucije, mogu koristiti ovu tipologiju za izračun i osmišljavanje programa i planova provedbe mjera energetske efikasnosti u sektoru stambenih objekata. Tipologija pomaže u određivanju sektorskih ciljeva i preciznom oblikovanju akcionih planova za energetsku efikasnost na različitim nivoima vlasti.
- Domaće i međunarodne institucije za finansiranje mogu koristiti matricu ove tipologije, kao i njene statističke informacije, za definiranje ciljnih tipova stambenih zgrada i ciljnog sektora stambenog fonda na koje žele usmjeriti svoje programe pomoći, kreditne linije i grantove, kao i za pronalaženje eventualnih mogućnosti uštede.
- Modeli sanacije se mogu iskoristiti i za pojednostavljene pristupe praćenju spomenutih programa.
- Firme koje se bave proizvodnjom građevinskog materijala i opreme na osnovu ovih podataka mogu izvršiti procjene tržišnih potencijala svojih proizvoda i oblikovati pristup vlasnicima određenih tipova zgrada.

PREFACE

Dear Reader,

With this publication you hold one of the most significant researches in the field of the energy efficiency and the residential building stock in Bosnia and Herzegovina in your hands. In a two-year intensive endeavor a team of dedicated experts from mechanical and architecture faculties of the country created the first ever database of the energy characteristics and potential refurbishment models of the entire residential building stock: The Residential Building Typology of Bosnia and Herzegovina!

By following the widely acknowledged European TABULA methodology (Typology Approach of Building Stock for Energy Efficiency Assessment) for this research, Bosnia and Herzegowina is now also part of a group of 14 EU-countries and Serbia, which uses this approach to collect and cluster data for strategic analysis and decision making in the energy efficiency sector.

In this book you will find an extensive analysis of the country's housing stock, its classification, the status quo of energy characteristics of 29 different representative building types and two levels of refurbishment models per type. Supplemented with vast statistical information on the housing stock, such as number of buildings per type, this unique database will serve a variety of purposes:

- Ministries, Environment and Energy Efficiency Funds and other government institutions can use the typology for calculation and design of implementation programmes and schemes for energy efficiency in the residential building sector. It supports the setting of sector targets and refining of action plans for energy efficiency on different levels of government.
- Domestic and international financing institutes can use the typology matrix and statistical information to define target types of building and target sector of the building stock for their support programmes, credit lines and grants, as well as to define the potential savings.
- The refurbishment models can as well be used for simplified monitoring approaches of above mentioned programmes.
- Companies of the construction material and building equipment production sector can use the data to estimate the market potentials of their products and may define their marketing approach to owners of certain building types.

- Inženjerima su ove informacije od koristi u svakodnevnom radu na zgradama koje su ovim obuhvaćene, jer se mogu saznati detalji o građevinskom materijalu i energetskom učinku, te mogućnostima za poboljšanja.
- Vlasnici zgrada, građani, kao i svi zainteresirani mogu lako prepoznati tip zgrade koji koriste i jednostavno doći do procjene stanja zgrade i mogućnosti za sanaciju odnosno njeno unapređenje.

Iskreno se nadamo da će zainteresirani često i rado koristiti ovu knjigu u navedene svrhe. Također bismo pozvali sve vas da se slobodno obratite autorima za eventualna pojašnjenja i dodatne informacije.

Na kraju, željeli bismo zahvaliti cjelokupnom istraživačkom timu na posvećenosti i profesionalnosti koje su pokazali radeći na ovoj tipologiji. Posebnu zahvalnicu želimo uputiti Tobiasu Logi, Nikolausu Diefenbachu i gospođi Britti Stein iz Instituta za stanovanje i okoliš (Institut für Wohnen und Umwelt - IWU), Darmstadt, koji su srdačno prihvatili Bosnu i Hercegovinu u Evropsku zajednicu istraživača tipologije i pružili korisne informacije tijekom rada. Profesorica Milica Jovanović-Popović i Dušan Ignjatović s Arhitektonskog fakulteta u Beogradu, Srbija, uvijek su nam bili na raspolaganju i s nama dijelili svoja iskustva u izradi tipologije u Srbiji.

Uživajte u knjizi i rezultatima istraživanja.

Lutz Jarczynski
Vođa Projekta energetske efikasnosti, GIZ

Esad Smajlovic
Viši savjetnik za energetsku efikasnost, GIZ

- Engineers find useful information for their day to day work, such as reference buildings, its construction materials and energy performance and refurbishment options.
- Building owners, citizens, interested members of the general public will recognize their building type and can easily obtain an estimate of the status quo of their building and potential options for refurbishment.

We sincerely hope that the book will be widely used by interested stakeholders for the above mentioned purposes! We would also like to encourage every reader to approach the authors for additional clarifications and information, in case the need arises.

Finally, we would like to thank the entire research team for their dedication and professional work to compile this typology. Special thanks has to be given to Mr. Tobias Loga, Mr. Nikolaus Diefenbach and Mrs. Britta Stein from the “Institut für Wohnen und Umwelt (IWU), Darmstadt”, who openly welcomed Bosnia and Herzegovina in the European typology research community and provided useful guidance throughout the process. Professor Milica Jovanovic-Popovic and Mr. Dusan Ignjatovic from the Faculty of Architecture of Belgrade, Serbia, were always available to share their experience from the typology creation in Serbia.

Enjoy the book and the research results!

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I. UVOD

Potrošnja energije iz neobnovljivih izvora dovodi do osiromašenja prirodnih resursa i degradacije životne sredine u svim segmentima: vazduh, voda i tlo, a jedna od direktnih posljedica je promjena klime i životnih uslova na Zemlji. Ključni pristup za ublažavanje klimatskih promjena jeste smanjenje nivoa korištenja energije, odnosno energetskog intenziteta, zadržavajući isti ili omogućavajući veći komfor koji pruža takvo djelovanje energije. Ovaj pristup predstavlja osnovu za sve aktivnosti koje se preduzimaju u oblasti povećanja energetske efikasnosti.

Za Bosnu i Hercegovinu, kao i većinu zemalja u tranziciji, karakterističan je visok energetski intenzitet. Prema podacima Međunarodne agencije za energiju [1] energetski intenzitet BiH je 0,5 toe/1000 USD BDP-a. Poređenja radi, to je četiri puta više od prosjeka u Evropskoj uniji i u zemljama članicama OECD-a. Prosječna evropska zemlja za istu količinu utrošene energije ostvari četiri puta više nacionalnog dohotka nego BiH. Prema istom izvoru, u poređenju sa zemljama Evropske unije, Bosna i Hercegovina ima deset puta niži BDP i troši tri puta manje primarne energije po stanovniku. Razlozi za to nalaze se u činjenici da je u Bosni i Hercegovini nizak životni standard i da je nedovoljno razvijena industrija. Energetski intenzitet Bosne i Hercegovine je sličan onom u Srbiji (0,52) i Bugarskoj (0,48), dok znatno bolji intenzitet imaju Hrvatska (0,17) i Slovenija (0,18), te Švajcarska (0,06).

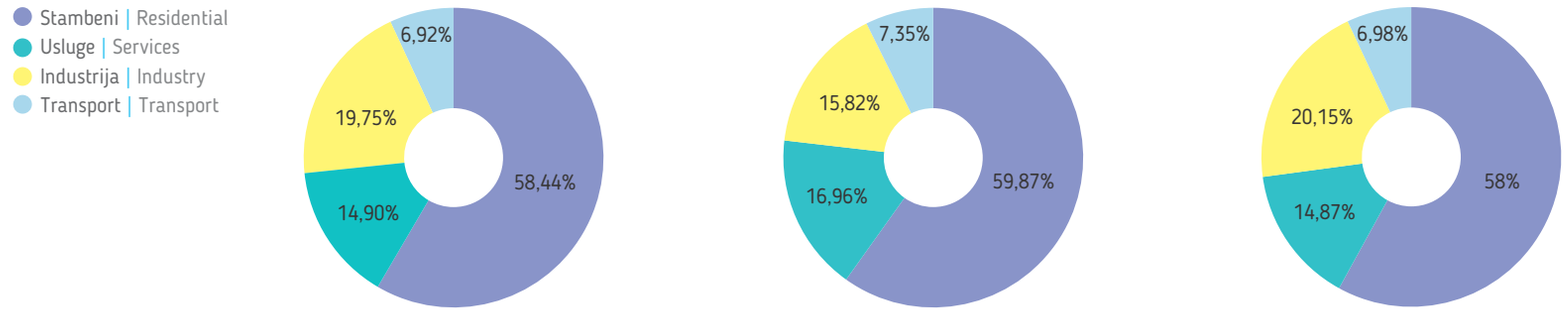
S obzirom na procjenu da se oko 58,44% od ukupne energije u Bosni i Hercegovini koristi u stambenom sektoru [2], što je značajno više od prosjeka EU, jedan od prioritetnih ciljeva treba da bude pronalaženje načina kako da se smanji potrošnja energije kako u postojećim tako i novim stambenim objektima (Slika1).

I. INTRODUCTION

Energy consumption from non-renewable sources results in depletion of natural resources and degradation of environment in all segments: air, water and soil, causing the climate change and affecting the living conditions on Earth. The key approach for climate change mitigation is reduction of the level of energy consumption, that is, of energy intensity by preserving the same or enabling greater comfort that such energy effect offers. This approach represents the foundation for all activities being undertaken in the field of energy efficiency increase.

High energy intensity is attributive to Bosnia and Herzegovina, as is for the most countries in transition. According to International Energy Agency data [1] the energy intensity of BiH is 0.5 toe/1000 USD of GDP. For comparison purposes, it is four times higher than the average in the European Union and in other OECD member states. An average European country for the same amount of consumed energy earns four times more national income than BiH. According to the same source, compared to European Union countries, Bosnia and Herzegovina has ten times lower GDP and consumes three times less primary energy per capita. Reasons for this can be found in the fact that standard of living in Bosnia and Herzegovina is low and that industry is insufficiently developed. Energy intensity of Bosnia and Herzegovina is similar to that in Serbia (0.52) and Bulgaria (0.48), whereas Croatia (0.17), Slovenia (0.18) and Switzerland (0.06) have significantly better intensity.

Given the estimate that about 58.44% of the total energy in Bosnia and Herzegovina is used in the residential sector [2], which is significantly higher than the EU average, one of the priority goals should be to find a way to reduce the energy consumption in residential buildings, both existing and new ones (Figure 1).



Slika 1. Pregled potrošnje finalne energije po sektorima za 2010. godinu prema Prvom nacionalnom akcionom planu za energetsku efikasnost (NEEAP) 2010-2018. iz 2012. godine u Bosni i Hercegovini (slika lijevo), odnosno u Republici Srpskoj (slika u sredini) i u Federaciji Bosne i Hercegovine (slika desno)
Figure 1. Overview of the final energy consumption per sectors for 2010 according to the First National Energy Efficiency Action Plan (NEEAP) 2010-2018 from 2012 in Bosnia and Herzegovina (figure on the left) that is in Republic of Srpska (figure in the middle) and in the Federation of Bosnia and Herzegovina (figure on the right)

Mnoštvo strateških dokumenata u Bosni i Hercegovini, s nivoa entiteta, regiona i lokalnih zajednica, bavilo se procjenama potrošnje energije u zgradama na nivou finalne energije i energenata (električne, toplotne, prirodnog gasa, nafte i naftnih derivata, uglja i biomase), kao i mogućnostima da se ona smanji. Procjene nisu vršene na osnovu pouzdanih podataka o potrošnji energije u zgradama koji su dobijeni putem energetskih audita/pregleda stambenih objekata, nego na osnovu statističkih podataka, energetskih bilansa i planova razvoja energetike, odnosno korišten je pristup "odozgo prema dole".

Zahvaljujući GIZ-u (Njemačkoj vladinoj organizaciji za tehničku pomoć i saradnju/Deutsche Gesellschaft für Internationale Zusammenarbeit) iniciran i realizovan je naučnoistraživački projekat pod nazivom *Tipologija stambenih objekata Bosne i Hercegovine* u trajanju od dvije godine. Prvi dio ovog projekta se sastojao od pripreme metodologije rada, obimnog terenskog istraživanja, angažmana statističke agencije za popis i prijedloga reprezentativnih objekata, a u drugom dijelu je dat izbor tipičnih objekata, energetski pregled izabranih objekta, proračun potrebne energije za grijanje objekata, tipizacija građevinskih konstrukcija tipičnih objekata, tipizacija termoenergetskih sistema za grijanje i pripremu potrošne tople vode, te prijedlog mjera za unapređenje arhitektonsko-građevinskih dijelova objekata i mjera unapređenja sistema grijanja i potrošne tople vode. Projekat je rađen u skladu s metodologijom evropskog projekta *TABULA*[1], koja podrazumijeva klasifikaciju tipologije i evaluaciju mjera energetske efikasnosti stambenih objekata u Bosni i Hercegovini. Rezultati projekta prezentovani su u knjizi i na web stranici projekta *EPISCOPE*[2], koji predstavlja nastavak projekta *TABULA*. Autorski tim knjige *Tipologija stambenih zgrada u Bosni i Hercegovini* čine nastavnici i saradnici Arhitektonskog fakulteta i Mašinskog fakulteta Univerziteta u Sarajevu, te Arhitektonsko-građevinsko-geodetskog fakulteta i Mašinskog fakulteta Univerziteta u Banjoj Luci, kao i nezavisni eksperti.

Knjiga *Tipologija stambenih zgrada Bosne i Hercegovine,* prvi put na području Bosne i Hercegovine, prezentuje klasifikaciju postojećih stambenih objekata prema vrsti i periodu gradnje sve do 2014. godine. Zahvaljujući brojnim informacijama koje knjiga sadrži, ona može da posluži kao polazna osnova u pripremi strategija koje imaju za cilj smanjivanje potrošnje energije u stambenom sektoru BiH.

[1] *TABULA*, skr. od *Typology Approach for Building Stock Energy Assessment*, engl. tipološki pristup energetskoj ocjeni građevinskog fonda.
[2] http://episcope.eu

A number of strategic documents in Bosnia and Herzegovina, at the level of entities, region and local communities, have dealt with energy consumption evaluations in buildings at the level of final energy and energy generating products (electric, heat, natural gas, oil and oil derivatives, coal and biomass) as well as possibilities for its reduction. Evaluations have not been done based on reliable data on energy consumption in buildings which have been obtained by energy audits of residential buildings, but based on statistical data, energy balance and energetics development plans, that is, a "top-down" approach has been used.

Thanks to the GIZ (a German governmental organisation for technical assistance and cooperation/Deutsche Gesellschaft für Internationale Zusammenarbeit) a scientific and research project titled *Typology of Residential Buildings in Bosnia and Herzegovina* was initiated and implemented over a period of two years. The first part of this project consisted of preparation of the work methodology, comprehensive field research, assistance of Agency for Statistics concerning inventory and proposals of representative buildings and the second part provided the choice of typical buildings, energy audits of selected buildings, calculation of energy need for heating of buildings, typification of building structures of typical buildings, typification of thermo-technical systems for heating and domestic hot water system as well as proposal of measures for improving architectural and construction building parts and measures for improving heating systems and domestic hot water system. The project was done in accordance with the methodology of the European project of *TABULA*[1], which implied classification of typology and evaluation of energy efficiency measures of residential buildings in Bosnia and Herzegovina. Project results were presented in the book and on the website of the project *EPISCOPE*[2], which is a continuation of the project *TABULA*. A team of authors of the book *Typology of Residential Buildings in Bosnia and Herzegovina* is composed of professors and associates of the Faculty of Architecture and Faculty of Mechanical Engineering of the Sarajevo University and Faculty of Architecture, Civil Engineering and Geodesy and Faculty of Mechanical Engineering of the University of Banja Luka as well as independent experts.

The book *Typology of Residential Buildings in Bosnia and Herzegovina* presents for the first time in the territory of Bosnia and Herzegovina the classification of existing residential buildings according to the type and period of construction until 2014. Thanks to numerous information contained in the book, it could serve as the starting point for preparation of strategies which have the goal of reducing the energy consumption in the residential sector of BiH.

[1] *TABULA*, abbr. from *Typology Approach for Building Stock Energy Assessment.*
[2] http://episcope.eu

METODOLOGIJA NAUČNO-ISTRAŽIVAČKOG RADA

Metodološki okvir istraživanja tipologije stambenih objekata Bosne i Hercegovine je baziran na evropskom internacionalnom istraživačkom projektu *TABULA* usklađenom s direktivama 2002/91/EC i 2006/32/EC, a sufinansiran je iz programa Evropske komisije IEE[3]. Projekat *TABULA*, čiji su inicijatori istraživači s Instituta za stanovanje i ekologiju IWU[4] iz Darmstadta, utvrđuje jedinstveni okvir za klasifikaciju tipologije stambenih objekata u Evropi, s definisanom metodologijom proračuna energetskih karakteristika objekata. Metodologija projekta *TABULA* primijenjena je u 20 evropskih država, a rezultati istraživanja javno su prezentovani na zvaničnoj web stranici projekta,[5] te u vidu knjiga i brošura u kojima su grafički ilustrovani energetski indikatori postojećeg stanja i efekti mjera unapređenja energetske efikasnosti. Istraživanje, koje je inicirano konceptom *TABULA*, nastavljeno je i prošireno u projektu *EPISCOPE*, kojim se prati proces implementacije mjera unapređenja energetske efikasnosti unutar evropskog fonda stambenih objekata.

Okosnicu projekta *TABULA* predstavlja kreiranje jedinstvenog tipološkog modela klasifikacije stambenih objekata, kojeg čine sljedeći elementi [3]:

- *Koncept klasifikacije postojećih stambenih objekata prema periodu izgradnje, veličini i drugim parametrima;*
- *Tipični objekti, koji predstavljaju tipične kategorije stambenih objekata;*
- *Vrijednosti potrošnje energije tipičnih objekata;*
- *Prikaz proračuna mogućih energetskih ušteda,*
- *Statistički podaci za objekte i sistema za snabdijevanje energijom.*

Zbog nedostatka podataka o postojećem stambenom fondu Bosne i Hercegovine, bosanskohercegovački ekspertni tim odlučio se za sprovođenje popisa objekata i primjenu statističkih analiza,[6] kao pouzdane osnove za klasifikaciju stambenih objekata na osnovu sličnosti njihovih opštih i specifičnih karakteristika.

Nakon definisanja ciljeva i zadataka istraživanja utvrđen je plan realizacije istraživačkog rada na projektu *Tipologija stambenih objekata Bosne i Hercegovine*, koji se sastojao iz sljedećih koraka:

[3] IEE, skr. od *Intelligent Energy Europe*
[4] IWU, skr. od Institut Wohnen und Umwelt GmbH
[5] http://episcope.eu/building-typology
[6] Za razliku od većine evropskih istraživačkih timova, učesnika projekta *TABULA*, koji su tipološku klasifikaciju i izbor tipičnog objekta izvršili na osnovu dostupnih statističkih podataka, tim eksperata s Univerziteta u Beogradu je, za specifične potrebe naučnoistraživačkog projekta "Nacionalna tipologija stambenih zgrada Srbije" (Jovanović Popović, i dr. 2013), sproveo namjenski popis stambenih objekata sa statističkom obradom podataka.

SCIENTIFIC RESEARCH METHODOLOGY

The methodological framework of typology of residential buildings research of Bosnia and Herzegovina is based on European international research project *TABULA* harmonised with the directives 2002/91/EC and 2006/32/EC, and co-financed from the European Commission IEE[3] programme. The *TABULA* project, whose initiators come from the Institute for housing and environment IWU[4] from Darmstadt, defines a single framework for classification of typology of residential buildings in Europe, with a defined methodology of calculation of energy characteristics of buildings. The *TABULA* project methodology has been applied in 20 European countries and research results have been presented to the public on the official website of the project,[5] and in the form of a book and leaflets in which energy indicators of the existing condition and effects of measures of energy efficiency improvement have been illustrated graphically. The research, initiated by the *TABULA* concept, has been continued and expanded in the *EPISCOPE* project that monitors the process of implementation of energy efficiency improvement measures within the European fund for residential buildings.

The basis of the *TABULA* project represents creation of a unique typological model of classification of residential buildings, composed of the following elements [3]:

- *Classification concept of the existing residential buildings according to the construction period, size and other parameters;*
- *Typical buildings, which represent typical categories of residential buildings;*
- *Values of energy consumption of typical buildings;*
- *Presentation of calculations of possible energy savings,*
- *Statistical data for buildings and energy supply systems.*

Due to a lack of data on the existing housing stock of Bosnia and Herzegovina, a team of experts of Bosnia and Herzegovina decided to implement the inventory of buildings and apply statistical analyses,[6] as reliable bases for classification of residential buildings based on similarity of their general and specific characteristics.

After defining goals and tasks of the research, the plan of implementation of the research paper on the project *Typology of Residential Buildings in Bosnia and Herzegovina* was defined, which consisted of the following steps:

[3] IEE, abbr. from *Intelligent Energy Europe*
[4] IWU, abbr. from Institut Wohnen und Umwelt GmbH
[5] http://episcope.eu/building-typology
[6] Unlike most European research teams, participants of the project *TABULA*, who carried out the typological classification and selection of typical buildings based on available statistical data, the team of experts of the University of Belgrade, implemented a special-purpose inventory of residential buildings with a statistical data processing for the specific requirements of the scientific-research project titled *"National Typology of Residential Buildings of Serbia"* (Jovanović Popović et al. 2013).

1. Analiza postojećih propisa, normativa i prethodnih istraživanja iz oblasti projektovanja i energetske efikasnosti stambene arhitekture Bosne i Hercegovine;
2. Utvrđivanje kriterija za klasifikaciju stambenih objekata u Bosni i Hercegovini;
3. Definisanje dvostepenih formulara (Upitnik „A“ i Upitnik „B“) namijenjenih terenskom radu statističke agencije;
4. Popis stambenih objekata, statistička i klaster analiza;
5. Kontrola kvalitete terenskog rada statističke agencije koju obavljaju ekspertni timovi;
6. Odabir tipičnih objekata - predstavnika kategorija stambenih objekata;
7. Tehničko snimanje i analiza tipičnih objekata;
8. Proračun energetskih karakteristika objekata;
9. Publikacija i diseminacija rezultata projekta.

U skladu s predstavljenim planom rada, u toku razvoja projekta *Tipologija stambenih objekata Bosne i Hercegovine*, primijenjene su sljedeće naučnoistraživačke metode:

A | Istorijska metoda
Istorijska metoda je primijenjena kroz analizu hronologije zakonskih propisa i tehničkih uslova iz oblasti projektovanja, izgradnje i energetske efikasnosti stambenih objekata, na osnovu koje su definisani osnovni parametri za periodizaciju postojećih stambenih objekata u Bosni i Hercegovini.

B | Induktivno-deduktivna metoda
Primjena induktivno-deduktivne metode je doprinijela da se na osnovu pojedinačnih činjenica i opštih logičkih obilježja utvrde jedinstveni kriteriji za periodizaciju i klasifikaciju stambenih objekata u Bosni i Hercegovini. Induktivno-deduktivna metoda je bila od presudnog značaja prilikom transponovanja pojedinačnih podataka o arhitektonskim i energetskim karakteristikama tipičnih objekata na nivo cjelokupnog stambenog fonda Bosne i Hercegovine.

C | Komparativna metoda
Komparativna metoda je korištena prilikom utvrđivanja urbanističko-arhitektonskih parametara u klasifikaciji stambenih objekata u Bosni i Hercegovini, pri čemu je izvršena usporedba s tipološkim principima koji su primijenjeni u drugim evropskim zemljama (npr. Njemačka, Grčka, Velika Britanija). S obzirom na društveno-istorijski kontekst i zajedničko porijeklo najvećeg dijela stambenog fonda (bivša Jugoslavija), tipologija stambenih objekata Bosne i Hercegovine je u velikoj mjeri uporediva s tipologijom stambenih objekata Republike Srbije, s izvjesnim razlikama u kriterijima periodizacije stambenog fonda.

1. Analysis of existing regulations, standards and previous researches in the field of design and energy efficiency of residential architecture of Bosnia and Herzegovina;
2. Establishment of criteria for classification of residential buildings in Bosnia and Herzegovina;
3. Defining two-stage forms (Questionnaire “A” and Questionnaire “B”) intended for the field work of the statistics agency;
4. Inventory of residential buildings, statistic and cluster analysis;
5. Quality control of field work of the agency for statistics conducted by expert teams;
6. Selection of typical buildings – representatives of residential building categories;
7. Technical recording and analysis of typical buildings;
8. Calculation of energy characteristics of buildings;
9. Publication and distribution of project results.

In accordance with the presented work plan, during development of the project *Typology of Residential Buildings in Bosnia and Herzegovina*, the following scientific-research methods were applied:

A | Historical method
The historical method was applied through the analysis of chronology of legal regulations and technical conditions in the field of designing, construction and energy efficiency of residential buildings, based on which basic parameters for periodization of the existing residential buildings in Bosnia and Herzegovina were defined.

B | Inductive-deductive method
The application of an inductive-deductive method contributed to establishment of unique criteria for periodization and classification of residential buildings in Bosnia and Herzegovina based on individual facts and general logical characteristics. The inductive-deductive method was of a crucial significance during transposition of individual data on architectural and energy characteristics of typical buildings to the level of the entire housing stock of Bosnia and Herzegovina.

C | Comparative method
The comparative method was used upon defining urban-architectural parameters in classification of residential buildings in Bosnia and Herzegovina upon which comparison with typological principles applied in other European countries (for example in Germany, Greece, Great Britain) was carried out. Bearing in mind the sociohistorical context and common origin of the greatest part of the housing stock (former Yugoslavia), typology of residential buildings of Bosnia and Herzegovina can to a great extend be compared to the typology of residential buildings of the Republic of Serbia, with certain differences in criteria of the housing stock periodization.

D | Statistička metoda

U okviru rada na projektu *Tipologija stambenih objekata Bosne i Hercegovine*, statistička agencija[7] je prikupila i obradila podatke na uzorku od 13.044 objekta individualnog i kolektivnog stanovanja u Bosni i Hercegovini, uzimajući u obzir regionalnu i tipološku zastupljenost predmetnog uzorka. Na osnovu prethodno utvrđenih arhitektonsko-urbanističkih kriterija eksperti za statistiku su izvršili ponderisanje podataka, nakon čega je sprovedena klaster analiza u kojoj su popisani objekti grupisani u šest relativno homogenih cjelina, te hronološki razvrstani prema periodu izgradnje, za potrebe odabira tipičnih objekata.

E | Metoda opservacije

Istraživanje uz primjenu metode opservacije realizovano je u prvoj fazi projekta kada su terenski timovi statističke agencije, prema zadatim uputstvima a na osnovu uvida u vanjski izgled objekta, zabilježili opšte podatke o stambenim objektima. Na ovaj način su, prema obrascu prvostepenog Upitnika „A“, prikupljeni i sistematizovani podaci o svim objektima, koji se odnose na veličinu, formu, godinu izgradnje, vanjski izgled, završnu materijalizaciju objekta i sl.

F | Anketna metoda

S ciljem da se dobiju detaljni podaci o stambenim objektima, u postupku istraživanja je primijenjena i anketna metoda. Anketiranje je podrazumijevalo popunjavanje Upitnika „B“, odnosno ulazak anketara u svako četvrto domaćinstvo popisano prema Upitniku „A“ (3.261 stambeni objekat) i razgovor s vlasnicima ili predstavnicima etažnih vlasnika, radi prikupljanja detaljnih podataka o karakteristikama zgrade koji utiču na energetsku efikasnost (materijalizacija omotača zgrade: krova, vanjskih zidova, podova, međuspratnih konstrukcija, vrste prozora, sistema grijanja itd.). Ukoliko postoji projektno-tehnička dokumentacija izvršena je provjera da li je objekat izveden prema projektu, te evidentirana eventualna odstupanja od projekta, kao i promjene izvornog oblika zgrade.

Metodologija popisa stambenih zgrada

Nakon utvrđene periodizacije i tipologije stambenih objekta u Bosni i Hercegovini, u skladu s ciljem i predmetom istraživanja, kreirani su dvostepeni formulari – Upitnik „A“ i Upitnik „B“, namijenjeni terenskom radu statističke agencije.

Pri određivanju sadržaja upitnika stavljen je akcenat na ključne varijable s jednostavnim, konkretnim i razumljivim pitanjima, pri čemu prvostepeni formular „A“ sadrži osnovne podatke o objektu, kao što su njegove geometrijske karakteristike, površina osnove, broj spratova, broj stanova itd., koji su prikupljeni opservacijskom metodom terenskih timova.

[7] Statistička agencija IPSOS.

D | Statistical method

Within the framework of work on the project Typology of Residential Buildings in Bosnia and Herzegovina, the statistics agency[7] collected and processed data on the sample of 13,044 buildings of single-family housing and collective housing in Bosnia and Herzegovina, taking into consideration regional and typological representation of the sample concerned. Based on previously defined architectural-urban criteria, statistics experts have carried out data weighing, after which a cluster analysis was carried out in which listed buildings were grouped in six relatively homogenous units and chronologically classified according to the construction period, for the requirements of typical building selections.

E | Observation method

Research with the use of observation method was implemented in the first phase of the project, when field teams of the statistics agency, in accordance with the given instructions and based on inspections of the external look of buildings, recorded general data on residential buildings. In this manner, according to the form of the first-stage Questionnaire “A”, were collected and systematized data on all buildings pertaining to size, form, construction year, external look, final materialization of buildings and similar.

F | Survey method

The survey method as well was applied in the research procedure with the goal of obtaining detailed data on residential buildings. The survey sampling implied filling in the Questionnaire “B”, that is, entrance of an interviewer in every fourth household listed in accordance with the Questionnaire “A” (3,261 residential building) and discussion with owners or representatives of condominium owners representatives for collection of detailed data on characteristics of buildings which influence the energy efficiency (materialization of building envelope: roof, external walls, floors, interfloor constructions, window types, heating systems etc.). If the project and technical documents existed, it was checked if the building had been constructed in accordance with the design and possible deviations from the project as well as changes to the original building shape were recorded.

Methodology of inventory of residential buildings

After determined periodization and typology of residential buildings in Bosnia and Herzegovina and in accordance with the goal and the research subject, two-stage forms were created – Questionnaire “A” and Questionnaire “B”, intended for the field work of the statistics agency.

When determining the questionnaire contents, the accent was placed on key variables with simple, concrete and understandable questions, upon which the first-stage form “A” included basic data on the building, such as its geometrical characteristics, floor area, number of floors, number of apartments etc., obtained by the observation method of field teams.

[7] Statistics agency IPSOS.

Drugostepeni formular „B“ je kompleksnijeg sadržaja, tako da su podaci prikupljeni anketnom metodom i razgovorom s predstavnicima svakog četvrtog stambenog objekta popisanog prema Upitniku „A“. Drugostepeni formular „B“ sadrži i specifična pitanja koja su bitna za klasifikaciju objekata, a koja se odnose na geometriju osnove objekta, preko karakteristika omotača, do primijenjenog energenta i sistema grijanja u objektu. Prije nego što je statistička agencija počela terenski rad, ekspertni tim projekta je obavio obuku popisivača, na kojoj su detaljno objašnjeni ciljevi istraživanja, sadržaji formulara i način njihovog popunjavanja.

U periodu juni-septembar 2015. godine statistička agencija je obradila, kompjuterski potpomognutim ličnim anketiranjem (CAPI), 13.044 objekta porodičnog i kolektivnog stanovanja u Bosni i Hercegovini uz procijenjenu mogućnost greške uzorka na +/- 0,92%.

Popisivani su samo stambeni objekti koji imaju kućne brojeve ili im broj još uvijek nije dodijeljen pa su označeni sa „bb“ (bez broja), dok ostali objekti nisu tretirani jer se smatraju privremenim strukturama.

S ciljem da se dobiju što precizniji podaci o broju stambenih jedinica po opštinama i optimalnog mapiranja zona (Slika 2), polaznih tačaka i kretanja anketara, korišten je model Agencije za statistiku Bosne i Hercegovine i preliminarni rezultati Popisa stanovništva, domaćinstava i stanova iz 2013. godine.

Stratumi uzorka su podijeljeni na dvije kategorije:

- I. stratum – entiteti
- II. stratum – tip naselja (urbani/ ruralni)

U opštinama s manje od 5.000 stambenih jedinica, s obzirom na predviđeni dvoetapni stratifikovani uzorak, jedinice prve etape su naselja unutar opština, dok su makrozone u naseljima s više od 5.000 stambenih jedinica.

Jedinice druge etape se, također, razlikuju u zavisnosti od veličine naselja tako da su biračka mjesta bila polazna osnova za naselja s manje od 5.000 stambenih jedinica, dok su mikrozone u gradovima s više od 5.000 stambenih jedinica. Na osnovu baze biračkih mjesta Centralne izborne komisije izvršen je odabir polaznih tačaka uzorka u ruralnim područjima tehnikom slučajnog kretanja i popisivanja 20 objekata po polaznoj tački.

Gradska područja opština su podijeljena na makrozone, koje su uslovljene relativnom homogenošću po teritoriji, tipologiji (individualno/ kolektivno stanovanje) i periodu izgradnje objekata. Makrozone su dodatno podijeljene na mikrozone, uz uslov da zadovoljavaju kriterij veličine (15-30 objekata) i s jasno definisanim okvirom ulica. Slučajnim odabirom jedne ili više mikrozona unutar makrozone izvršeno je anketiranje i popis stambenih objekata u zavisnosti od veličina uzorka koji su planirani za pojedine opštine. Posebno je obrađena zona nebodera, zgrada s 8 i više spratova, koje su u potpunosti popisane u odabranim opštinama. Svaki pojedinačni objekat je fotografisan iz različitih uglova, što je bila osnova ekspertnom timu za provjeru podataka.

The second-stage form “B” had more complex contents, so data were obtained by the survey method and talk to representatives of each fourth residential building listed according to the Questionnaire “A”. The second-stage form “B” also contained specific questions significant for a building classification, pertaining to the geometry of the building's base, envelope characteristics, applied energy carrier and heating system in the building. Before the statistics agency started with the field work, the expert team of the project had completed the training of enumerators, in which research goals, form contents and manner of their completion had been explained.

In the period between June and September 2015, the statistics agency processed, by computer-assisted personal interviewing (CAPI), 13,044 buildings of family and collective residence in Bosnia and Herzegovina with an estimated sampling error of +/- 0.92%.

Only those buildings with house numbers or those which still have not been marked with a number and were marked with “nn” (no number) were listed, whereas other buildings were not listed since they were considered temporary structures.

The model of the Agency for Statistics of Bosnia and Herzegovina and preliminary results of 2013 Census of Population, Households and Dwellings were used with the goal of obtaining as precise data on the number of dwelling units per municipalities and optimal zone mapping (Figure 2), starting points and enumerators' movements as possible.

Sample stratums were divided into two categories:

- I. stratum – entities
- II. stratum – settlement type (urban/ rural)

In municipalities with less than 5,000 dwelling units, having in view the provided two-stage stratified sample, first-stage units are settlements within municipalities, whereas macrozones are in settlements with more than 5,000 dwelling units.

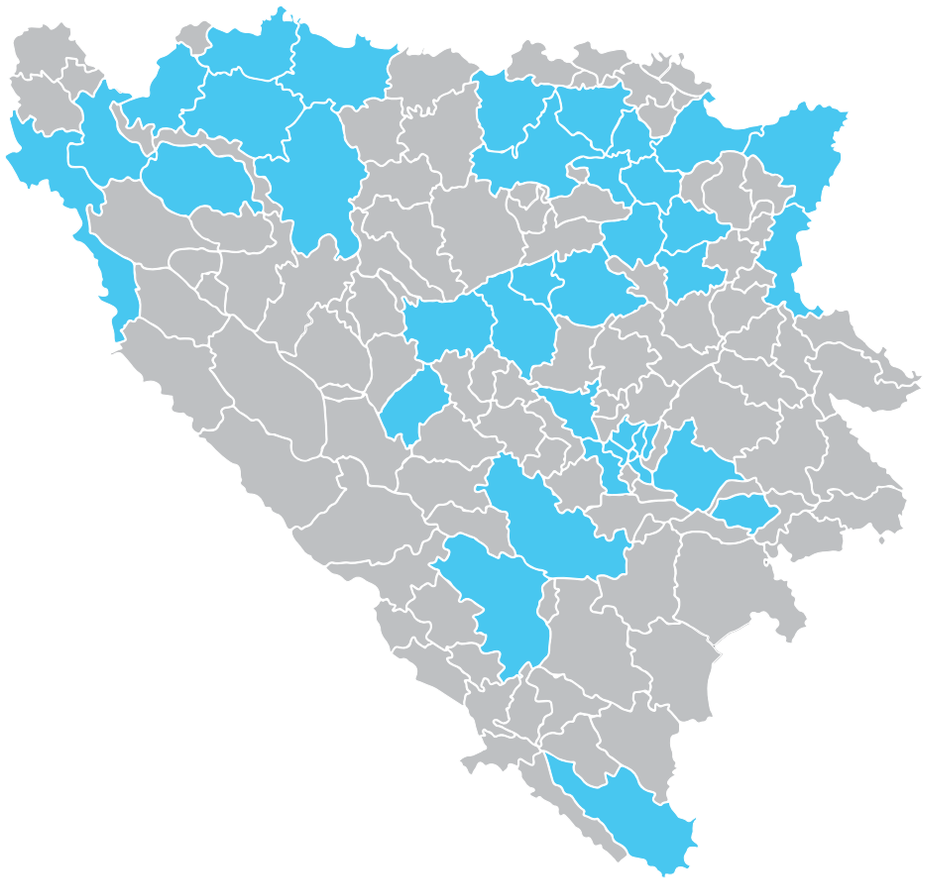
Second-stage units also differ from one another, depending on the size of the settlement, therefore polling stations were the starting points for settlements with less than 5,000 dwelling units, and microzones were the starting points in towns with over 5,000 dwelling units. Based on the polling stations basis of the Central Electoral Committee, a selection of starting points of samples in rural areas was made by random walk technique and listing of 20 buildings per starting point.

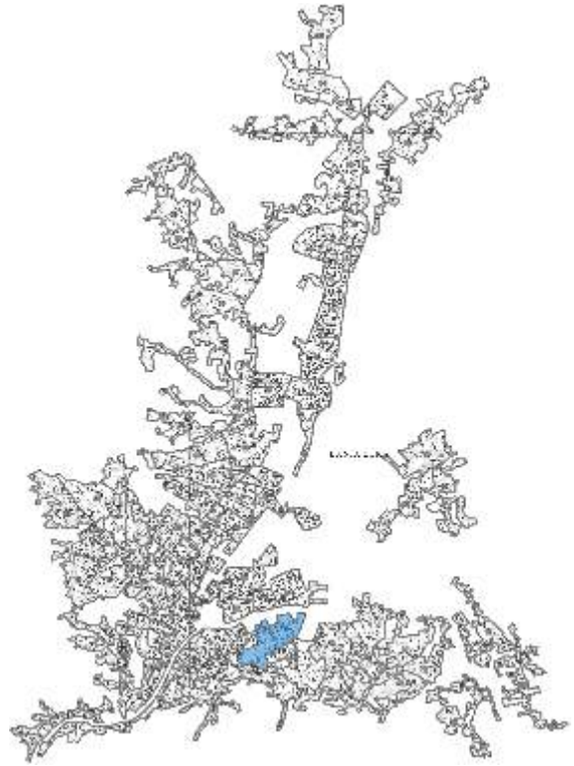
Urban areas of municipalities were divided into macrozones, which were conditioned by a relative homogeneity of territories, typology (single-family housing / collective housing) and construction period of buildings. Macrozones were further divided into microzones, given that they met the size criteria (15-30 buildings) with clearly defined street framework. Interviewing and listing of residential buildings depending on the sample size planned for certain municipalities was carried out by a random selection of one or more microzones within a macrozone. The skyscraper zone, buildings with 8 and more floors, completely listed in the selected municipalities, was processed separately. Each individual building was photographed from different angles, which was the basis for data control by the expert team.

BROJ STAMBENIH JEDINICA | TOTAL NUMBER OF DWELLING UNITS

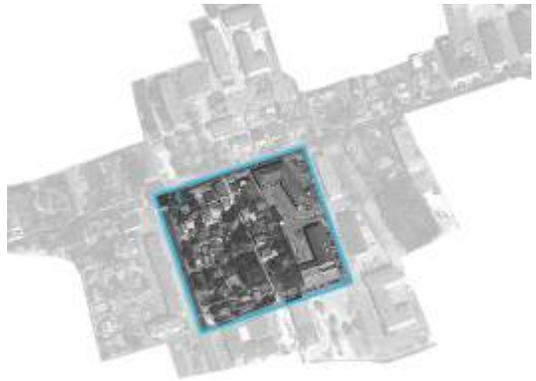
Brčko Distrikt	
Brčko	22 610
FBiH	
Bihać	19 112
Bosanska Krupa	6 737
Bugojno	7 089
Centar Sarajevo	30 227
Goražde	6 259
Gračanica	11 362
Mostar	37 059
Gradačac	7 530
Ilidža	35 427
Konjic	5 487
Lukavac	13 003
Novi Grad Sarajevo	54 011
Novo Sarajevo	34 020
Sanski Most	5 649
Srebrenik	5 064
Stari Grad Sarajevo	19 107
Travnik	8 851
Tuzla	45 302
Visoko	5 697
Vogošća	10 169
Zavidovići	5 666
Zenica	38 501
Žepče	5 306
Živinice	13 863
RS	
Banja Luka	78 645
Bijeljina	33 796
Derventa	5 314
Doboj	14 429
Gradiška	7 823
Istočno Novo Sarajevo	3 772
Kozarska Dubica	5 589
Modriča	4 164
Novi Grad	5 720
Pale	6 565
Prijedor	22 132
Trebinje	11 617
Zvornik	6 948

OPĆINE U BIH | MUNICIPALITIES IN BIH





PRIMJER ODABIRA MAKROZONE (BANJA LUKA)
MACRO-ZONE SELECTION IN THE CASE OF THE CITY OF BANJA LUKA



PRIMJER ODABIRA MIKROZONE (BANJA LUKA)
MICRO-ZONE SELECTION IN THE CASE OF THE CITY OF BANJA LUKA

Slika 2. Prikaz odabranih makrozona na nivou BiH
Figure 2. Macro-zones on the level of BiH

Nakon što su podaci prikupljeni na terenu, izvršena je kontrola kvaliteta, pri čemu je pristupljeno telefonskoj kontroli rada anketara na 10% realizovanog uzorka faze A i terenskoj kontroli na 5% realizovanog uzorka faze B, kao i i logička kontrola podataka uz upotrebu SPSS softvera.[8]

Uzimajući u obzir broj mikrozona u pojedinim makrozonoma u urbanim područjima i odnos ukupnog broja biračkih mjesta i broja biračkih mjesta u uzorku, izvršeno je ponderisanje podataka korištenjem SPSS softvera.

U završnoj fazi ekspertni timovi su pregledali cjelokupnu bazu podataka s fotografijama popisanih objekata, pri čemu je izvršena kontrola arhitektonsko-urbanističkih parametara i perioda izgradnje. Finalno ponderisanje objekata je uslijedilo nakon višestruke provjere terenskog rada popisivača, s obzirom na potrebe korekcije uočenih grešaka koje su se odnosile na procjenu perioda i tipološku kategoriju stambenih objekata.[9]

Klaster analiza i odabir tipičnih zgrada

Popis stambenih objekata pružio je brojne mogućnosti statističke obrade i analize dobijenih podataka. Među njima se izdvaja klaster analiza, zbog svog značaja u odabiru tipičnih objekata, koji predstavljaju stvarne reprezente tipoloških kategorija stambenih objekata.

Ulazni parametri za klaster analizu podataka dobijenih iz statističkog popisa objekata su prevashodno uključivali geometrijske karakteristike stambenih objekata kao što su površina osnove, broj spratova, broj stanova, ali i specifična arhitektonska obilježja kao što su karakter krova, starost prozorskih otvora, namjena prizemne etaže itd. Klaster analiza je podrazumijevala grupisanje objekata u šest relativno homogenih grupa sa sličnim karakteristikama, na osnovu čega su izvedene prosječne vrijednosti za svaku pojedinačnu kategoriju objekata. Uporednom analizom karakteristika popisanih objekata i prosječnih vrijednosti tipičnih objekata dobijenih klaster analizom identifikovani su stvarni predstavnici objekata svake pojedinačne tipološke kategorije. U postupku finalnog odabira tipičnog objekta u dominantnom klasteru vodilo se računa o teritorijalnoj zastupljenosti objekata na prostoru Bosne i Hercegovine. U zbirnoj matrici tipologije stambenih objekata izostavljeni su tipični objekti u pojedinim vremenskim periodima zbog njihove male zastupljenosti u ukupnom broju objekata, tj. zbog toga što u takvim slučajevima broj popisanih objekata u dominantnom klasteru nije zadovoljavao minimalni uzorak od 25 objekata.

[8] SPSS - *Statistical Package for the Social Sciences*, Statistički program za društvene nauke

[9] Procjena perioda izgradnje na osnovu vizuelnih karakteristika pojedinog objekta bio je veoma kompleksan zadatak za popisivače. Podaci za ovu ključnu komponentu za izradu tipološke matrice su najvećim dijelom dobijeni prethodnim razgovorom sa stanarima, kao i na osnovu uvida u obilježja i natpisa godine izgradnje na fasadama objekata.

After collecting data in the field, a quality control was conducted, upon which phone check of work of interviewers was carried out on 10% of implemented sample of phase A and field check on 5% of implemented sample of the phase B, as well as logistic control with the use of SPSS software.[8]

Taking into consideration the number of microzones in certain macrozones of urban areas and the ratio of the total number of polling stations to the number of polling stations in the sample, data weighing was carried out by using SPSS software.

In the final stage, expert teams overviewed the entire data base with photos of listed buildings, upon which a control of architectural-urban parameters and construction periods was carried out. The final building weighing came after multiple inspection of field work of enumerators, having in view needs for correction of the detected errors pertaining to period assessment and typological category of residential buildings.[9]

Cluster analysis and selection of typical buildings

Inventory of residential buildings offered numerous possibilities for statistical processing and analyses of the obtained data. Among them is singled out a cluster analysis, due to its significance in the selection of typical buildings which represent real representatives of typological categories of residential buildings.

Input parameters for the cluster analysis of data obtained from the statistical inventory of buildings primarily included geometrical characteristics of residential buildings such as floor areas, number of floors, number of apartments but also specific architectural characteristics such as the roof character, age of window openings, purpose of the ground floor etc. The cluster analysis implied grouping of buildings into six relatively homogenous groups with similar characteristics, based on which average values for each individual category of buildings was derived. Real representatives of buildings of each individual typological category were identified by the comparison analysis of characteristics of listed buildings and average values of typical buildings obtained by the cluster analysis. In the procedure of final selection of a typical building in the dominant cluster, attention was paid to territorial representation of buildings in the territory of Bosnia and Herzegovina. Typical buildings in certain time periods were left out from the collective matrix of typology of residential buildings because of their small representation in the total number of buildings, that is, because in such cases the number of listed buildings in a dominant cluster did not meet the minimal sample of 25 buildings required.

[8] SPSS - Statistical Package for the Social Sciences, *Statistički program za društvene nauke*

[9] Assessment of the construction period based on visual characteristics of a certain building was a very complex task for enumerators. Data for this key component for making the typological matrix have mostly been obtained by previous talks to residents, as well as based on inspection of characteristics and signs on facades of buildings noting the year of construction.

Terenski rad stručnih timova

Nakon odabira tipičnih objekata istraživanje je nastavljeno u vidu terenskog stručnog rada, u koji su uključeni timovi stručnjaka s Arhitektonskog i Mašinskog fakulteta iz Sarajeva i Banje Luke. Terenski timovi su tehnički snimili i evidentirali arhitektonske i energetske karakteristike odabranog objekta, te analizirali njegovu konstrukciju, materijale korištene za izgradnju i sistem grijanja. U slučaju nemogućnosti pronalaska originalne tehničke dokumentacije, posebno kod objekata kolektivnog stanovanja, istraživački rad je zahtijevao da ekspertni i terenski timovi izvrše detaljan uvid u način i tehnologiju građenja, primijenjeni konstruktivni sistem i materijale. Terenski angažman timova arhitektonske i mašinske struke je, pored de-taljnog mjerenja i grafičkog prikazivanja objekata, podrazumijevao i razgovore s vlasnicima, odnosno predstavnicima etažnih vlasnika stambenih objekata, čije je poznavanje objekata predstavljalo dodatni izvor relevantnih informacija.

Termografsko snimanje tipičnih zgrada

Termografsko snimanje je bezkontaktna metoda mjerenja koja uključuje snimanje elemenata omotača zgrade termovizijskom kamerom. Termografskim snimanjem objekta mogu se generisati kvantitativni i kvalitativni snimci elemenata omotača koji omogućavaju detekciju elemenata različite materijalizacije, loše izolovanih i dijelova s oštećenom izolacijom, elemenata konstrukcije na kojim je došlo do prodora vlage u elemente konstrukcije itd. Termografski snimci su bili od velike koristi kod detekcije elemenata omotača različite materijalizacije, te procjene doprinosa toplotnih mostova u toplotnim gubicima objekta.

Proračun energetskih performansi zgrada

Nakon provedenog terenskog snimanja objekata i pripreme podataka izvršen je proračun energetskih performansi objekata. Proračun je baziran na važećim zakonskim propisima u FBiH [4,5] i RS koji uređuju oblast energetskog certificiranja i proračuna energetskih performansi objekata [6,7], te su izračunate ukupna i specifična energija potrebna za grijanje tipičnih objekata. Uzimajući u obzir dominantni sistem grijanja, energent i stepene iskorištenja sistema, izračunate su isporučena i primarna energija kao i emisija CO_2. Analiziran je sistem za pripremu potrošne tople vode dominantan za kategoriju objekata kojoj pripada tipični objekat i njegov stepen iskorištenja.

Field work of expert teams

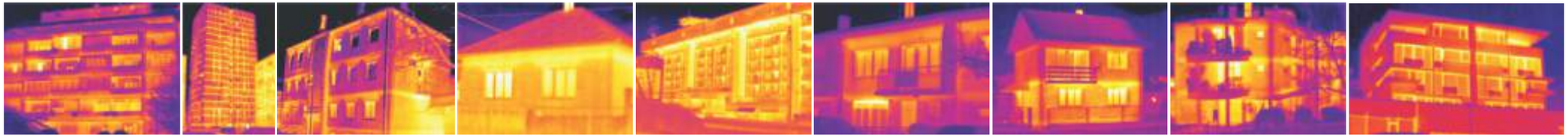
After selection of typical buildings, the research continued in the form of a field expert work that included teams of experts from the Faculty of Architecture and Faculty of Mechanical Engineering in Sarajevo and Banja Luka. Field teams did a technical recording and recorded architectural and energy-related characteristics of a selected building and analysed its construction, used materials and heating system. In case of impossibility to find the original technical documents, especially in cases of collective residence buildings, the research work required expert and field teams to carry out detailed examination of the manner and technology of construction, applied construction system and materials. Field engagement of teams of architects and mechanical engineers, in addition to a detailed measuring and graphical representation of buildings, also implied discussions with owners, that is, with representatives of condominium owners, which knowledge on the buildings was an additional source of relevant information.

Thermographic recording of typical buildings

Thermographic recording is a non-contact measurement method which includes recording of elements of a building's envelope by a thermal imaging camera. Quantitative and qualitative recordings of the envelope elements can be generated by thermographic recording, which enable detection of elements of different materialization, poorly isolated parts and parts with damaged isolation, elements of construction in which moisture passed through the construction elements etc. Thermographic elements were of great use for detection of envelope elements of different materialization and assessment of contributions of thermal bridges in heat losses of buildings.

Calculation of energy performances of buildings

After completed thermal recording of buildings and data preparations, a calculation of energy performances of buildings was made. The calculation was based on valid legal regulations in the FBiH [4.5] and in RS which regulate the field of energy certification and calculation of energy performances of buildings [6.7], therefore total and specific energy needed for heating of typical buildings were calculated. Bearing in mind the dominant heating system, energy fuel for heating system and system efficiency, delivered and primary energy were calculated as well as the CO_2 emission. Domestic hot water system was analysed, dominant for the categories of buildings which the typical buildings belonged to and the level of its utilization.



Nakon definisanja mjera koje mogu da dovedu do smanjivanja potrošnje energije u zgradama izvršen je proračun energetskih performansi tipičnih zgrada s pretpostavkom da su mjere sprovedene. Sve mjere su definisane kao unapređenje 1 (standardne mjere) i unapređenje 2 (nestandardne mjere). Kao rezultat dobijene su moguće uštede nakon provođenja standardnih mjera, kao i uštede nakon primjene nestandardnih mjera, i to iskazane u količini isporučene i primarne energija, kao i emisija CO_2.

TIPOLOGIJA STAMBENIH ZGRADA BOSNE I HERCEGOVINE

Primarni zadatak u radu na naučnoistraživačkom projektu *Tipologija stambenih objekata Bosne i Hercegovine* je podrazumijevao utvrđivanje kriterija za klasifikaciju stambenih objekata. Na osnovu usporedne analize metodološkog okvira međunarodnog projekta *TABULA* i specifičnosti graditeljskog naslijeđa Bosne i Hercegovine utvrđeni su osnovni kriteriji za definisanje tipologije stambenih objekata: vremenski period izgradnje i arhitektonsko-urbanistička obilježja objekata. Primjenom tipološkog pristupa klasifikacije stambenih objekata kreiran je prvi sistematičan pregled karakteristika postojećih tipova stambenih objekata u Bosni i Hercegovini. Rezultati projekta su stvorili bazu podataka koja može da predstavlja osnovu za druge naučnoistraživačke i stručne projekte.

Sistematizovanje stambenih objekata prema zadatim kriterijima rezultiralo je *matricom* tipologije stambenih objekata, odnosno, grafičkim i tabelarnim prikazom hronološkog razvoja tipologije stambene arhitekture Bosne i Hercegovine. Uloga matrice tipologije je da na jednostavan i sistematičan način ilustruje suštinski značaj tipološkog pristupa klasifikaciji stambenih objekata.

Periodizacija stambenih zgrada u Bosni i Hercegovini

S ciljem kreiranja hronološkog prikaza razvoja tipologije stambenih objekata definisani su karakteristični vremenski periodi, uslovljeni društveno-istorijskim kontekstom, tehnologijom građenja i primijenjenim materijalima, te regulativom koja uređuje oblast toplotne zaštite zgrada. U tom smislu utvrđeni su ključni istorijski pragovi u kojima su zabilježene pojave novih koncepata izgradnje, arhitektonskih stilova ili upotreba novih tehnoloških postupaka i materijalizacije objekata.

S druge strane, na periodizaciju tipova stambenih objekata uticala je i primjena regulative iz oblasti toplotne zaštite objekata. Energetska efikasnost kao pojam u arhitekturi ne pojavljuje se do 70-ih godina prošlog vijeka. Prvi propis koji je samostalno tretirao toplotnu zaštitu objekata[10] donesen je 1970. godine kao *Pravilnik o tehničkim mjerama i uslovima za toplotnu zaštitu zgrada*. Dekadu poslije, 1980. godine, donesen je *Pravilnik o jugoslovenskim stan-*

[10] Prije ovog pravilnika mjera toplotne zaštite se pojavljuje, po prvi put, u okviru Pravilnika o minimalnim tehničkim uslovima za izgradnju stanova iz 1967. godine

After defining measures which could result in reduction of energy consumption in buildings, calculation of energy performances of typical buildings was made with the assumption that measures had been implemented. All measures are defined as improvement 1 (standard measures) and improvement 2 (non-standard measures). As a result, possible savings were obtained after implementation of standard measures as well as savings after application of non-standard measures expressed in quantity of delivered and primary energy and CO_2 emissions.

TYPOLOGY OF RESIDENTIAL BUILDINGS IN BOSNIA AND HERZEGOVINA

The primary task in the work on scientific and research project *Typology of Residential Buildings in Bosnia and Herzegovina* implied establishment of criteria for classification of residential buildings. Based on a comparative analysis of the methodological framework of international project *TABULA* and specificity of construction heritage of Bosnia and Herzegovina, basic criteria for defining typology of residential buildings were defined: period of construction and architectural and urban characteristics of buildings. By application of typological approaches of classification of residential buildings, the first systematic overview of characteristics of the existing types of residential buildings in Bosnia and Herzegovina was created. Project results have created a data base which could serve as the basis for other scientific and research and expert projects.

Systematization of residential buildings according to given criteria resulted in the typology *matrix* of residential buildings, that is, in graphical and table representation of chronological development of typology of residential architecture of Bosnia and Herzegovina. The role of the typology matrix is to illustration the significance of typological approach to classification of residential buildings in a simple and systematic manner.

Periodization of residential buildings in Bosnia and Herzegovina

Having the goal to create a chronological overview of development of typology of residential buildings, characteristic periods were defined, conditioned with the socio-historical context, construction technology and applied material as well as regulations regulating the field of thermal protection of buildings. Key historical thresholds were established in this respect in which new concepts of construction, architectural styles or use of new technological procedures and building materializations were recorded.

On the other hand, periodization of types of residential buildings was influenced also by application of regulations in the field of thermal protection of buildings. Energy efficiency, as a term in architecture, did not appear before the 70s. The first regulation that independently analysed thermal protection of buildings[10] was enacted in 1970 as the *Rulebook on Technical Measures and Conditions for Thermal Protection of Buildings*. A decade later, in 1980, was

[10] Before enactment of this rulebook, the thermal protection measure appeared for the first time within the framework of the Rulebook on Minimal Technical Conditions for Construction of Apartments dated 1967.

dardima za toplotnu tehniku u građevinarstvu i prateći standardi: *JUS U.J5.600 - Toplotna tehnika u građevinarstvu, tehnički uslovi za projektovanje i građenje zgrada, JUS U.J5.510 - Toplotna tehnika u građevinarstvu, Metode proračuna koeficijenata toplote u zgradama, JU UJ5.520 - Toplotna tehnika u građevinarstvu, Metode proračuna difuzije vodene pare, JUS U.J5.530 - Toplotna tehnika u građevinarstvu, Metode proračuna karakteristika toplotne stabilnosti spoljašnjih građevinskih konstrukcija zgrada za ljetno razdoblje.* Ovaj pravilnik je inoviran 1987. godine, te se više ne posmatraju samo toplotni gubici u pojedinim elementima vanjskog omotača nego se zgrada posmatra kao cjelina. Novi pravilnik pratila je i izmjena standarda *JUS U.J5.510 i JUS U.J5.600.* Ovaj pravilnik, zajedno s pratećim standardima, ostao je na snazi dugi niz godina, sve do donošenja nove regulative u Federaciji Bosne i Hercegovine 2009. godine, a u Republici Srpskoj 2015. godine.

Na osnovu analize istorijskog aspekta najbitnijih arhitektonsko-urbanističkih karakteristika, kao i pregledom regulative, definisana je sljedeća periodizacija tipologije stambenih objekata u Bosni i Hercegovini:

Period do 1919. godine

Završetak I. svjetskog rata predstavlja istorijski reper u definisanju prvog vremenskog perioda, koji obuhvata tipologiju stambenih objekata u Bosni i Hercegovini izgrađenih do kraja austrougarskog perioda.

Ovaj period uključuje objekte s različitim konceptima izgradnje i i materijalima korištenim za izgradnju. Stambeni objekti koji datiraju iz osmanskog perioda su, u većini slučajeva, prizemni i jednospratni, pri čemu je visina objekta uslovljena tradicionalnim načinom gradnje i materijalizacijom.[11] Većina objekata, koji potiču iz ovog perioda, je skeletne drvene konstrukcije s ispunom od nepečene gline, građeni u tzv. *bondruk* sistemu, dok u seoskim područjima ima donekle sačuvanih objekata masivne drvene konstrukcije tipa brvnara, polubrvnara i talpara. U austrougarskom periodu dolazi i do donošenja regulative, te je 1880. godine donesen *Građevinski pravilnik*. Počinje gradnja višespratnih stambenih zgrada, tipa činovničkih paviljona namijenjenih kolektivnom stanovanju. Zgrade se grade kvalitetnije, od opeke starog austrougarskog formata, masivnih zidova debljine 45cm i 60cm, te su zbog toga toplotni gubici relativno niski.

Period od 1919. do 1945. godine

Ovaj period predstavlja vrijeme između dva svjetska rata, kada dolazi i do promjene društvenog sistema u Bosni i Hercegovini. Pored kontinuiteta u gradnji porodičnih stambenih objekata, ovaj period karakteriše i izgradnja višespratnih objekata za kolektivno stanovanje u

[11] "Gradske stambene kuće iz osmanskog perioda su građene u dijalogu s prirodnim i izgrađenim okruženjem, a karakteriše ih povoljna orijentacija i poštivanje 'nepisanih pravila' kao što je pravo na vidik, a gledano iz savremene perspektive, elementi ovojnice ovih zgrada su posjedovali povoljne toplinske karakteristike."

enacted the *Rulebook on Yugoslav Standards for Thermal Equipment in Construction Work* with corresponding standards: *JUS U.J5.600 – Thermal Equipment in Construction Work, Technical Requirements for the Design and Construction of Buildings, JUS U.J5.510 – Thermal Equipment in Construction Work, Methods for Calculating the Heat Coefficient in Buildings, JU UJ5.520 –Thermal Equipment in Construction Work, Methods for Calculating Diffused Water Vapour, JUS U.J5.530 – Thermal Equipment in Construction Work, Methods for Calculating Thermal Stability of External Structure Constructions of Buildings for Summer Period.* This rulebook was innovated in 1987, therefore not only heat losses in certain elements of external envelope were observed but a building as a whole. The new rulebook was also followed by amendments to the standards *JUS U.J5.510 and JUS U.J5.600.* This rulebook, together with the associated standards, remained in effect for a number of years, all until enactment of the new regulations in the Federation of Bosnia and Herzegovina in 2009 and in Republic of Srpska in 2015.

Based on the analysis of a historical aspect of the most important architectural and urban characteristics, as well as by overview of regulations, the following periodization of typology of residential buildings in Bosnia and Herzegovina was defined:

Period before 1919

End of the World War I represents a historical landmark in defining the first period which encompasses typology of residential buildings in Bosnia and Herzegovina constructed by the end of Austro-Hungarian period.

This period includes buildings with different concepts of construction and used materials. Residential buildings dating back to the Ottoman period are, in most cases, ground level or one-floor buildings, upon which the height of a building is conditioned by a traditional manner of construction and materialization.[11] Most buildings originating from this period have a wood skeleton construction with panels made of unbaked clay, constructed in the so-called *bondruk* system, whereas in rural areas there are some buildings preserved, made of solid wood construction such as log cabins, semi-log cabin and plank houses. In Austro-Hungarian period, a regulation was enacted so in 1880 was enacted *Construction Work Rulebook*. After that started construction of multi-floor residential buildings such as clerical pavilions intended for collective residence. More quality buildings made of bricks and in the old Austro-Hungarian format, with massive walls the thickness of 45cm and 60cm were constructed, for which reason heat losses were relatively low.

Period from 1919 to 1945

This period represents the time between the two World Wars, when there happened a change of the social system in Bosnia and Herzegovina. In addition to continuity of

[11] "Houses in urban areas built in the Ottoman period were constructed to fit in the natural and urban surroundings. They are characterised by favourable orientation and use of *"unspoken rules"*, such as the right to a view. In terms of modern perspective, elements of their envelope feature favourable thermal properties."

stilskom izrazu *moderne*. Stambene zgrade su masivne konstrukcije, grade se najčešće primjenom opeke, prvo starog a zatim novog formata, a počinje i primjena novog materijala - armiranog betona. Smanjivanje debljine vanjskih zidova dovodi do gradnje zgrada koje imaju lošije termoizolacione karakteristike nego zgrade građene u austrougarskom periodu.

S obzirom na relativno mali procenat stambenih objekata izgrađenih prije 1919. godine u odnosu na cjelokupni stambeni fond Bosne i Hercegovine svi objekti, bez obzira na njihova arhitektonska ili stilska obilježja, svrstani su u jedinstven vremenski obuhvat. (do 1945.)

Period od 1945. do 1960. godine

Prvi poslijeratni period obilježen je velikim migracionim talasima stanovništva ka urbanim centrima i ograničenim investicijama u stambenu izgradnju, kao refleksijom društvenog i ekonomskog stanja države. Izgradnju stambenih objekata iz vremena ekonomske oskudice karakteriše korištenje masivnih konstrukcija, od opeke i armiranog betona, s vanjskim zidovima bez toplotne izolacije.

Period od 1961. do 1970. godine

Intenziviranje stambene izgradnje, a s ciljem rješavanja socijalne i stambene krize, počinje šezdesetih godina 20. vijeka. U ovom periodu počinje izgradnja velikih stambenih naselja, racionalnih i unificiranih kolektivnih stambenih zgrada. Zgrade se grade s vanjskim zidovima bez primjene elemenata toplotne zaštite, tj. toplotne izolacije, a toplotno se ne izoluju ni ostali dijelovi omotača zgrade, te su toplotni gubici u njima veliki.

Period od 1971. do 1980. godine

U jeku najveće ekspanzije u izgradnji objekata kolektivnog stanovanja, 1970. godine, je donesen *Pravilnik o tehničkim mjerama i uslovima za toplotnu zaštitu zgrada* [8]. Ovim pravilnikom su određene najveće dozvoljene vrijednosti koeficijenta prolaza toplote (k) za pojedine građevinske elemente u odnosu na određenu klimatsku zonu. Stambene zgrade građene u ovom periodu imaju loše termoizolacione karakteristike zbog primjene tankih slojeva izolacionih materijala, lošeg kvaliteta prozora, s brojnim toplotnim mostovima na spojevima različitih materijala i elemenata konstrukcije. Toplotni mostovi, usljed kondenzacije vodene pare iz vazduha, uzrokuju pojavu vlage i plijesni, tako da je najveći procenat stambenih objekata iz ovog perioda zbog ovoga, ali i zbog lošeg održavanja, u izrazito lošem građevinskom stanju.

Period od 1981. do 1991. godine

Osamdesetih godina 20. vijeka intenzivirana je izgradnja prefabrikovanih stambenih objekata kolektivnog stanovanja. Novi pravilnik s pratećim standardima pooštrava kriterije za toplotnu zaštitu objekta tako što smanjuje vrijednosti dozvoljenih koeficijenata prolaza

construction of family residential buildings, this period is characterised also by a construction of multi-floor buildings for collective residence in the stylistic expression of *modernism*. Residential buildings have massive constructions and are mostly constructed of bricks, first in an old and then the new format and also the use of a new material begun – reinforced concrete. Reduction of thickness of external walls resulted in construction of buildings with a poorer thermal insulation characteristics than in those buildings constructed in Austro-Hungarian period.

Bearing in mind a relatively small percentage of residential building constructed before 1919 compared to the entire housing stock of Bosnia and Herzegovina, all buildings regardless of their architectural or stylistic characteristics were grouped in a single time frame (do 1945.).

Period from 1945 to 1960

The first post-war period was marked by great migration waves of population toward urban centres and limited investments in residential construction, as a reflection of a social and economic situation of the state. Construction of residential buildings from the period of economic hardship was characterised by use of massive construction from bricks and reinforced concrete, with external walls without thermal insulation.

Period from 1961 to 1970

A more intensive residential construction with the goal of solving social and residential crisis begun in 1960s. In this period started construction of large residential settlements, rational and unified collective residential buildings. Buildings with large external walls were constructed without use of thermal protection elements, that is, without thermal insulation, and the other parts of buildings' envelopes were not thermally insulated either, so heat losses in them were great.

Period from 1971 to 1980

In the midst of the greatest expansion of construction of collective residence building, in 1970 was enacted the *Rulebook on Technical Measures and Conditions for Thermal Protection of Buildings* [8]. This rulebook defined the highest possible values of the heat transfer coefficient (k) for certain construction elements with regards to a certain climate zone. Residential buildings constructed in this period have poor thermal insulation characteristics because of use of thin layers of thermal insulation, poor quality of windows with numerous heat bridges on joints made of different materials and elements of construction. Due to condensation of water vapour from air, heat bridges cause dampness and mould, so the greatest percentage of residential buildings from this period is in an extremely poor constructional condition for this reason and for the poor maintenance.

Period from 1981 to 1991

In 1980s was intensified construction of precast residential buildings of collective residence. The new rulebook with associated standards raised the criteria for thermal protection of buildings

toplote (U) za oko 30%, određuje minimalnu toplotnu izolaciju građevinskih elemenata i ograničava toplotne gubitke u zgradama.

Ovaj pravilnik, kao i prateći standardi, kojima se ograničavaju toplotni gubici u zgradi kao cjelini, a ne samo kroz pojedine elemente vanjskog omotača, korigovan je 1987. godine. U ovom periodu se na fasadnim zidovima objekata primjenjuje toplotna izolacija debljine 5cm, najčešće izvedena od ekspandiranog polistirena, u sistemu kontaktne fasade. Pored toga, često se primjenjuju i fasadni zidovi složenog sistema, tzv. sendvič zidovi s oblogom od fasadne opeke, termoizolacijom koja je ugrađena u zid, sa slojem vazduha za provjetravanje ili bez njega. U ovom periodu počinje primjena kvalitetnije fasadne stolarije s dvostrukim termoizolacionim staklima. Kao vremenska odrednica završetka ovog perioda uzeta je 1991. godina, kada je sproveden popis stanovništva u Socijalističkoj Federativnoj Republici Jugoslaviji.

Period od 1992. do 2014. godine

Prve tri godine ovog perioda obilježene su, usljed ratnih zbivanja, devastacijom velikog broja stambenih zgrada. Poslijeratnu izgradnju karakteriše obnova oštećenih zgrada, te izgradnja većeg broja novih objekata porodičnog i kolektivnog stanovanja. Stambene zgrade koje su obnovljene završene su u većini slučajeva u cijelosti, a fasadni zidovi su izolovani sa toplotnom izolacijom od 5 cm, u skladu sa propisima. Stambene zgrade se grade u skladu s važećim propisima, a tek krajem perioda, usljed porasta svijesti o značaju gradnje energetski efikasnih zgrada, investitori koji grade zgrade za tržište počinju da ugrađuju toplotnu izolaciju i veće debljine nego što je propisano. Porodične kuće, nažalost, u velikom broju ostaju ostaju nezavršene u potpunosti, te su fasadni zidovi i krovovi neizolovani.

Urbanističko-arhitektonski parametri u klasifikaciji stambenih zgrada u Bosni i Hercegovini

Urbanističko-arhitektonski parametri, na osnovu kojih je izvršena klasifikacija stambenih objekata Bosne i Hercegovine, proizašli su iz metodologije evropskog projekta *TABULA*. Ova metodologija dozvoljava izvjesna odstupanja i modifikacije univerzalne matrice, u skladu sa specifičnostima nacionalne stambene tipologije.[12] Matrica tipologije stambenih objekata Bosne i Hercegovine je u osnovi usklađena s principima projekta *TABULA* uz uvođenje dvije dodatne kategorije stambenih objekata: „stambene zgrade u gradskom bloku“ i „visoki stambeni objekti-neboderi“.

Klasifikacija objekata je izvršena na osnovu sljedećih kriterija: položaj objekta na parceli, veza objekta sa susjednim objektima, broj etaža, broj kućnih brojeva i broj stambenih jedinica.

[12] Tipologija je redukovana na dvije osnovne kategorije porodičnog i višeporodičnog stanovanja prilikom klasifikacije stambenih objekata u Grčkoj, dok je u Njemačkoj posebno obrađena tipologija kolektivnog stanovanja, karakteristična za bivšu Istočnu Njemačku.

buildings by reducing the value of allowed heat transfer coefficients (U) for about 30%, defining minimal thermal insulation of construction elements and limiting heat losses in buildings.

This rulebook, as well as its associated standards, which limit heat losses in a building as a whole and not only through certain elements of external envelope, was corrected in 1987. In this period thermal insulation the thickness of 5cm was applied on facade walls of a building, mostly made of expanded polystyrene in the contact facade system. In addition to this, complex system facade walls were often applied, the so-called sandwich walls with a cladding made of facade brick, thermal insulation imbedded in the wall, with an air layer for ventilation or without it. The application of a more quality facade joinery with double glazed thermally insulated windows begun in this period. The year of 1991 was taken as the year in which this period ended, when the census of population in the Socialist Federal Republic of Yugoslavia was implemented.

Period from 1992 to 2014

Due to the war, the first three years of this period were marked by devastation of a great number of residential buildings. The post-war construction is characterised by reconstruction of damaged buildings and construction of a great number of new buildings of family and collective residence. The reconstructed residential buildings were in most cases rebuilt entirely, and facade walls were covered with 5cm insulation in line with regulations. Residential buildings were constructed in accordance with valid regulations and only by the end of the period and due to increase of awareness on the significance of construction of energy efficient buildings did investors who built buildings, started installing thermal insulation of greater thickness than required. A great number of family houses, unfortunately, have not been completed, so they remained without insulated facade walls and roofs.

Urban-architectural parameters in classification of residential buildings in Bosnia and Herzegovina

Urban-architectural parameters, based on which classification of residential buildings of Bosnia and Herzegovina had been carried out, derived from the methodology of the European project of *TABULA*. This methodology allows certain deviations from and modifications of universal matrix, in accordance with specificities of a national, residential typology.[12] The typology matrix of residential buildings of Bosnia and Herzegovina has basically been harmonised with principles of the project *TABULA* with introduction of two additional categories of residential buildings: “attached appartment building in urban blocks” and “high residential buildings - high-rise building”.

The classification of buildings was carried out based on the following criteria: position of a building on a lot, connection of a building with adjacent buildings, number of floors, number of house numbers and number of dwelling units.

[12] The typology has been reduced to two basic categories of family and multi-family residence upon classification of residential buildings in Greece, whereas in Germany was separately processed typology of collective housing, attributive to the former East Germany.

Na osnovu navedenih kriterija formirana je matrica tipologije stambenih objekata u Bosni i Hercegovini, koju čine dvije kategorije individualnog i četiri kategorije kolektivnog stanovanja:[13]

Individualno stanovanje: slobodnostojeće kuće

Slobodnostojeća kuća je objekat individualnog stanovanja s najviše tri etaže (⩽ 3 etaže) i najviše tri stambene jedinice (⩽ 3 stambene jedinice), koji se nalazi na zasebnoj parceli i ne graniči se sa susjednim objektima.

Individualno stanovanje: kuće u nizu

Kuća u nizu je objekat individualnog stanovanja s najviše tri etaže (⩽ 3 etaže) i najviše tri stambene jedinice (⩽ 3 stambene jedinice), koji se nalazi na zasebnoj parceli, u okviru niza objekata i graniči se sa susjednim objektima.

Kolektivno stanovanje: manje stambene zgrade

Manja stambena zgrada je slobodnostojeći objekat kolektivnog stanovanja s više od tri etaže (> 3 etaže), više od tri stambene jedinice (> 3 stambene jedinice) i s najviše dva kućna broja, koji se nalazi na zasebnoj parceli i ne graniči se sa susjednim objektima.

Kolektivno stanovanje: stambene zgrade u nizu/gradskom bloku

Stambena zgrada u nizu/gradskom bloku je objekat s više od tri etaže (>3 etaže), više od tri stambene jedinice (> 3 stambene jedinice), koji se nalazi u okviru niza objekata u gradskom bloku, odnosno graniči se sa susjednim objektima.

Kolektivno stanovanje: veliki stambeni blokovi/stambene lamele

Veliki stambeni blok ili stambena lamela je višespratni objekat velike površine osnove, s tri i više kućnih brojeva.

Kolektivno stanovanje: neboderi

Neboder je slobodnostojeći objekat velike spratnosti, s najmanje osam etaža (⩾ 8 etaža), s najviše dva kućna broja, koji se nalazi na zasebnoj parceli i ne graniči sa susjednim objektima.

[13] Prema usvojenoj terminologiji iz projekta *TABULA*, terminološki slobodnostojeća kuća odgovara kategoriji "Single family house – SH", kuća u nizu je ekvivalent "Terraced house (single family) – TH", manja stambena zgrada odgovara kategoriji "Multi-family house – MH", veliki stambeni blok ekvivalent je "Apartment block – AB". Posebna kategorija stambena zgrada u gradskom bloku je imenovana kao "Apartment block – AB1" a neboderi su „Highrise – H", više na http://episcope.eu/building-typology/tabula-structure/concept

Based on the given criteria, a typology matrix of residential buildings in Bosnia and Herzegovina was created, made of two categories of single-family housing and four categories of collective housing:[13]

Single-family housing: single family houses

A single family house is a building of individual housing with three floors maximum (⩽ 3 floors) and three dwelling units maximum (⩽ 3 dwelling units) which is on a separate lot and does not border with adjacent buildings.

Single-family housing: terraced houses

A terraced house is a building of individual housing with three floors maximum (⩽ 3 floors) and three dwelling units maximum (⩽ 3 dwelling units) which is on a separate lot within the framework of a row of buildings and it borders with adjacent buildings.

Collective housing: multi-family house

A multi-family house is a self-supporting building of collective housing with more than three floors (>3 floors), with more than three dwelling units (>3 dwelling units) and two house numbers maximum, which is on a separate lot and does not border with adjacent buildings.

Collective housing: attached apartment building in urban blocks

An attached apartment building in urban block is a building with more than three floors (>3 dwelling units), which are in the framework of a row of buildings in an urban block, that is, it borders with adjacent buildings.

Collective housing: apartment block

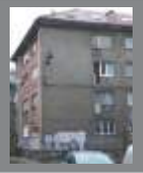
A large residential block is a multi-floor building of great floor area, with three and more house numbers.

Collective housing: high-rise building

A high-rise building is a freestanding building with many floors, at least eight floors (⩾8 floors), and with maximum two house numbers that is on a separate lot and does not border with adjacent buildings.

[13] According to the adopted terminology from the TABULA project, a term "single family house" corresponds to the category "Single family house – SH", a "house in line" is the equivalent of "Terraced house (single family) – TH", "multi-family house" corresponds to the category "Multi-family house – MH", "apartment block" is the equivalent of "Apartment block – AB". A separate category of residential building in a urban block was named as "apartment block-AB1" and skyscrapers are "Highrise-H", more available on: http://episcope.eu/building-typology/tabula-structure/concept

Tabela 1. Matrica tipologije stambenih zgrada BiH usklađena s projektom Tabula | **Table 1.** Residential buildings typology matrix in BiH adjusted with Tabula project

	INDIVIDUALNO STANOVANJE SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE COLLECTIVE HOUSING			DODATNE KATEGORIJE ADDITIONAL CATEGORIES	
	SLOBODNOSTOJEĆE KUĆE SINGLE-FAMILY HOUSES SH	KUĆE U NIZU TERRACED HOUSES TH	MANJE STAMBENE ZGRADE MULTI-FAMILY HOUSES MH	VELIKI STAMBENI BLOKOVI APARTMENT BLOCKS AB		STAMBENE ZGRADE U NIZU / GRADSKOM BLOKU ATTACHED APARTMENT BUILDINGS IN URBAN BLOCKS AB	NEBODERI HIGH-RISE BUILDINGS H
A					A		
B					B		
C					C		
D					D		
E					E		
F					F		

Specifičnosti tipologije stambenih zgrada u Bosni i Hercegovini

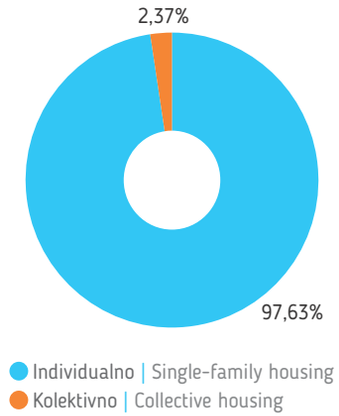
Nakon popisa stambenih objekata koji je obavila statistička agencija došlo se do podataka o broju objekata prema periodima građenja. Zbog izuzetno malog broja objekata iz perioda do 1919. godine ekspertski tim je donio odluku da se izvrši spajanje dva perioda, te su objekti građeni do 1919. godine i objekti građeni u periodu 1919-1945, u daljem radu svrstani u jedan - period do 1945.

Rezultati popisa stambenih objekata u Bosni i Hercegovini ukazuju na činjenicu da je znatno veći broj objekata individualnog stanovanja (97,63%) u odnosu na kolektivno stanovanje (2,37%) (Slika 3). Međutim, kada se posmatra broj stambenih jedinica, razlika u zastupljenosti individualnog (66,47%) i kolektivnog (33,53%) stanovanja manje je izražena (Slika 4). Prema ukupnoj površini stambenog prostora preovladavaju individualne kuće (73,71%), dok su ostali tipovi zastupljeni značajno manje: veliki stambeni blokovi/stambene lamele (11,49%), manje stambene zgrade (8,77%), individualne kuće u nizu (2,81%), stambene zgrade u nizu/gradskom bloku (2,51%) i neboderi (0,70%) (Slika 5).

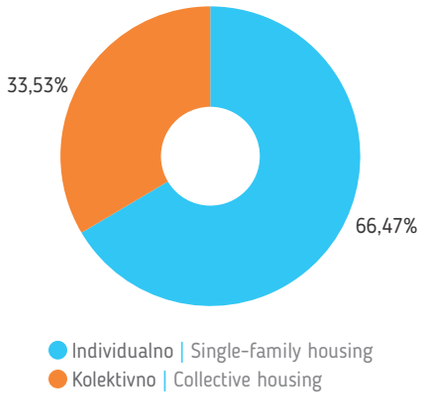
Specificities of typology of residential buildings in Bosnia and Herzegovina

After the inventory of residential buildings made by the statistics agency, data were obtained on the number of buildings according to construction periods. Due to extremely small number of buildings constructed in the period up to 1919, the expert team made a decision to merge two periods, so buildings constructed up to 1919 and buildings constructed in the period between 1919 and 1945 were all put in one period – up to 1945.

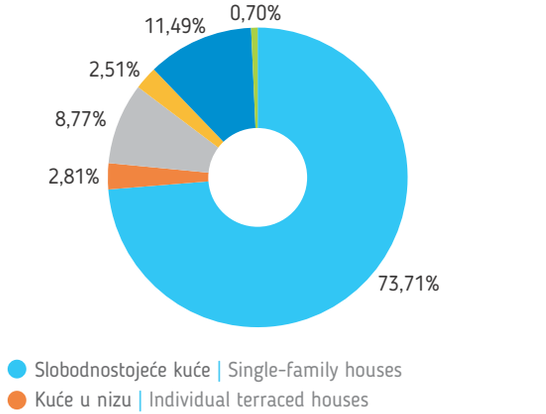
Results of inventory of residential buildings in Bosnia and Herzegovina point to the fact that a number of buildings of single-family housing (97.63%) compared to collective housing (2.37%) is significantly higher (Figure 3). However, if we analyse the number of dwelling units, difference in representation of single-family (66.47%) and collective (33.53%) housing is less expressed (Figure 4). According to the gross surface of residential space, single-family houses dominate (73.71%) whereas other types are present significantly lesser: apartment block (11.49%), multi-family house (8.77%), individual terraced houses (2.81%), attached apartment building in urban blocks (2.51%) and high-rise buildings (0.70%) (Figure 5).



Slika 3. Odnos individualnog i kolektivnog stanovanja prema ukupnom broju objekata
Figure 3. Ratio of single-family and collective housing by total number of buildings



Slika 4. Odnos individualnog i kolektivnog stanovanja prema ukupnom broju stanova
Figure 4. Ratio of single-family and collective housing by total number of dwelling units



Slika 5. Zastupljenost tipova stambenih objekata u BiH prema brutto površini
Figure 5. Distribution of typologies of residential buildings in BiH by gross surface

U kategoriji individualnih stambenih objekata dominantni udio čine slobodnostojeće kuće (96,2%), dok su kuće u nizu u malom procentu (3,8%).[13]

U kategoriji kolektivnog stanovanja najbrojnije su manje stambene zgrade (58,6%), a potom slijede veliki stambeni blokovi (21,2%), stambene zgrade u nizu (19,3%) I neboderi (0,9%).

Na osnovu statističkih podataka utvrđeno je da je izgradnja stambenih objekata bila najizraženija u sljedećim vremenskim periodima: 1992-2014. (30,9%), 1981-1991. (28,3%) i 1971-1980. (24,1%).

Kako je u fokusu ovog istraživanja energetska efikasnost u stambenoj arhitekturi, na terenu je metodom opservacije utvrđen nivo završenosti i obrade fasada stambenih objekata. Rezultati popisa pokazuju da čak 25,9% objekata u Bosni i Hercegovini nema završenu fasadu, dok je u 26,9% fasada urađeno naknadno.

ENERGETSKE POTREBE ZGRADA

U skladu s važećim pravilnicima u FBiH i RS, kao i standardom BAS EN ISO 13790, energetske potrebe objekata se računaju i izražavaju prema godišnjoj potrebnoj energiji za grijanje [4,5,6,7,14]. Klasifikacija objekata u energetske razrede se vrši prema vrijednosti specifične godišnje energije za grijanje izražene preko korisne, grijane površine. U toku rada na projektu *Tipologija stambenih objekata Bosne i Hercegovine* izračunata je apsolutna i specifična godišnja potrebna energija za grijanje za ukupno 29 reprezentativnih stambenih objekata, koji predstavljaju šest kategorija objekata razvrstanih u šest perioda izgradnje prema *TABULA* metodologiji [13]. Za potrebe proračuna pretpostavljeno je da se grije kompletna površina objekta koja se koristi za potrebe stanovanja. U zemljama u regionu je procijenjeno da se u samo 50% domaćinstava grije preko 50% korisne površine [12] sa nešto povoljnijiim indikatorima za zemlje Evropske unije [11]. Prema tome, ovaj kriterij nije ispunjen za nekoliko kategorija objekata, a posebno za slobodnostojeće porodične kuće koje prema udjelu u ukupnoj površini stambenog fonda predstavljaju dominantnu kategoriju. Ovo je jedan od razloga zašto izračunate vrijednosti potrebne energije za grijanje, (potrebne, isporučene i primarne), odstupaju od procjena dobijenih odgovarajućim studijama i statističkim podacima za Bosnu i Hercegovinu i zemlje u regionu [11, 12]. Osnovne karakteristike proračuna energetskih potreba su: korištenje jedinstvenih klimatskih podataka, arhitektonsko-građevinske karakteristike objekata svedene na projektne vrijednosti, standardizovane vrijednosti koje uzimaju u obzir ponašanje korisnika kao što su broj sati grijanja i unutrašnji prilivi toplote, te je pretpostavljena projektna temperatura u grijanom prostoru 20°C.

[13] Za Bosnu i Hercegovinu nije karakterisitčna izgradnja kuća u nizu i one su građene, uglavnom, u gradovima.

In the category of single-family housing, a dominant part is made of single family houses (96.2%) whereas terraced houses hold small percentage (3.8%).[13]

In the category of collective housing, the most numerous are multi-family houses (58.6%) followed by apartment blocks (21.2%), attached apartment building in urban blocks (19.3%) and high-rise buildings (0.9%).

Based on statistical data, it was established that a construction of residential buildings had been expressed the most in the following periods: 1992-2014. (20.9%), 1981-1991. (28.3%) and (1971-1980. (24.1%).

Since the focus of this research was energy efficiency of residential architecture, by the use of observation method in the field was established the level of completion and processing of facades of residential buildings. Inventory results show that as much as 25.9% of buildings in Bosnia and Herzegovina do not have a completed facade, whereas 26.9% facades were built afterwards.

ENERGY NEED OF BUILDINGS

In accordance with valid rulebooks in the FBiH and RS, as well as the BAS EN ISO 13790 standard, energy requirements of buildings are calculated and expressed in accordance with annual heating energy requirement [4,5,6,7,14]. Classification of buildings into energy classes is done in accordance with the value of specific energy need for heating expressed through a useful, heated surface. During the work on the project *Typology of Residential Buildings in Bosnia and Herzegovina*, an absolute and specific energy need for heating was calculated for the total of 29 representative residential buildings, which represent six categories of buildings classified into six periods of construction according to the *TABULA* methodology [13]. For the calculation requirements, it was assumed that the entire building surface used for residential purposes was heated. In regional countries it was estimated that only 50% of households heated over 50% of conditioned area [12] whereas indicators for the EU countries are somewhat better [11]. Therefore, several building categories, especially single family houses which according to share in the total surface of the housing stock represent a dominant category, have not met this criteria. This is one of the reasons why the calculated values of energy needs for heating, (needed, delivered and primary) deviate from the estimates obtained by the relevant studies and statistical data for Bosnia-Herzegovina and the countries in the region [11, 12]. Basic characteristics of calculations of energy requirements are: use of unified climate data, architectural and construction characteristics of buildings reduced to project values, standardised values that take into account user behaviour such as the number of heating hours and internal heat gains and assumed project temperature in the heated space of 20°C.

[13] Construction of terraced houses is not an attributive construction for Bosnia and Herzegovina and they were mostly constructed in towns.

U proračun su uključeni transmisioni i ventilacioni gubici, te dobici toplote (unutrašnji i solarni dobici). Kod računanja solarnih dobitaka toplote uzeta je u obzir orijentacija elementa omotača. Izvršen je detaljni proračun transmisionog toplotnog gubitka kroz negrijane prostore. U okviru III. poglavlja ove knjige, u kojem su predstavljene odabrane tipične zgrade, prikazane su vrijednosti koeficijenta transmisionog toplotnog gubitka za svaki elemenat omotača, gdje se može vidjeti koji elemenat predstavlja izvor najvećih transmisionih gubitaka. Proračun godišnje potrebne energije za grijanje rađen je za kontinuirani rad i rad s prekidima sa standardizovanim brojem sati grijanja koji iznosi 17h dnevno, 7 dana u sedmici, za sve razmatrane objekte. Odstupanja od broja sati grijanja su također razlog odstupanja od procijenjene potrebne energije za grijanje i podataka iz studija i statističkih pregleda. Broj izmjena vazduha je standardizovan i iznosi minimalno 0,5 h^{-1} za sve kategorije objekata iz perioda 1992–2014. do maksimalne vrijednosti 1,2 h^{-1} za zgrade kolektivnog stanovanja izgrađene u periodu prije 1970. godine i sve nebodere. S obzirom da je za analizu i proračun posmatrano projektno stanje tipičnih zgrada, broj izmjena vazduha je u najvećoj mjeri funkcija starosti objekta odnosno ugrađenih prozora. U III. poglavlju je za tipične zgrade dat prikaz ventilacionog i ukupnog transmisionog koeficijenta gubitaka. Za sve razmatrane kategorije izračunate su specifična godišnja, isporučena i primarna energija, kao i godišnja emisija CO_2.

Vrijednosti specifične godišnje potrebne toplotne energije su najveće za kategoriju slobodnostojećih kuća s vrijednostima i preko 400 kWh/m^2/god. Analize izvršene u zemljama u regionu također pokazuju da su slobodnostojeće porodične kuće kategorija s najvećom specifičnom energijom za grijanje [12]. Za ovu kategoriju zabilježene su i najveće vrijednosti faktora oblika, što je indikator za veću vrijednost potrebne energije za grijanje. Niti jedna tipična zgrada u kategoriji slobodnostojećih kuća ne zadovoljava dozvoljene vrijednosti godišnje energije za grijanje prema važećim entitetskim pravilnicima.[14] Uzimajući u obzir da je ova kategorija objekata najveća po udjelu površine u ukupnom stambenom fondu, sa čak 73,71%, dobijeni rezultati pokazuju da upravo ova kategorija objekata ima najveći potencijal za uštedu. Primjenom arhitektonsko-građevinskih mjera i mjera koje se odnose na sanaciju termotehničkih sistema u individualnim slobodnostojećim kućama moguće su značajne uštede isporučene i primarne energije, te emisije CO_2.

[14] Pravilnik o energetskom certificiranju objekata, "Službene novine Federacije BiH", 50/10 i Pravilnik o minimalnim zahtjevima za energetske karakteristike zgrada, "Službeni glasnik Republike Srpske", 30/15.

The calculation includes transmission and ventilation losses, and heat gains (internal and solar gains). The orientation of envelope elements has been taken into account upon calculation of solar heat gains. A detailed calculation of transmission heat loss through unheated spaces was carried out. In the III chapter of this book, in which selected representation buildings were presented, values of transmission heat transfer coefficient for each envelope element were showed, where it was possible to see which element represented the source of the greatest transmission losses. The calculation of energy need for heating was carried out for continuous work and intermitted work with a standardized number of heating hours which was 17 hours a day, 7 days a week for all analysed buildings. Deviations from the number of heating hours were also the reason for deviations from the estimated heating energy and data from studies and statistical overviews. The number of air changes has been standardised and is at least 0.5 h^{-1} for all categories of buildings from the period between 1992 and 2014 up to the maximum value of 1.2h^{-1} for collective residence buildings constructed before 1970 and all skyscrapers. Given that the project state of representative buildings was taken for the analysis and calculation, the number of air changes is mostly in function of building age, that is, of inbuilt windows. In the III chapter, for representative buildings is provided a description of ventilation and the heat transfer coefficient. Specific energy need, delivered and primary energy as well as annual CO_2 emission were calculated for all analysed categories.

Values of the specific energy need for heating are the highest for the category of single family houses with values of even over 400 kWh/m^2/year. Analyses carried out in the regional countries also show that single family houses are the category with the highest specific energy need for heating [12]. The highest values of the shape-factor have been recorded for this category, which is the indicator for a higher value of the energy need for heating. Neither representative building in the category of single family houses does meet the allowed values of annual heating energy according to the valid rulebooks of entities.[14] Bearing in mind that this category of buildings is the largest by the share of surface in the entire housing stock with as much as 73.71%, the obtained results show that this category of buildings in fact has the greatest savings potential. By applying architectural and construction measures and improvement measures of thermal and technical systems in individual, single family houses, it is possible to make significant savings of delivered and primary energy and CO_2 emission.

[14] Rulebook on Energy Certification of Buildings, "Official Gazette of the Federation of BiH", 50/10 and Rulebook on Minimal Requirements for Energy Characteristics of Buildings, "Official Gazette of Republic of Srpska", 30/15.

MJERE UNAPREĐENJA ENERGETSKIH KARAKTERISTIKA ZGRADA

Definisanje mjera koje treba da doprinesu energetskim uštedama nije bilo uvjetovano kriterijima ekonomske isplativosti, kao i eventualnim tehničkim i arhitektonskim ograničenjima primjene predloženih mjera u svakom konktrenom slučaju.

Sve mjere koje mogu dovesti do smanjivanja potrošnje energije u stambenim zgradama sistematizovane su u tri grupe:

1. Mjere unapređenja elemenata termičkog omotača zgrade (arhitektonsko-građevinske mjere);
2. Mjere unapređenja sistema grijanja prostora (termotehničke mjere);
3. Mjere unapređenja sistema za pripremu tople sanitarne vode (termotehničke mjere).

Mjere unapređenja termičkog omotača zgrade – arhitektonsko-građevinske mjere

Predložene arhitektonsko-građevinske mjere date su za dva moguća nivoa unapređenja energetskih karakteristika zgrada:

- **Unapređenje 1** – standardne mjere unapređenja koje su definisane u skladu s uobičajenim mjerama koje se primjenjuju prilikom sanacija zgrada na području BiH (poboljšanje termičkih karakteristika zidova i tavanica tehnički uobičajenim postupcima), kao i eventualna zamjena postojećih prozora novim, boljih karakteristika (definisane minimalne vrijednosti koeficijenata prolaza toplote);
- **Unapređenje 2** – nestandardne mjere koje značajno unapređuju energetsku klasu/razred zgrade, obuhvataju kompletan termički omotač, a rijetko se primjenjuju zbog visoke cijene koštanja.

Predložene mjere unapređenja nisu određene s ciljem da objekat dostigne određeni energetski razred, već isključivo s ciljem da se smanji potrošnja energije. Predložene mjere su tipične mjere koje je moguće provesti s ciljem da se smanji potrošnja energije, ali se za svaku zgradu mora detaljno razmotriti koje će mjere biti provedene, imajući u vidu karakteristike zgrade, kao i ekonomske i tehničke preduslove za njihovo provođenje. Predložene mjere za oba nivoa unapređenja su date u Tabeli 2.

IMPROVEMENT MEASURES OF ENERGY CHARACTERISTICS OF BUILDINGS

Defining measures that should contribute to energy savings was neither conditioned by the criteria of economic viability nor possible technical and architectural constraints of application of the proposed measures in every observed case.

All measures that could result in decrease of energy consumption in residential buildings have been systematised into three groups:

1. Measures of improving elements of thermal envelope of a building (architectural and construction measures);
2. Measures of improving space heating systems (thermo-technical measures);
3. Measures of improving systems for domestic hot water system (thermo-technical measures).

Measures of improving thermal envelope of a building – architectural and construction measures

The proposed architectural and construction measures are provided for two possible levels of improvement of energy characteristics of buildings:

- **Improvement 1** – standard improvement measures defined in accordance with usual measures applied during building reconstruction in the territory of BiH (improvement of thermal characteristics of walls and ceilings by technically common procedures) as well as a possible replacement of the existing windows with new ones, with better characteristics (defined minimal values of heat transfer coefficient);
- **Improvement 2** – non-standard measures which significantly improve the energy class/building class, include the entire thermal envelope and are rarely applied due to a high price.

Proposed improvement measures have not been defined for the purpose of a building reaching a certain energy class, but exclusively with the goal of reducing the energy consumption. The proposed measures are typical measures which can be implemented with the goal of reducing the energy consumption, but for each building it is necessary to analyse in details which measures will be implemented, bearing in mind building characteristics as well as economic and technical preconditions for their implementation. The proposed measures for both improvement levels are provided in the Table 2.

Tabela 2. Predložene mjere za unapređenje energetskih karakteristika zgrada | **Table 2.** Proposed measures for improvement of energy characteristics of buildings		
TIP KONSTRUKCIJE | CONSTRUCTION TYPE	Debljina termoizolacije (λ=0,041 W/mK): UNAPREĐENJE 1 Thermal insulation (λ=0,041 W/mK) thickness: IMPROVEMENT 1	Debljina termoizolacije (λ=0,041 W/mK): UNAPREĐENJE 2 Thermal insulation (λ=0,041 W/mK) thickness: IMPROVEMENT 2
vanjski zid | exterior wall	10cm	20cm
unutrašnji zid između grijanog i negrijanog prostora | interior wall between heated and unheated space	-	5cm
tavanica prema negrijanom tavanu | ceiling toward non-heated attic	10cm	20cm
tavanica prema negrijanom podrumu | ceiling toward non-heated basement	10cm	20cm
ravan krov | flat roof	20cm	30cm
kosi krov | sloped roof	20cm	30cm
pod na tlu | floor on the ground	-	10cm
prozori | windows	1,6 W/m^2K s dvostrukim izolacionim staklom | with double isolation glass	1,0 W/m^2K s trostrukim izolacionim staklom | with triple isolation glass

Mjere unapređenja sistema grijanja prostora - termotehničke mjere

Tipičnim zgradama pridruženi su sistem grijanja, energent, stepen efikasnosti sistema grijanja koji uključuje efikasnost kotao-regulacija-distribucija i faktor primarne energije, procijenjeni na osnovu statističkih podataka i dostupnih studija iz oblasti energetske efikasnosti na području Bosne i Hercegovine.

Pregledom statističkih podataka može se uočiti velika zastupljenost drveta kao energenta koji se koristi za grijanje, posebno kod porodičnih kuća sa sistemom grijanja koji uključuje pojedinačne peći na čvrsto gorivo s ručnim loženjem, ali i kod velikog broja kategorija zgrada kolektivnog stanovanja (gdje takođe dominiraju sistemi s ručnim loženjem). Ovo je direktna posljedica ratnih razaranja sistema daljinskog grijanja ili dugog prekida njihovog rada koji se desio u toku ratnog i poslijeratnog perioda. Kako je veliki broj ovih sistema bio vezan za toplane lokalnih fabrika, ti sistemi daljinskog grijanja su ili potpuno oštećeni tokom rata ili su odvojeni od fabričkih toplana koje ne rade. Za dvije kategorije zgrada provedenim istraživanjem je utvrđeno da dominantno koriste električnu energiju za zagrijavanje prostora (kuće u nizu i male stambene zgrade). Kod zgrada kolektivnog stanovanja dominantan je sistem daljinskog grijanja s ugljem, mazutom i prirodnim gasom kao energentom. Statistički podaci pokazuju da prirodni gas nije dominantno gorivo ni u jednoj kategoriji objekata, jer je njime pokriveno svega 7% grijanja stanova u BiH. Kod proračuna parametara iz daljinskog grijanja statistički je dobijen odnos zastupljenosti goriva: mazut 37,3%, prirodni gas 47,8% i ugalj 14,9%. Nažalost, način korištenja drveta kao goriva je neefikasan, jer se jednim dijelom i tehničko drvo koristi kao energent, a s druge strane peći i kotlovi koji se koriste za sagorijevanje drveta imaju vrlo nizak stepen iskorištenja.

Kod predlaganja mjera unapređenja sistema grijanja nisu mijenjani energenti već su predlagani sistemi grijanja s većim stepenom efikasnosti i sistemi koji omogućavaju postizanje boljih uslova toplotnog komfora kao što su: postavljanje termostatskih ventila i hidrauličko

Measures of improving space heating systems – thermo-technical measures

Heating system, system fuel, heating system efficiency have been associated with representative buildings that include efficiency of boiler-regulation-distribution and primary energy factor, evaluated based on statistical data and available studies in the field of energy efficiency in the territory of Bosnia and Herzegovina.

By reviewing statistical data, a great presence of wood as a fuel for the heating system, can be noticed, especially in family houses with the heating system that includes individual hand-firing solid-fuel furnaces, but also in a great number of categories of collective housing buildings (in which also dominate hand-firing systems). This is a direct consequence of war destructions of district heating systems or a long interruption of their work that happened during and after the war. Since a great number of these systems were connected to district heating plants of local factories, these district heating systems had either been completely destroyed during the war or were separated from the factory heating plants which are not in function. The implemented research established that two categories of buildings were using dominantly electric power for heating up spaces (terraced houses and multi-family buildings). A district heating system with coal, crude oil and natural gas, as a fuel for the heating system, is dominant in collective housing buildings. Statistical data show that natural gas is not a dominant fuel in any building category, because it is used only to heat 7% of apartments in BiH. Upon calculating parameters of district heating system, proportional representation of fuels was obtained statistically: crude oil 37.3%, natural gas 47.8% and coal 14.9%. Unfortunately, the manner of using wood as fuel is inefficient, because partially technical wood is also used as a fuel and on the other hand furnaces and boilers used for wood combustion have a very low system efficiency.

When measures of heating system improvement were proposed, fuels were not changed, but heating systems with a higher efficiency were proposed and systems that enable better

balansiranje sistema. Ugradnja mjerila potrošnje toplotne energije je predložena za sve sisteme na kojima je to ostvarivo kao efikasna mjera koja omogućava praćenje i smanjivanje potrošnje toplotne energije.

Dominantni sistemi grijanja za sve periode izgradnje slobodnostojećih porodičnih kuća i kuća u nizu (individualno stanovanje) su pojedinačne peći na čvrsto gorivo s drvetom i ugljem kao energentima. Analiza potrošnje ukazuje da je odnos zastupljenosti drveta prema uglju 80:20%. Pretpostavlja se da je stepen efikasnosti ovakvih sistema veoma nizak i da iznosi 50%. Predložene mjere sanacije uključuju prelazak na centralni sistem grijanja s pirolitičkim kotlom na drva i akumulatorom toplote ili kotlom na pelet, uz povećanje stepena efikasnosti na 85 % (unapređenje 1) i centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima sa stepenom efikasnosti 90 % (unapređenje 2).

Grijanje na pojedinačne peći s drvetom i ugljem kao energentom zastupljeno je i kod kategorija kolektivnog stanovanja, kao što su stambene zgrade izgrađene u periodu prije 1945. godine i u periodu od 1971. do 1980. godine, stambene zgrade u nizu i stambene lamele izgrađene u periodu prije 1960. godine. Razlog tome je ranije naveden i odnosi se na ratna razaranja. Predložene mjere sanacije uključuju prelazak na centralni sistem grijanja na drvo ili pelet uz povećanje stepena efikasnosti na 85% (unapređenje 1) i centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima sa stepenom efikasnosti 90% (unapređenje 2). Drugi nivo mjera unapređenja uključuje i primjenu mjera hidrauličkog balansiranja mreže i postavljanje termostatskih ventila kao mjere kojim se postiže bolji toplotni komfor u objektu, a kod sistema koji se pregrijavaju omogućavaju uštedu u potrošnji toplotne energije.

Za kategoriju porodičnih kuća u nizu izgrađenih u periodu do 1945. godine i za stambene zgrade izgrađene u periodu od 1946. do 1960. godine dominantni sistem grijanja je grijanje električnim pećima (grijalice + termoakumulacionepeći) sa stepenom efikasnosti sistema procijenjenim na 98%. Predložene mjere sanacije uključuju primjenu toplotne pumpe vazduh-vazduh s vršnim električnim grijačem uz povećanje stepena efikasnosti na 300% (unapređenje 1) i centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima sa stepenom efikasnosti 90% (unapređenje 2). Drugi nivo mjera unapređenja za stambene zgrade uključuje i primjenu mjere hidrauličkog balansiranja mreže i postavljanje termostatskih ventila. Prelazak s pojedinačnih toplotnih pumpi na centralni sistem zagrijavanja je vezan za veći termalni komfor i postizanje funkcije grijanja i pri niskim spoljnim temperaturama.

Sistem daljinskog grijanja je dominantni sistem grijanja za sve ostale kategorije stambenih zgrada s ugljem, mazutom i prirodnim gasom kao energentom. Stepen iskorištenja ovakvog sistema procijenjen je na 85%. Mjere poboljšanja termotehničkog sistema uključuju ugradnju nove ili rekonstrukciju postojeće toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpe s promjenjivim protokom, daljinskim upravljanjem podstanicom i mjerenjem isporučene toplote (unapređenje 1), a za unapređenje 2, uz ove mjere

conditions of thermal comfort such as: installing thermostatic valves and hydraulic balancing of system. Installation of meter for heating energy consumption was proposed for all systems in which that could be done as an efficient measure which enabled monitoring and reduction of heating energy consumption.

Dominant heating systems for all periods of construction of single family houses and terraced houses (individual housing) are individual solid-fuel furnaces with wood and coal as fuel for the heating system. The consumption analysis shows that representation ration of wood to coal is 80:20%. It is assumed that the efficiency of these systems is very low and amounts to 50%. The proposed measures of repair include transition to the central heating system with wood pyrolysis boiler and heat accumulator or pellet boiler, with an increased efficiency level out 85% (improvement 1) and wood or pellet-fired central heating system and thermostatic valves with the efficiency of 90% (improvement 2).

Heating with individual furnaces on wood and coal as fuel is also present in collective residence categories such as residential buildings constructed in the period before 1945 and period from 1971 to 1980, residential buildings in a row and residential bays constructed before 1960. The reason for this has previously been mentioned and pertains to war destructions. The proposed repair measures include transition to the central heating system with wood or pellet with an increased efficiency level to 85% (improvement 1) and central heating system with wood or pellet with heat accumulator and thermostatic valves with the efficiency level of 90% (improvement 2). The second level of improvement measures includes also application of measures of hydraulic balancing of heating distribution system and installation of thermostatic valves as a measure by which a better thermal comfort in a building is achieved and in systems which overheat, they enable greater savings of heating energy consumption.

For the category of family terraced houses constructed in the period before 1945 and for residential buildings constructed in the period between 1946 and 1960, the dominant heating system was heating with electric furnaces (electric heaters + thermo-accumulation furnaces) with system efficiency level evaluated to 98%. The proposed repair measures include application of air to air heat pump with peak electric heater and an increase of efficiency level to 300% (improvement 1) and central heating system with wood or pellet, with heat accumulator and thermostatic valves with the efficiency level of 90% (improvement 2). The second level of improvement measures for residential buildings includes also application of measures of hydraulic balancing of heating distribution system and installation of thermostatic valves. A transition from individual heat pumps to the central heating system is related to a higher thermal comfort and reaching heating function even at low external temperatures.

District heating system is a dominant heating system in all other categories of residential buildings with coal, crude oil and natural gas as fuel. Efficiency of this system has been estimated to 85%. Improvement measures of thermo-technical system include installation of

preporučuje se i primjena mjere hidrauličkog balansiranja mreže i postavljanje termostatskih ventila. Procijenjeni stepen efikasnosti sistema grijanja za nivo mjera unapređenja 1 iznosi 90%, a za nivo mjera unapređenja 2 je 95%.

Mjere unapređenja sistema za pripremu tople sanitarne vode – termotehničke mjere

Za pripremu potrošne tople vode u svim kategorijama tradicionalno se koristi električna energija, tj. individualni akumulacioni bojleri. Predložene mjere poboljšanja sistema pripreme potrošne tople vode uključuju prelazak na akumulacioni bojler s izmjenjivačem, koji koristi toplu vodu iz sistema grijanja za pripremu PTV (unapređenje 1) i prelazak na centralni sistem pripreme potrošne tople vode povezan sa sistemom grijanja i sistemom solarnih kolektora (unapređenje 2). Za objekte koji su priključeni na daljinski sistem grijanja predviđa se da će se centralna priprema potrošne tople vode vršiti preko spremnika tople vode u podstanici.

a new or reconstruction of the existing heating substation with temperature regulation according to the external temperature, pumps with variable flow, remote control heating substation and measurement of delivered heat (improvement 1), and for the improvement 2, along with these measures is recommended installation of thermostatic valves. The estimated efficiency of heating systems for the level of improvement measures 1 is 90% and for the level of improvement measures 2, 95%.

Measures of improving systems for domestic hot water system – thermo-technical measures

Electric power, that is, individual accumulation boilers are traditionally used for domestic hot water system in all categories. The proposed measures of improving the domestic hot water system include transition to accumulation boiler with exchanger, which uses hot water from the heating system to prepare the domestic hot water (improvement 1) and transition to the central system of preparation of domestic hot water in conjunction with the heating system and solar collectors system (improvement 2). For buildings which are connected to the remote heating system, it is anticipated that the central preparation of domestic hot water will be carried out through hot water tanks in the heating substation.

	INDIVIDUALNO STANOVANJE SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE COLLECTIVE HOUSING			
	SLOBODNOSTOJEĆE KUĆE SINGLE-FAMILY HOUSES SH 1	KUĆE U NIZU TERRACED HOUSES TH 2	MANJE STAMBENE ZGRADE MULTI-FAMILY HOUSES MH 3	STAMBENE ZGRADE U NIZU / GRADSKOM BLOKU ATTACHED APARTMENT BUILDINGS IN URBAN BLOCKS AB1 4	VELIKI STAMBENI BLOKOVI / STAMBENE LAMELE APARTMENT BLOCKS AB2 5	NEBODERI HIGH-RISE BUILDING H 6
A <1945						
B 1946-1960						
C 1961-1970						
D 1971-1980						
E 1981-1990						
F 1991-2014						

REZULTATI POPISA ZGRADA | BUILDINGS SURVEY RESULTS

II. REZULTATI POPISA ZGRADA

Zastupljenost tipova stambenih zgrada prema bruto površini

Analizom opštih podataka iz Upitnika A, u okviru prvostepenog popisa objekata, dobijeni su kvantitativni pokazatelji o ukupnim bruto površinama pojedinih tipova stambenih zgrada, koji su klasifikovani prema usvojenoj matrici na nivou BiH i prikazani u Tabeli 3. U Tabeli 4 dat je prikaz bruto površina stambenih objekata u FBiH, a u Tabeli 5 dati su podaci za Republiku Srpsku. Prosječne bruto površine objekata izračunate su na osnovu ulaznih podataka o dimenzijama osnove i prosječnog broja nadzemnih etaža objekata, te uključuju i površine nestambenih sadržaja kao što su poslovni prostori, garaže i slično, koji se obično nalaze u suterenu i prizemlju objekata. Iz ovog razloga, za potrebe proračuna potrebne toplotne energije za grijanje objekata, korišteni su posebni koeficijenti,[1] kako je pojašnjeno u opisu Tabele 6.

Podaci o bruto površinama objekata pojedinih tipova stambenih objekata ukazuju na činjenicu da je individualno stanovanje u porodičnim kućama dominantan oblik stanovanja u BiH/FBiH i RS. Slobodnostojeće kuće i kuće u nizu zajedno čine čak 76,52% ukupne bruto površine stambenog fonda, te predstavljaju potencijal o kojem treba voditi računa prilikom pripreme strategija za unapređenje energetskih karakteristika objekata u BiH/FBiH/RS). Podaci o velikim stambenim blokovima/stambenim lamelama iz perioda do 1945. godine ne postoje, jer ovaj tip stambenih objekata počinje da se gradi tek u periodu nakon II. svjetskog rata, kada se zbog naglog priliva stanovništva u gradove, koji je izazvan procesom industrijalizacije, grade nova velika stambena naselja.

[1] Uvođenjem koeficijenta odnosa bruto površine prosječnog stambenog objekta i bruto površine tipičnog objekta, te koeficijenta odnosa neto i bruto površina tipičnog objekta, riješena su odstupanja u površinama prosječnog popisanog objekta i tipičnog, stvarnog objekta.

II. BUILDINGS SURVEY RESULTS

Share of different types of residential buildings in the total gross surface

Analysis of the general data from the Questionnaire A, of the first-instance building survey, resulted in quantitative indicators of the total gross size of specific types of residential buildings, categorised according to the matrix adopted on the BiH level, as shown in Table 3. Table 4 shows the gross surface of residential buildings in the FBiH, while Table 5 presents data for Republika Srpska. Average gross surface of buildings was calculated based on entry data on dimensions of the footprint and the average number of floors above the ground, which also include the size of non-residential areas such as business offices, garages, etc., usually located in the basement or on the ground floor. Due to this reason, special coefficients were used in calculating the required energy for heating of buildings,[1] as explained in the description of Table 6.

Data on gross surface of buildings of certain types of residential buildings show that individual housing in single-family houses is the predominant type of housing in BiH/FBiH and RS. Single-family houses and terraced houses account for 76.52% of the total gross surface in the housing stock, indicating the potential that should be taken into account during drafting of strategies for improvement of energy efficiency of buildings in BiH/FBiH/RS). Data on large apartment blocks built before 1945 do not exist, since this type of buildings started to be built only after the WWII, when migrations from rural to urban areas caused by industrialisation, created the need for new, large residential blocks.

[1] Introduction of coefficient representing the ratio between the average gross surface of the average residential building and gross surface of the typical building, and of the coefficient of ratio between net and gross surface of a typical building, resolved discrepancies in size of an average surveyed building and typical, actual building.

Tabela 3. Bruto površine stambenih objekata u BiH po tipovima | **Table 3.** Gross surface of residential buildings in BiH per type

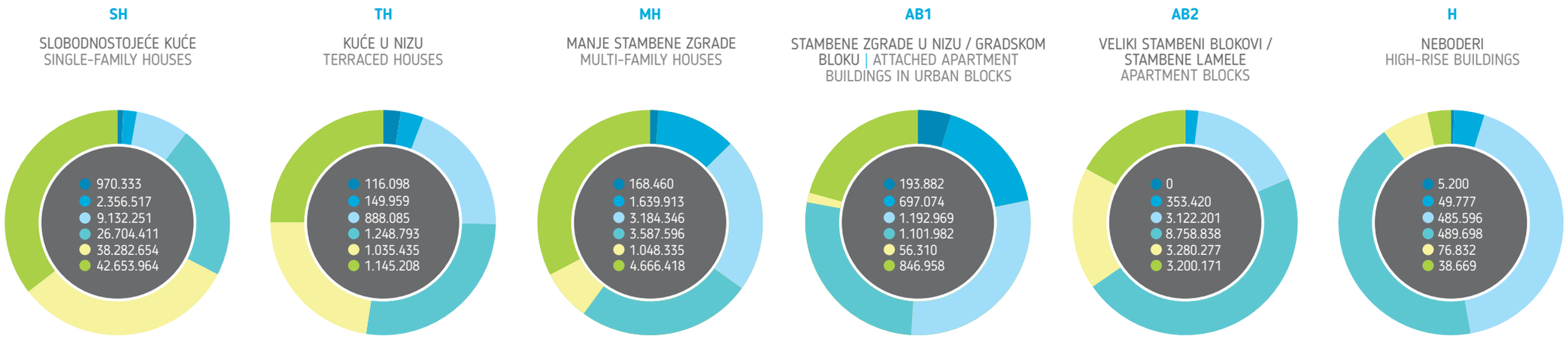
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	970.333	116.098	168.460	193.882		5.200	**1.453.973**	**0,89%**
1946-1960	2.356.517	149.959	1.639.913	697.074	353.420	49.777	**5.246.660**	**3,22%**
1961-1970	9.132.251	888.085	3.184.346	1.192.969	3.122.201	485.596	**18.005.448**	**11,05%**
1971-1980	26.704.411	1.248.793	3.587.596	1.101.982	8.758.838	489.698	**41.891.319**	**25,71%**
1981-1991	38.282.654	1.035.435	1.048.335	56.310	3.280.277	76.832	**43.779.843**	**26,87%**
1992-2014	42.653.964	1.145.208	4.666.418	846.958	3.200.171	38.669	**52.551.387**	**32,25%**
UKUPNO | TOTAL	**120.100.130**	**4.583.578**	**14.295.068**	**4.089.175**	**18.714.906**	**1.145.772**	**162.928.630**	**100,00%**
UKUPNO | TOTAL	**73,71%**	**2,81%**	**8,77%**	**2,51%**	**11,49%**	**0,70%**	**100,00%**	

Tabela 4. Bruto površine stambenih objekata u FBiH po tipovima | **Table 4.** Gross surface of residential buildings in FBiH per type

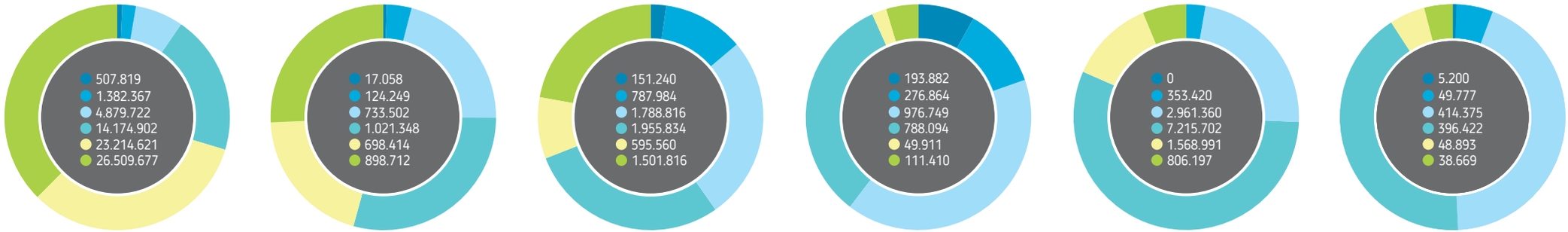
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	507.819	17.058	151.240	193.882		5.200	**875.199**	**0,90%**
1946-1960	1.382.367	124.249	787.984	276.864	353.420	49.777	**2.974.661**	**3,06%**
1961-1970	4.879.722	733.502	1.788.816	976.749	2.961.360	414.375	**11.754.524**	**12,09%**
1971-1980	14.174.902	1.021.348	1.955.834	788.094	7.215.702	396.422	**25.552.303**	**26,29%**
1981-1991	23.214.621	698.414	595.560	49.911	1.568.991	48.893	**26.176.390**	**26,93%**
1992-2014	26.509.677	898.712	1.501.816	111.410	806.197	38.669	**29.866.480**	**30,73%**
UKUPNO | TOTAL	**70.669.108**	**3.493.283**	**6.781.249**	**2.396.910**	**12.905.670**	**953.337**	**97.199.558**	**100,00%**
UKUPNO | TOTAL	**72,71%**	**3,59%**	**6,98%**	**2,47%**	**13,28%**	**0,98%**	**100,00%**	

Tabela 5. Bruto površine stambenih objekata u RS po tipovima | **Table 5.** Gross surface of residential buildings in RS per type

	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	460.082	99.040	7.113	0	0	0	**566.234**	**0,94%**
1946-1960	927.259	25.710	851.929	420.210	0	0	**2.225.108**	**3,67%**
1961-1970	4.154.009	151.378	1.280.293	216.220	160.841	71.221	**6.033.962**	**9,96%**
1971-1980	12.016.958	223.803	1.320.717	313.888	1.543.136	93.276	**15.511.778**	**25,62%**
1981-1991	14.046.568	332.286	452.776	6.399	1.711.286	27.939	**16.577.253**	**27,38%**
1992-2014	14.543.921	237.201	2.697.104	440.849	1.720.092	0	**19.639.166**	**32,43%**
UKUPNO | TOTAL	**46.148.795**	**1.069.418**	**6.609.932**	**1.397.567**	**5.135.354**	**192.436**	**60.553.501**	**100,00%**
UKUPNO | TOTAL	**76,21%**	**1,77%**	**10,92%**	**2,31%**	**8,48%**	**0,32%**	**100,00%**	



Slika 6. Grafički prikaz bruto površina stambenih objekata u BiH po tipovima | **Picture 6.** Graphic view of gross surface of residential buildings in BiH per type



Slika 7. Grafički prikaz bruto površina stambenih objekata u FBiH po tipovima | **Picture 7.** Graphic view of gross surface of residential buildings in FBiH per type

Slika 8. Grafički prikaz bruto površina stambenih objekata u RS po tipovima | **Picture 8.** Graphic view of gross surface of residential buildings in RS per type

do 1945. | up to 1945 · 1946-1960 · 1961-1970 · 1971-1980 · 1981-1991 · 1992-2014

Zastupljenost tipova stambenih zgrada prema njihovom ukupnom broju

Obradom prikupljenih podataka eksperti iz statističke agencije izvršili su procjenu ukupnog broja stambenih objekata i procentualne zastupljenosti pojedinih tipova objekata na nivou BiH/FBiH/RS. Rezultati navedene kvantitativne analize pokazuju da individualno stanovanje predstavlja dominantnu formu stanovanja u BiH/FBiH/RS, s obzirom da ova kategorija objekata, u koju se ubrajaju slobodnostojeće kuće i kuće u nizu, čini čak 97,63% ukupnog stambenog fonda u BiH.

Brojčana zastupljenost kuća u nizu znatno je manja u poređenju sa slobodnostojećim kućama, što predstavlja jednu od specifičnosti stambene tipologije u BiH/FBiH/RS. Istraživanje je pokazalo da je procentualna zastupljenost objekata iz kategorije „neboderi“ najmanja u odnosu na ukupni broj objekata. Neboderi su najintenzivnije građeni u periodu od 1961. do 1980., i to isključivo u urbanim područjima. Njihova izgradnja bila je omogućena napretkom građevinskog sektora i predstavljala je odgovor na potrebe da se smjesti veći broj stanovnika usljed migracije ruralnog stanovništva u urbane centre.

Share of different types in the total number of residential buildings

By processing the collected data, experts of the Agency for Statistics came up with the total number of residential buildings and individual shares in percentage for each level - BiH/FBiH/RS. The results of the aforementioned quantitative analysis show that individual housing is the predominant form of housing in BiH/FBiH/RS since this building category, which includes single-family and terraced houses, accounts for as much as 97.63% of the entire housing stock in BiH.

Terraced houses are much less frequent than single-family houses, which is one of the traits of the housing typology in BiH/FBiH/RS. Research has shown that high-rise building category has the smallest share in the total number of buildings. High-rise buildings were most popular in the period from 1961 to 1980, and they were only built in urban areas. They were built due to the advances made in the construction sector, as a response to the need to provide housing solutions for a large population coming from rural areas into urban centres.

Tabela 6. Broj stambenih objekata u BiH po tipovima | **Table 6.** Number of residential buildings in BiH per type

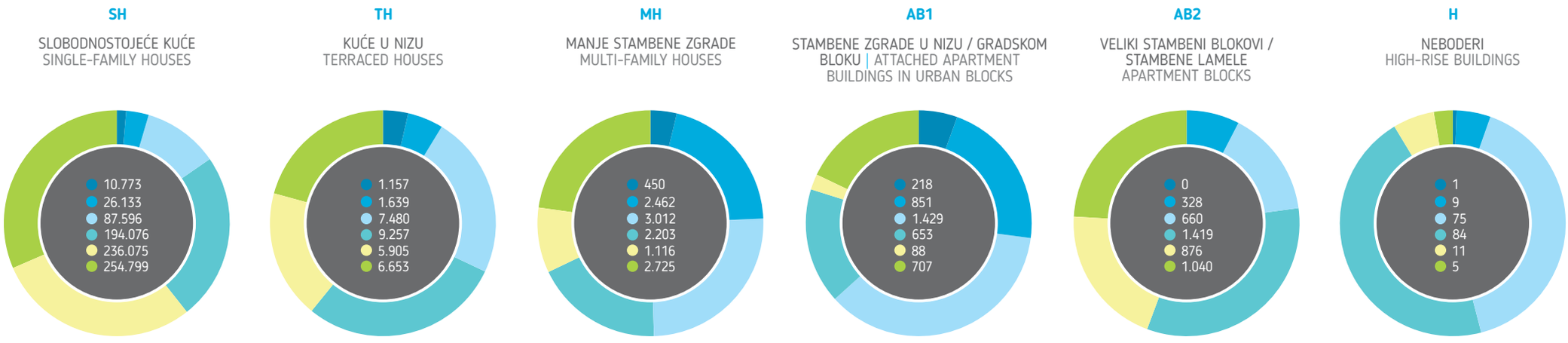
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	10.773	1.157	450	218		1	**12.599**	**1,46%**
1946-1960	26.133	1.639	2.462	851	328	9	**31.422**	**3,65%**
1961-1970	87.596	7.480	3.012	1.429	660	75	**100.252**	**11,63%**
1971-1980	194.076	9.257	2.203	653	1.419	84	**207.692**	**24,10%**
1981-1991	236.075	5.905	1.116	88	876	11	**244.071**	**28,32%**
1992-2014	254.799	6.653	2.725	707	1.040	5	**265.929**	**30,85%**
UKUPNO | TOTAL	**809.452**	**32.091**	**11.968**	**3.946**	**4.323**	**185**	**861.965**	**100,00%**
UKUPNO | TOTAL	**93,91%**	**3,72%**	**1,39%**	**0,46%**	**0,50%**	**0,02%**	**100,00%**	

Tabela 7. Broj stambenih objekata u FBiH po tipovima | **Table 7.** Number of residential buildings in FBiH per type

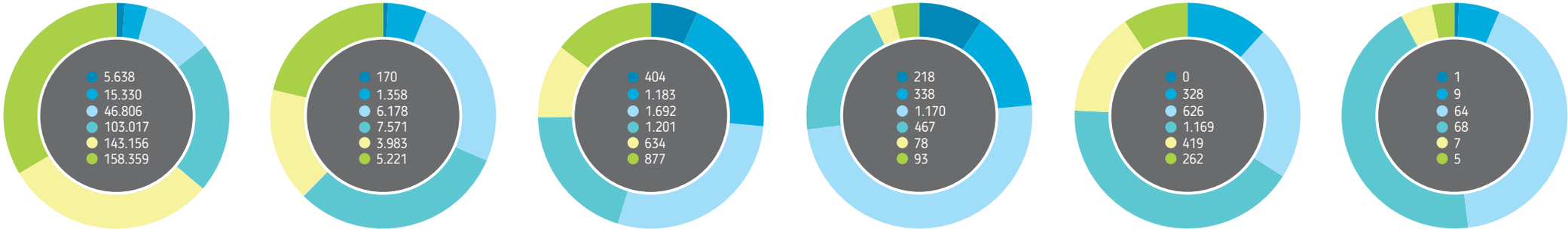
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	5.638	170	404	218		1	**6.431**	**1,27%**
1946-1960	15.330	1.358	1.183	338	328	9	**18.546**	**3,65%**
1961-1970	46.806	6.178	1.692	1.170	626	64	**56.536**	**11,13%**
1971-1980	103.017	7.571	1.201	467	1.169	68	**113.493**	**22,34%**
1981-1991	143.156	3.983	634	78	419	7	**148.277**	**29,18%**
1992-2014	158.359	5.221	877	93	262	5	**164.817**	**32,44%**
UKUPNO | TOTAL	**472.306**	**24.481**	**5.991**	**2.364**	**2.804**	**154**	**508.100**	**100,00%**
UKUPNO | TOTAL	**92,96%**	**4,82%**	**1,18%**	**0,47%**	**0,55%**	**0,03%**	**100,00%**	

Tabela 8. Broj stambenih objekata u RS po tipovima | **Table 8.** Number of residential buildings in RS per type

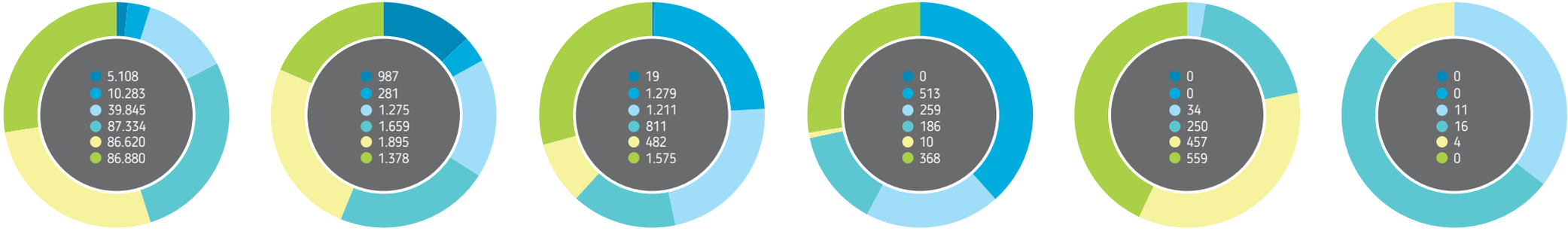
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	5.108	987	19	0	0	0	**6.114**	**1,84%**
1946-1960	10.283	281	1.279	513	0	0	**12.356**	**3,73%**
1961-1970	39.845	1.275	1.211	259	34	11	**42.635**	**12,86%**
1971-1980	87.334	1.659	811	186	250	16	**90.256**	**27,22%**
1981-1991	86.620	1.895	482	10	457	4	**89.468**	**26,98%**
1992-2014	86.880	1.378	1.575	368	559	0	**90.760**	**27,37%**
UKUPNO | TOTAL	**316.070**	**7.475**	**5.377**	**1.336**	**1.300**	**31**	**331.589**	**100,00%**
UKUPNO | TOTAL	**95,32%**	**2,25%**	**1,62%**	**0,40%**	**0,39%**	**0,01%**	**100,00%**	



Slika 9. Grafički prikaz broja stambenih objekata u BiH po tipovima | **Picture 9.** Graphic view of the number of residential buildings in BiH per type



Slika 10. Grafički prikaz broja stambenih objekata u FBiH po tipovima | **Picture 10.** Graphic view of the number of residential buildings in FBiH per type



Slika 11. Grafički prikaz broja stambenih objekata u RS po tipovima | **Picture 11.** Graphic view of the number of residential buildings in RS per type

do 1945. | up to 1945 · 1946-1960 · 1961-1970 · 1971-1980 · 1981-1991 · 1992-2014

Zastupljenost tipova stambenih zgrada prema broju stambenih jedinica

Na osnovu popisa objekata porodičnog i kolektivnog stanovanja u Bosni i Hercegovini i podataka iz prvostepenog anketnog formulara - Upitnik A, izvršena je statistička procjena ukupnog broja stambenih jedinica prema usvojenoj matrici na nivou BiH. Analiza ovih podataka pokazuje da individualno stanovanje predstavlja dominantnu formu stanovanja u BiH/FBiH/RS, s obzirom da je 66,47% stambenih jedinica zastupljeno u prve dvije kategorije objekata, slobodnostojećih kuća i kuća u nizu, dok 33,53% stambenih jedinica pripada kategorijama kolektivnog stanovanja. S druge strane, ovi procentualni odnosi potvrđuju opravdanost izgradnje objekata kolektivnog stanovanja, kao racionalnijeg rješenja u poređenju s izraženom brojnosti objekata individualnog stanovanja. Druga kategorija po brojnosti stambenih jedinica su veliki stambeni blokovi/stambene lamele, a na trećem mjestu su manje stambene zgrade. Poređenjem podataka iz Tabele 6 i Tabele 9 može se uočiti aspekt racionalnosti pri izgradnji kolektivnih stambenih objekata, iskazana kroz relaciju broja objekata i stambenih jedinica. Tako je broj zgrada za kolektivno stanovanje daleko manji u odnosu na broj individualnih kuća, dok je broj stambenih jedinica u kolektivnim stambenim zgradama znatno veći u odnosu na njihov broj u kućama. Dakle, urbanističko-ekonomski aspekti racionalnog korištenja građevinskog zemljišta jasno ukazuju na prednost izgradnje objekata za kolektivno stanovanje. S druge strane, učešće velikog broja stanara kolektivnih stambenih zgrada u procesima unapređenja energetskih karakteristika objekta potencijalno usložnjavaju njihovu moguću implementaciju. Razmatranje navedenih faktora zaslužuje posebnu pažnju, posebno u pogledu razvoja strategija i unapređenja energetskih karakteristika objekata kolektivnog stanovanja u BiH/FBiH/RS).

Share of different types of residential buildings according to the number of apartments/dwelling units

Based on the survey of buildings of individual and collective housing in Bosnia and Herzegovina, and the data from the first-instance survey sheet - Questionnaire A, a statistical estimate of the total number of dwelling units was made according to the matrix adopted for the level of BiH. Analysis of these data shows that individual housing is the most prominent form of housing in BiH/FBiH/RS, since 66.47% of all dwelling units belong to the first two building categories (single-family houses and terraced houses), while 33.53% of dwelling units falls into the collective housing category. However, all percentage ratios justify the building of collective residential buildings, since it is more rational solution than predominant single-family houses. The second largest category of residential units is large apartment blocks, and the third place goes to multi-family houses. Comparison of data shown in Table 6 and Table 9 shows a rationality aspect of building collective residential buildings, expressed as a ratio between the number of buildings and the number of dwelling units. Hence, the number of collective housing buildings is much smaller than the number of single-family houses; however, the number of dwelling units in collective residential buildings is significantly higher than in single-family houses. Therefore, spatial planning and economic aspects of rational use of construction land clearly indicate advantages of collective residential buildings. However, involvement of large numbers of residents in collective housing buildings in the processes of energy performance improvement potential complicates their eventual implementation. These factors need to be considered carefully with regards to strategy development and energy performance improvement in collective residential buildings in BiH/FBiH/RS).

Tabela 9. Broj stambenih jedinica po tipovima stambenih objekata u BiH | **Table 9.** Number of dwelling units per type of residential buildings in BiH

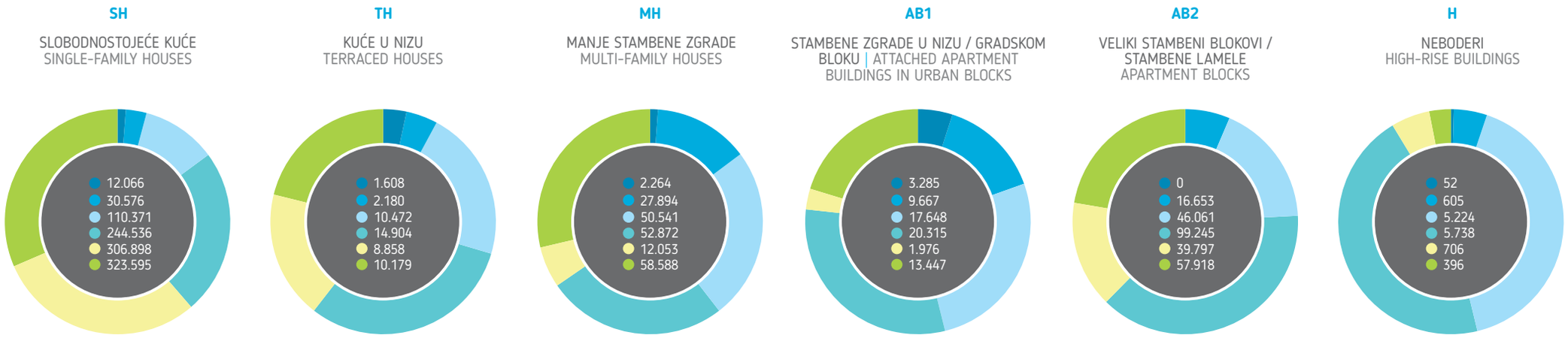
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	12.066	1.608	2.264	3.285		52	**19.275**	**1,19%**
1946-1960	30.576	2.180	27.894	9.667	16.653	605	**87.575**	**5,41%**
1961-1970	110.371	10.472	50.541	17.648	46.061	5.224	**240.318**	**14,84%**
1971-1980	244.536	14.904	52.872	20.315	99.245	5.738	**437.609**	**27,03%**
1981-1991	306.898	8.858	12.053	1.976	39.797	706	**370.287**	**22,87%**
1992-2014	323.595	10.179	58.588	13.447	57.918	396	**464.122**	**28,66%**
UKUPNO | TOTAL	**1.028.040**	**48.200**	**204.212**	**66.339**	**259.673**	**12.721**	**1.619.185**	**100,00%**
UKUPNO | TOTAL	**63,49%**	**2,98%**	**12,61%**	**4,10%**	**16,04%**	**0,79%**	**100,00%**	

Tabela 10. Broj stambenih jedinica po tipovima stambenih objekata u FBiH | **Table 10.** Number of dwelling units per type of residential buildings in FBiH

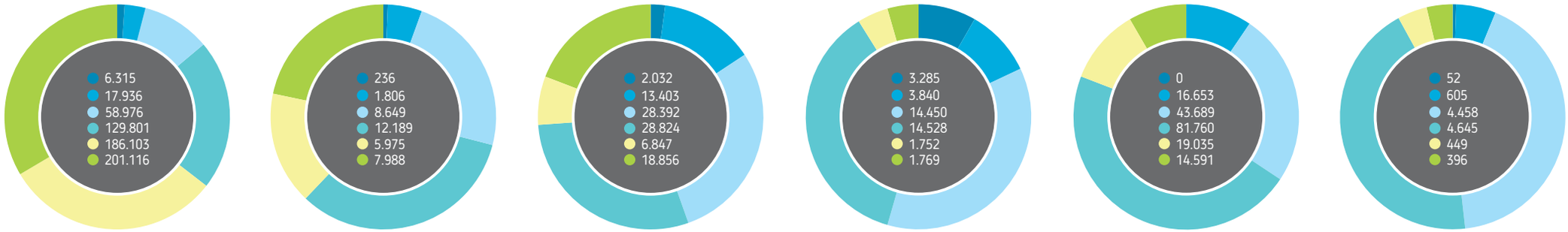
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	6.315	236	2.032	3.285		52	**11.920**	**1,24%**
1946-1960	17.936	1.806	13.403	3.840	16.653	605	**54.243**	**5,64%**
1961-1970	58.976	8.649	28.392	14.450	43.689	4.458	**158.612**	**16,50%**
1971-1980	129.801	12.189	28.824	14.528	81.760	4.645	**271.748**	**28,27%**
1981-1991	186.103	5.975	6.847	1.752	19.035	449	**220.161**	**22,90%**
1992-2014	201.116	7.988	18.856	1.769	14.591	396	**244.715**	**25,45%**
UKUPNO | TOTAL	**600.246**	**36.844**	**98.354**	**39.624**	**175.727**	**10.605**	**961.399**	**100,00%**
UKUPNO | TOTAL	**62,43%**	**3,83%**	**10,23%**	**4,12%**	**18,28%**	**1,10%**	**100,00%**	

Tabela 11. Broj stambenih jedinica po tipovima stambenih objekata u RS | **Table 11.** Number of dwelling units per type of residential buildings in RS

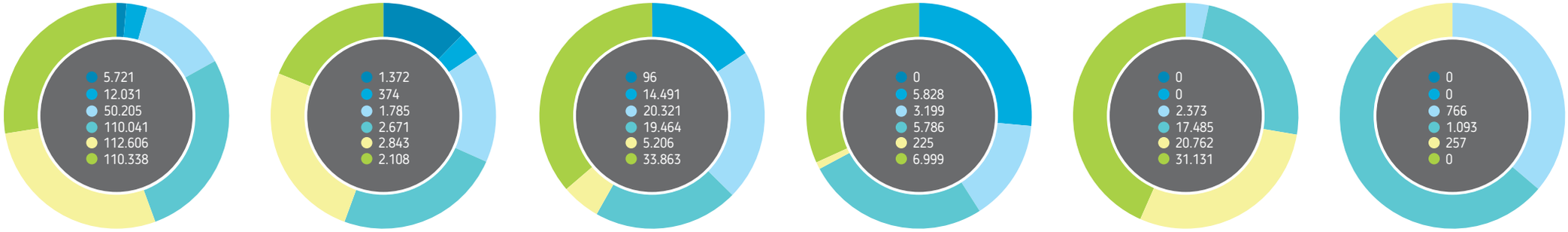
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	5.721	1.372	96	0	0	0	**7.188**	**1,20%**
1946-1960	12.031	374	14.491	5.828	0	0	**32.724**	**5,44%**
1961-1970	50.205	1.785	20.321	3.199	2.373	766	**78.648**	**13,08%**
1971-1980	110.041	2.671	19.464	5.786	17.485	1.093	**156.540**	**26,03%**
1981-1991	112.606	2.843	5.206	225	20.762	257	**141.897**	**23,59%**
1992-2014	110.338	2.108	33.863	6.999	31.131	0	**184.439**	**30,67%**
UKUPNO | TOTAL	**400.941**	**11.152**	**93.439**	**22.037**	**71.750**	**2.116**	**601.436**	**100,00%**
UKUPNO | TOTAL	**66,66%**	**1,85%**	**15,54%**	**3,66%**	**11,93%**	**0,35%**	**100,00%**	



Slika 12. Grafički prikaz broja stambenih jedinica po tipovima stambenih objekata u BiH | **Picture 12.** Graphic view of the dwelling units per type of residential buildings in BiH



Slika 13. Grafički prikaz broja stambenih jedinica po tipovima stambenih objekata u FBiH | **Picture 13.** Graphic view of the dwelling units per type of residential buildings in FBiH



Slika 14. Grafički prikaz broja stambenih jedinica po tipovima stambenih objekata u RS | **Picture 14.** Graphic view of the dwelling units per type of residential buildings in RS

do 1945. | up to 1945 · 1946-1960 · 1961-1970 · 1971-1980 · 1981-1991 · 1992-2014

Toplotna energija potrebna za grijanje stambenih zgrada u BiH/FBiH/RS

Podaci o godišnjoj toplotnoj energiji potrebnoj za grijanje stambenih objekata na području Bosne i Hercegovine/FBiH/RS, dobijeni su na osnovu statističkih podataka o ukupnom broju objekata i stvarnih podataka o tipičnim objektima (Tabele 12-14). Toplotna energija potrebna za grijanje izračunata je uz pomoć prosječnih vrijednosti bruto površina pojedinih kategorija objekata i energije potrebne za grijanje tipičnih objekata. Projekcija podataka o potrošnji energije s nivoa tipičnih objekata na nivo kategorije omogućena je uvođenjem koeficijenta odnosa prosječne bruto površine određene kategorije i bruto površine tipičnog objekta, i koeficijenta odnosa neto i bruto površina tipičnog objekta.

Uporednom analizom Tabele 3 i Tabele 13 može se uočiti da energija potrebna za grijanje slobodnostojećih kuća iznosi 85,22% od energije potrebne za grijanje cijelog stambenog fonda, dok njihovo procentualno učešće u ukupnoj bruto površini svih stambenih objekata iznosi 73,71%. Slobodnostojeće kuće, zbog faktora oblika, predstavljaju kategoriju energetski neefikasnih stambenih objekata. Toplotna energija potrebna za grijanje najveća je za objekte građene u periodu od 1971. do 1980. (37,74%), a posebno treba izdvojiti slobodnostojeće kuće (32,14%).

Energy need for heating of residential buildings in BiH/FBiH/RS

Data on the annual energy need for heating in residential buildings in Bosnia and Herzegovina/FBiH/RS, were obtained based on statistical data on the total number of buildings and actual data on typical buildings (Tables 12-14). Energy need for heating was calculated relying on average value of gross surface of specific building categories and energy required for heating of typical buildings. Energy consumption data on the level of typical buildings were projected to the level of the entire category with introduction of the coefficient of the ratio between the average gross surface of a category and gross surface of the typical building, and the coefficient of the ratio between net and gross surface of a typical building.

Comparison of Table 3 and Table 13 shows that energy required for heating of single-family houses is 85.22% of the energy required for heating of the entire housing stock, while the percentage of their share in the gross surface of the entire housing stock is 73.71%. Single-family houses, due to their shape factor, represent the category of energy inefficient residential buildings. The highest heat energy demand for heating is typical of residential buildings built between 1971 and 1980, (37.74%), especially of single-family houses (32.14%).

Tabela 12. Potrebna toplotna energija za grijanje stambenih objekata u BiH (MWh/god.) | **Table 12.** Energy need for heating of residential buildings in BiH (MWh/year)

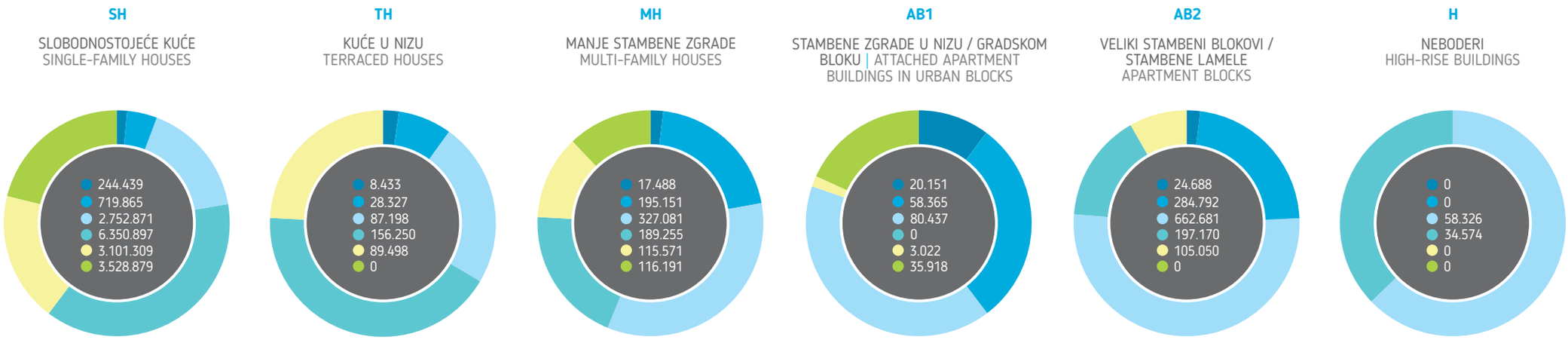
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO** **TOTAL**	**UKUPNO** **TOTAL**
do 1945. | up to 1945	244.439	8.433	17.488	20.151			**290.512**	**1,48%**
1946-1960	719.865	28.327	195.151	58.365	24.688		**1.026.397**	**5,24%**
1961-1970	2.752.871	87.198	327.081	80.437	284.792	58.326	**3.590.706**	**18,32%**
1971-1980	6.350.897	156.250	189.255		662.681	34.574	**7.393.657**	**37,74%**
1981-1991	3.101.309	89.498	115.571	3.022	197.170		**3.506.571**	**17,90%**
1992-2014	3.528.879		116.191	35.918	105.050		**3.786.038**	**19,32%**
UKUPNO | TOTAL	**16.698.261**	**369.706**	**960.738**	**197.893**	**1.274.382**	**92.900**	**19.593.880**	**100,00%**
UKUPNO | TOTAL	**85,22%**	**1,89%**	**4,90%**	**1,01%**	**6,50%**	**0,48%**	**100,00%**	

Tabela 13. Potrebna toplotna energija za grijanje stambenih objekata FBiH (MWh/god.) | **Table 13.** Energy need for heating of residential buildings in FBiH (MWh/year)

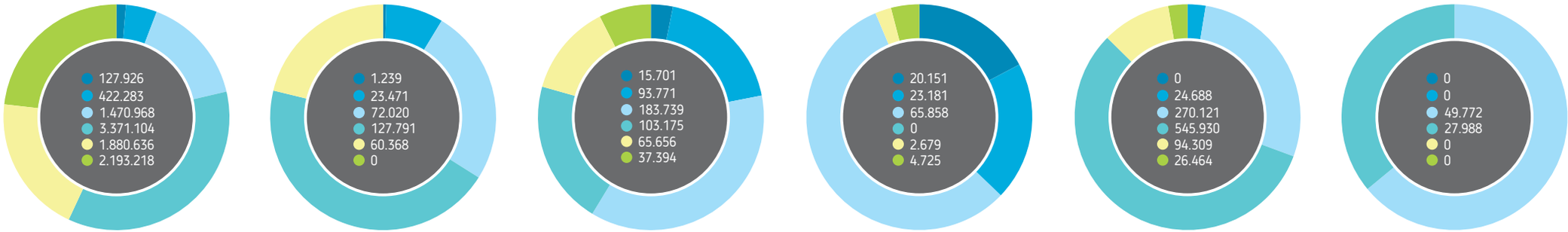
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO** **TOTAL**	**UKUPNO** **TOTAL**
do 1945. | up to 1945	127.926	1.239	15.701	20.151			**165.017**	**1,45%**
1946-1960	422.283	23.471	93.771	23.181	24.688		**587.395**	**5,15%**
1961-1970	1.470.968	72.020	183.739	65.858	270.121	49.772	**2.112.477**	**18,52%**
1971-1980	3.371.104	127.791	103.175		545.930	27.988	**4.175.989**	**36,61%**
1981-1991	1.880.636	60.368	65.656	2.679	94.309		**2.103.647**	**18,44%**
1992-2014	2.193.218		37.394	4.725	26.464		**2.261.801**	**19,83%**
UKUPNO | TOTAL	**9.466.135**	**284.889**	**499.436**	**116.594**	**961.512**	**77.760**	**11.406.326**	**100,00%**
UKUPNO | TOTAL	**83,00%**	**2,49%**	**4,38%**	**1,02%**	**8,43%**	**0,68%**	**100,00%**	

Tabela 14. Potrebna toplotna energija za grijanje stambenih objekata RS (MWh/god.) | **Table 14.** Energy need for heating of residential buildings in RS (MWh/year)

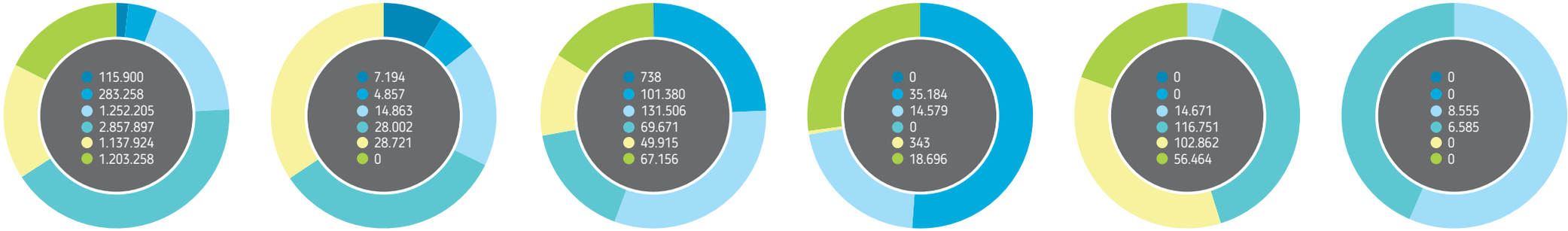
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO** **TOTAL**	**UKUPNO** **TOTAL**
do 1945. | up to 1945	115.900	7.194	738	0			**123.833**	**1,60%**
1946-1960	283.258	4.857	101.380	35.184	0		**424.678**	**5,49%**
1961-1970	1.252.205	14.863	131.506	14.579	14.671	8.555	**1.436.379**	**18,58%**
1971-1980	2.857.897	28.002	69.671		116.751	6.585	**3.078.908**	**39,84%**
1981-1991	1.137.924	28.721	49.915	343	102.862		**1.319.766**	**17,08%**
1992-2014	1.203.258		67.156	18.696	56.464		**1.345.575**	**17,41%**
UKUPNO | TOTAL	**6.850.443**	**83.638**	**420.368**	**68.801**	**290.749**	**15.140**	**7.729.138**	**100,00%**
UKUPNO | TOTAL	**88,63%**	**1,08%**	**5,44%**	**0,89%**	**3,76%**	**0,20%**	**100,00%**	



Slika 15. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u BiH (MWh/god.)
Picture 15. Graphic view of energy need for heating of residential buildings on the territory of BiH after implementation of improved measures (MWh/year)



Slika 16. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u FBiH (MWh/god.)
Picture 16. Graphic view of energy need for heating of residential buildings on the territory of FBiH after implementation of improved measures (MWh/year)



Slika 17. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u RS (MWh/god.)
Picture 17. Graphic view of energy need for heating of residential buildings on the territory of RS after implementation of improved measures (MWh/year)

do 1945. | up to 1945 · 1946-1960 · 1961-1970 · 1971-1980 · 1981-1991 · 1992-2014

Toplotna energija potrebna za grijanje stambenih zgrada u BiH/FBiH/RS nakon primjene mjera unapređenja 1 – set standardnih mjera

Primjenom standardnih mjera unapređenja omotača postojećih stambenih objekata moguće je smanjiti godišnju toplotnu energiju potrebnu za grijanje za 55,23%. Poređenjem Tabele 12 i Tabele 15 može se uočiti da potrošnja energije od 19.593.880 MWh (70,53PJ), primjenom seta standardnih mjera unapređenja, može da se smanji na 8.771.954 MWh (31,58PJ). Rezultati pokazuju da slobodnostojeće kuće, i nakon primjene seta standardnih mjera unapređenja, čine dominantnu kategoriju u ukupnoj potrošnji energije s 86,98%, te da se u ovoj kategoriji mogu postići najveće apsolutne vrijednosti uštede.

S druge strane, upoređujući sve tipove i periode izgradnje, najveće relativne uštede primjenom seta standardnih mjera mogu da se postignu kod nebodera izgrađenih u periodu 1961-1970, i to 74,94%, a zatim kod stambenih zgrada u nizu iz perioda 1946-1960 (73,12%). S druge strane, najmanje relativne uštede moguće su kod slobodnostojećih kuća izgrađenih u periodu 1992-2014. (32,43%), te kod manjih stambenih zgrada iz perioda 1992-2014. (33,77%), zbog boljih termičkih karakteristika elemenata omotača objekata građenih u tom periodu.

Energy need for heating of residential buildings in BiH/FBiH/RS after implementation of Improvement measures 1 – a set of standard improvement measures

By introducing standard improvement measures for envelopes of the existing residential buildings, it is possible to reduce energy need for heating by 55.23%. Comparison of Table 12 and Table 15 indicates that energy need of 19.593.880 MWh (70.53PJ), could be reduced to 8.771.954 MWh (31.58PJ) if the set of standard improvement measures is implemented. Results indicate that single-family houses, even after implementation of the standard improvement measures, dominate as a category in the overall consumption of energy, accounting for 86.98%, hence this category has the potential for highest absolute savings.

However, comparison of all types and building periods, the highest relative savings achievable through the standard improvement measures is possible in high-rise buildings built in 1961-1970, i.e. 74.94%, followed by attached apartment buildings in urban blocks built in 1946-1960, (73.12%). However, the smallest relative savings are achievable in case of single-family houses built in 1992-2014. (32.43%), and in smaller residential buildings built in 1992-2014. (33.77%), due to better thermal performance of envelope elements of buildings built in that period.

Tabela 15. Energija potrebna za grijanje stambenih objekata na području BiH nakon primjene standardnih mjera (MWh/god.) | **Table 15.** Energy need for heating of residential buildings on the territory of BiH after implementation of standard measures (MWh/year)

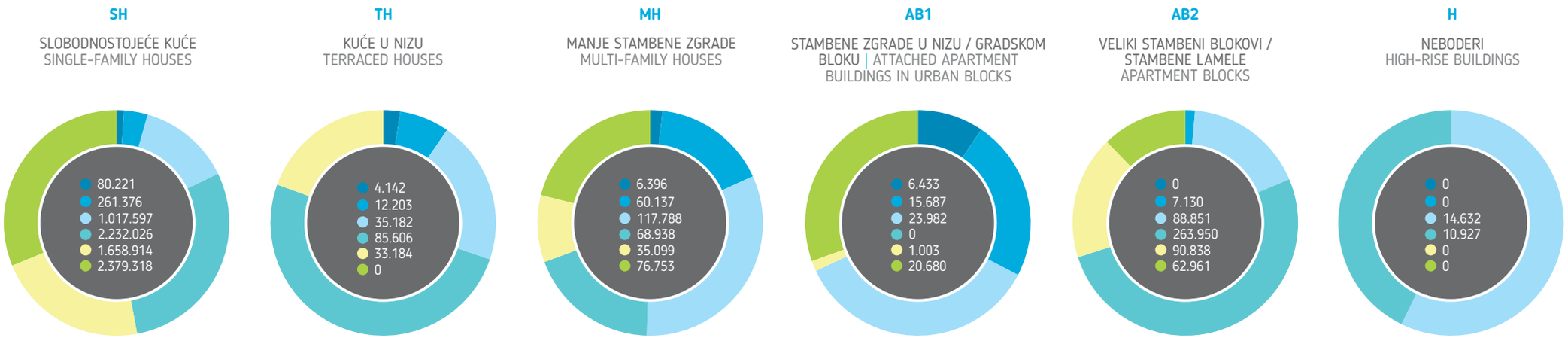
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	80.221	4.142	6.396	6.433			**97.191**	**1,11%**
1946-1960	261.376	12.203	60.137	15.687	7.130		**356.533**	**4,06%**
1961-1970	1.017.597	35.182	117.788	23.982	88.851	14.632	**1.298.032**	**14,80%**
1971-1980	2.232.026	85.606	68.938		263.950	10.927	**2.661.448**	**30,34%**
1981-1991	1.658.914	33.184	35.099	1.003	90.838		**1.819.038**	**20,74%**
1992-2014	2.379.318		76.753	20.680	62.961		**2.539.712**	**28,95%**
UKUPNO | TOTAL	**7.629.451**	**170.318**	**365.111**	**67.785**	**513.730**	**25.560**	**8.771.954**	**100,00%**
UKUPNO | TOTAL	**86,98%**	**1,94%**	**4,16%**	**0,77%**	**5,86%**	**0,29%**	**100,00%**	

Tabela 16. Energija potrebna za grijanje stambenih objekata na području FBiH nakon primjene standardnih mjera (MWh/god.) | **Table 16.** Energy need for heating of residential buildings on the territory of FBiH after implementation of standard measures (MWh/year)

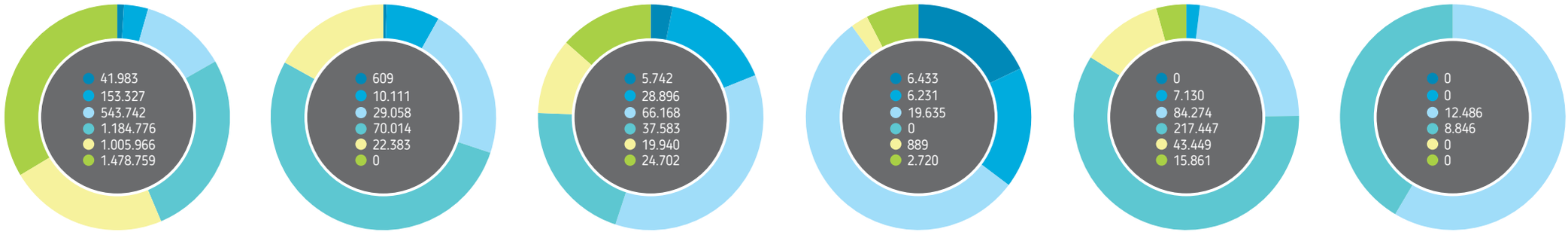
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	41.983	609	5.742	6.433			**54.766**	**1,06%**
1946-1960	153.327	10.111	28.896	6.231	7.130		**205.694**	**4,00%**
1961-1970	543.742	29.058	66.168	19.635	84.274	12.486	**755.364**	**14,67%**
1971-1980	1.184.776	70.014	37.583		217.447	8.846	**1.518.666**	**29,50%**
1981-1991	1.005.966	22.383	19.940	889	43.449		**1.092.627**	**21,22%**
1992-2014	1.478.759		24.702	2.720	15.861		**1.522.043**	**29,56%**
UKUPNO | TOTAL	**4.408.554**	**132.175**	**183.030**	**35.908**	**368.161**	**21.332**	**5.149.160**	**100,00%**
UKUPNO | TOTAL	**85,62%**	**2,57%**	**3,55%**	**0,70%**	**7,15%**	**0,41%**	**100,00%**	

Tabela 17. Energija potrebna za grijanje stambenih objekata na području RS nakon primjene standardnih mjera (MWh/god.) | **Table 17.** need for heating of residential buildings on the territory of RS after implementation of standard measures (MWh/year)

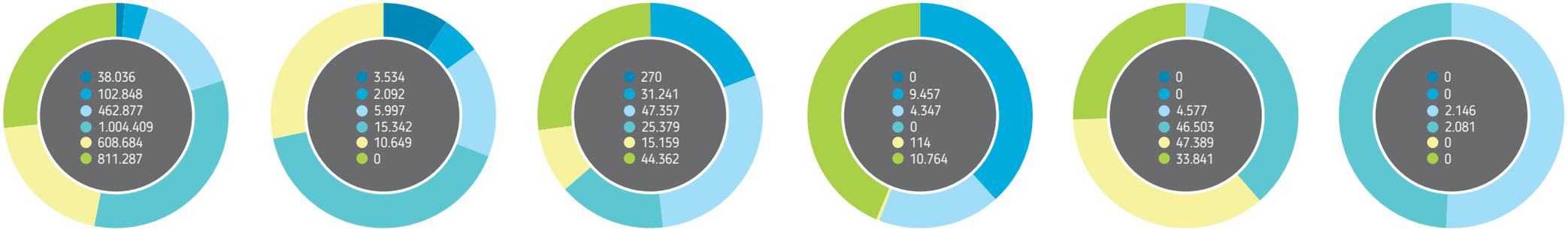
	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO TOTAL**	**UKUPNO TOTAL**
do 1945. | up to 1945	38.036	3.534	270	0			**41.840**	**1,23%**
1946-1960	102.848	2.092	31.241	9.457	0		**145.638**	**4,30%**
1961-1970	462.877	5.997	47.357	4.347	4.577	2.146	**527.301**	**15,55%**
1971-1980	1.004.409	15.342	25.379		46.503	2.081	**1.093.714**	**32,26%**
1981-1991	608.684	10.649	15.159	114	47.389		**681.996**	**20,11%**
1992-2014	811.287		44.362	10.764	33.841		**900.255**	**26,55%**
UKUPNO | TOTAL	**3.028.142**	**37.614**	**163.768**	**24.681**	**132.311**	**4.227**	**3.390.744**	**100,00%**
UKUPNO | TOTAL	**89,31%**	**1,11%**	**4,83%**	**0,73%**	**3,90%**	**0,12%**	**100,00%**	



Slika 18. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u BiH nakon primjene standardnih mjera (MWh/god.)
Picture 18. Graphic view of energy need for heating of residential buildings on the territory of BiH after implementation of standard measures (MWh/year)



Slika 19. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u FBiH nakon primjene standardnih mjera (MWh/god.)
Picture 19. Graphic view of energy need for heating of residential buildings on the territory of FBiH after implementation of standard measures (MWh/year)



Slika 20. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u RS nakon primjene standardnih mjera (MWh/god.)
Picture 20. Graphic view of energy need for heating of residential buildings on the territory of RS after implementation of standard measures (MWh/year)

do 1945. | up to 1945 · 1946-1960 · 1961-1970 · 1971-1980 · 1981-1991 · 1992-2014

Toplotna energija potrebna za grijanje stambenih zgrada u BiH/FBiH/RS nakon primjene mjera unapređenja 2 - set nestandardnih mjera unapređenja

Primjenom nestandardnih mjera unapređenja omotača postojećih stambenih objekata moguće je smanjiti godišnju toplotnu energiju potrebnu za grijanje za 69,07%. Poređenjem podataka u Tabeli 12 i Tabeli 18 može se uočiti da potrošnja energije od 19.593.880 MWh (70,53PJ) u postojećim zgradama, primjenom seta nestandardnih mjera unapređenja, može da se smanji na 6.059.306 MWh (21,81PJ). Rezultati pokazuju da slobodnostojeće kuće, i nakon primjene nestandardnih mjera unapređenja, čine dominantnu kategoriju u ukupnoj potrošnji energije s 86,82%, te da se u ovoj kategoriji mogu postići najveće apsolutne vrijednosti uštede.

S druge strane, upoređujući sve tipove i periode izgradnje, najveće relativne uštede nakon primjene seta nestandardnih mjera mogu da se postignu kod nebodera koji su izgrađeni u periodu 1961-1970, i to 83,79%, a zatim kod stambenih zgrada u nizu iz perioda 1946-1960, (82,27%). S druge strane, najmanje relativne uštede moguće je postići kod slobodnostojećih kuća izgrađenih u periodu 1992-2014. (47,37%), te kod manjih stambenih zgrada iz perioda 1992-2014. (51,92%), zbog boljih termičkih karakteristika elemenata omotača objekata građenih u tom periodu.

Energy need for heating of residential buildings in BiH/FBiH/RS after implementation of Improvement measures 2 - a set of non-standard improvement measures

By introducing non-standard improvement measures for envelopes of the existing residential buildings, it is possible to reduce annual energy need for heating by 69.07%. Comparison of data shown in Table 12 and Table 18 indicates that energy need of 19.593.880 MWh (70.53PJ) in the existing buildings, could be reduced to 6.059.306 MWh (21.81PJ) if the set of non-standard improvement measures is implemented. Results indicate that single-family houses, even after implementation of the non-standard improvement measures, dominate as a category in the overall consumption of energy, accounting for 86.82%, hence this category has the potential for highest absolute savings.

However, comparison of all types and building periods, the highest relative savings achievable through the non-standard improvement measures is possible in high-rise buildings built in 1961-1970, i.e. 83.79%, followed by attached apartment buildings in urban blocks built in 1946-1960, (82.27%). However, the smallest relative savings are achievable in case of single-family houses built in 1992-2014. (47.37%), and in smaller residential buildings built in 1992-2014. (51.92%), due to better thermal performance of envelope elements of buildings built in that period.

Tabela 18. Potrebna toplotna energija za grijanje stambenih objekata na području BiH nakon primjene poboljšanih mjera (MWh/god.) | **Table 18.** Energy need for heating of residential buildings on the territory of BiH after implementation of improvement measures (MWh/year)

	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO** **TOTAL**	**UKUPNO** **TOTAL**
do 1945. | up to 1945	51.499	2.850	4.489	4.607			**63.446**	**1,05%**
1946-1960	159.978	8.481	42.805	10.349	4.484		**226.097**	**3,73%**
1961-1970	632.053	23.023	74.939	15.622	54.343	9.444	**809.424**	**13,36%**
1971-1980	1.302.168	64.999	45.615		205.413	6.252	**1.624.448**	**26,81%**
1981-1991	1.257.590	25.138	24.709	743	49.840		**1.358.019**	**22,41%**
1992-2014	1.857.494		55.952	15.706	48.720		**1.977.873**	**32,64%**
UKUPNO | TOTAL	**5.260.782**	**124.490**	**248.509**	**47.028**	**362.800**	**15.696**	**6.059.306**	**100,00%**
UKUPNO | TOTAL	**86,82%**	**2,05%**	**4,10%**	**0,78%**	**5,99%**	**0,26%**	**100,00%**	

Tabela 19. Potrebna toplotna energija za grijanje stambenih objekata na području FBiH nakon primjene poboljšanih mjera (MWh/god.) | **Table 19.** Energy need for heating of residential buildings on the territory of FBiH after implementation of improvement measures (MWh/year)

	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO** **TOTAL**	**UKUPNO** **TOTAL**
do 1945. | up to 1945	26.952	419	4.030	4.607			**36.008**	**1,00%**
1946-1960	93.846	7.027	20.568	4.110	4.484		**130.035**	**3,63%**
1961-1970	337.731	19.015	42.097	12.791	51.543	8.059	**471.236**	**13,14%**
1971-1980	691.200	53.161	24.868		169.224	5.061	**943.514**	**26,31%**
1981-1991	762.603	16.956	14.037	658	23.839		**818.093**	**22,82%**
1992-2014	1.154.443		18.007	2.066	12.274		**1.186.790**	**33,10%**
UKUPNO | TOTAL	**3.066.775**	**96.577**	**123.608**	**24.233**	**261.363**	**13.120**	**3.585.676**	**100,00%**
UKUPNO | TOTAL	**85,53%**	**2,69%**	**3,45%**	**0,67%**	**7,29%**	**0,37%**	**100,00%**	

Tabela 20. Potrebna toplotna energija za grijanje stambenih objekata na području RS nakon primjene poboljšanih mjera (MWh/god.) | **Table 20.** Energy need for heating of residential buildings on the territory of RS after implementation of improvement measures (MWh/year)

	INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING		KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING					
	Slobodnostojeća kuća Single-family house **SF**	Kuća u nizu Terraced house **TH**	Manja stambena zgrada Multi-family house **MH**	Stambena zgrada u nizu/ gradskom bloku Attached apartment building in urban blocks **AB1**	Veliki stambeni blok/ stambena lamela Apartment block **AB2**	Neboderi High-rise building **H**	**UKUPNO** **TOTAL**	**UKUPNO** **TOTAL**
do 1945. | up to 1945	24.418	2.431	190	0			**27.039**	**1,17%**
1946-1960	62.949	1.454	22.237	6.239	0		**92.879**	**4,03%**
1961-1970	287.504	3.924	30.130	2.832	2.799	1.385	**328.574**	**14,24%**
1971-1980	585.974	11.649	16.792		36.190	1.191	**651.796**	**28,26%**
1981-1991	461.431	8.067	10.672	84	26.001		**506.256**	**21,95%**
1992-2014	633.358		32.339	8.175	26.187		**700.060**	**30,35%**
UKUPNO | TOTAL	**2.055.635**	**27.525**	**112.360**	**17.330**	**91.178**	**2.576**	**2.306.604**	**100,00%**
UKUPNO | TOTAL	**89,12%**	**1,20%**	**4,87%**	**0,75%**	**3,95%**	**0,11%**	**100,00%**	

SH

SLOBODNOSTOJEĆE KUĆE
SINGLE-FAMILY HOUSES

TH

KUĆE U NIZU
TERRACED HOUSES

MH

MANJE STAMBENE ZGRADE
MULTI-FAMILY HOUSES

AB1

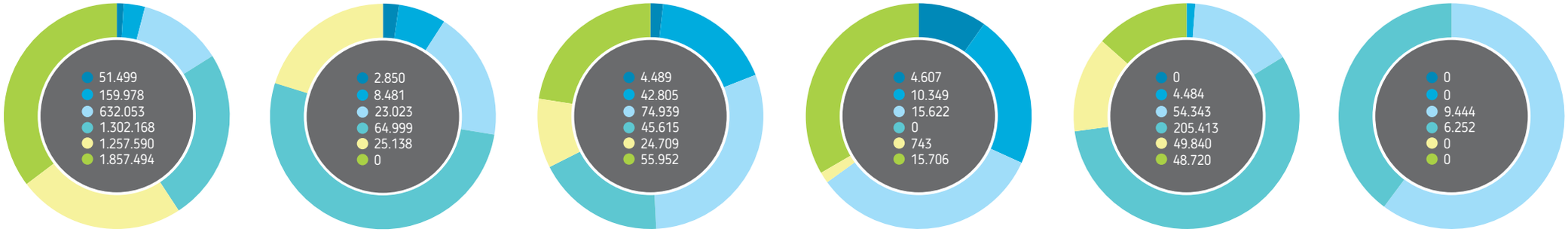
STAMBENE ZGRADE U NIZU / GRADSKOM BLOKU | ATTACHED APARTMENT BUILDINGS IN URBAN BLOCKS

AB2

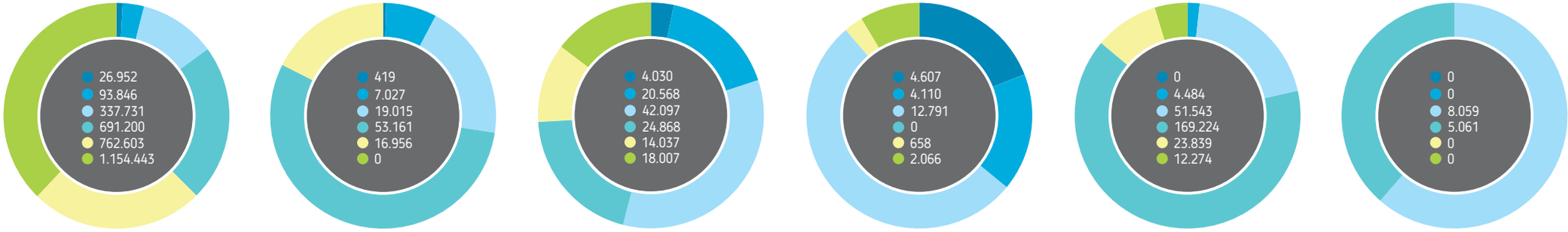
VELIKI STAMBENI BLOKOVI / STAMBENE LAMELE
APARTMENT BLOCKS

H

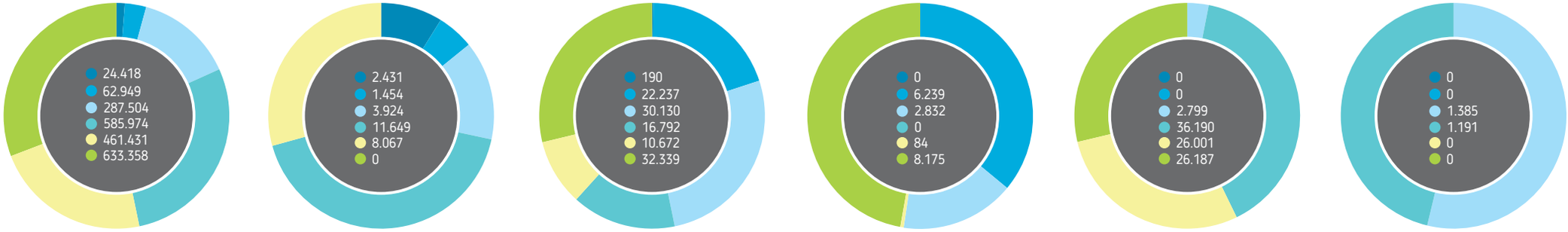
NEBODERI
HIGH-RISE BUILDINGS



Slika 21. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u BiH nakon primjene poboljšanih mjera (MWh/god.)
Picture 21. Graphic view of energy need for heating of residential buildings on the territory of BiH after implementation of improved measures (MWh/year)



Slika 22. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u FBiH nakon primjene poboljšanih mjera (MWh/god.)
Picture 22. Graphic view of energy need for heating of residential buildings on the territory of FBiH after implementation of improved measures (MWh/year)



Slika 23. Grafički prikaz toplotne energije potrebne za grijanje stambenih objekata u RS nakon primjene poboljšanih mjera (MWh/god.)
Picture 23. Graphic view of energy need for heating of residential buildings on the territory of RS after implementation of improved measures (MWh/year)

do 1945. | up to 1945 · 1946-1960 · 1961-1970 · 1971-1980 · 1981-1991 · 1992-2014

MATRICA I TABELARNI PREGLED TIPOVA STAMBENIH ZGRADA U BIH | MATRIX AND TABLE REVIEW OF RESIDENTIAL BUILDING TYPES OF BIH

INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING | KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING

	SLOBODNOSTOJEĆE KUĆE SINGLE-FAMILY HOUSES	KUĆE U NIZU TERRACED HOUSES	MANJE STAMBENE ZGRADE MULTI-FAMILY HOUSES	STAMBENE ZGRADE U NIZU / GRADSKOM BLOKU ATTACHED APARTMENT BUILDINGS IN URBAN BLOCKS	VELIKI STAMBENI BLOKOVI / STAMBENE LAMELE APARTMENT BLOCKS	NEBODERI HIGH-RISE BUILDINGS
	SH 1	TH 2	MH 3	AB1 4	AB2 5	H 6
A <1945						
B 1946-1960						
C 1961-1970						

INDIVIDUALNO STANOVANJE | SINGLE-FAMILY HOUSING | KOLEKTIVNO STANOVANJE | COLLECTIVE HOUSING

	SLOBODNOSTOJEĆE KUĆE SINGLE-FAMILY HOUSES SH 1	KUĆE U NIZU TERRACED HOUSES TH 2	MANJE STAMBENE ZGRADE MULTI-FAMILY HOUSES MH 3	STAMBENE ZGRADE U NIZU / GRADSKOM BLOKU ATTACHED APARTMENT BUILDINGS IN URBAN BLOCKS AB1 4	VELIKI STAMBENI BLOKOVI / STAMBENE LAMELE APARTMENT BLOCKS AB2 5	NEBODERI HIGH-RISE BUILDINGS H 6
D 1971-1980						
E 1981-1990						
F 1991-2014						

A1 | SH do 1945. godine | up to 1945

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	10.773	1.25%
	Broj stanova | Number of apartments	12.066	0,745%
	Površina (m^2) | Surface (m^2)	970.333	0,595%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	244.439	1,237%
	Unapređenje 1 | Improvement 1	80.221	-
	Unapređenje 2 | Improvement 2	51.499	-

B1 | SH 1946-1960.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	26.133	3,03%
	Broj stanova | Number of apartments	30.576	1,89%
	Površina (m^2) | Surface (m^2)	2.356.517	1,446%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	719.865	3,67%
	Unapređenje 1 | Improvement 1	261.376	-
	Unapređenje 2 | Improvement 2	159.978	-

C1 | SH 1961-1970.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	87.596	10,16%
	Broj stanova | Number of apartments	110.371	6,816%
	Površina (m^2) | Surface (m^2)	9.132.251	5,65%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	2.752.871	14,05%
	Unapređenje 1 | Improvement 1	1.017.597	-
	Unapređenje 2 | Improvement 2	632.053	-

D1 | SH 1971-1980.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	194.076	22,51%
	Broj stanova | Number of apartments	244.536	15,10%
	Površina (m^2) | Surface (m^2)	26.704.411	16,39%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	6.350.897	32,41%
	Unapređenje 1 | Improvement 1	2.232.026	-
	Unapređenje 2 | Improvement 2	1.302.168	-

E1 | SH 1981-1991.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	236.075	27,39%
	Broj stanova | Number of apartments	306.898	18,95%
	Površina (m^2) | Surface (m^2)	38.282.654	23,4965%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	3.101.309	15,83%
	Unapređenje 1 | Improvement 1	1.658.914	-
	Unapređenje 2 | Improvement 2	1.257.590	-

F1 | SH 1992-2014.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	254.799	29,56%
	Broj stanova | Number of apartments	323.595	19,985%
	Površina (m^2) | Surface (m^2)	42.653.964	26,18%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	3.528.879	18,01%
	Unapređenje 1 | Improvement 1	2.379.318	-
	Unapređenje 2 | Improvement 2	1.857.494	-

A2 | TH do 1945. godine | up to 1945

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	1.157	0,134%
	Broj stanova | Number of apartments	1.608	0,10%
	Površina (m^2) | Surface (m^2)	116.098	0,071%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	8.433	0,043%
	Unapređenje 1 | Improvement 1	4.142	-
	Unapređenje 2 | Improvement 2	2.850	-

B2 | TH 1946-1960.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	1.639	0,190%
	Broj stanova | Number of apartments	2.180	0,1346%
	Površina (m^2) | Surface (m^2)	149.959	0,092%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	28.327	0,144%
	Unapređenje 1 | Improvement 1	12.203	-
	Unapređenje 2 | Improvement 2	8.481	-

C2 | TH 1961-1970.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	7.480	0,868%
	Broj stanova | Number of apartments	10.472	0,647%
	Površina (m^2) | Surface (m^2)	888.085	0,545%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	87.198	0,445%
	Unapređenje 1 | Improvement 1	35.182	-
	Unapređenje 2 | Improvement 2	23.023	-

D2 | TH 1971-1980.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	9.257	1,0739%
	Broj stanova | Number of apartments	14.904	0,920%
	Površina (m^2) | Surface (m^2)	1.248.793	0,766%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	156.250	0,797%
	Unapređenje 1 | Improvement 1	85.606	-
	Unapređenje 2 | Improvement 2	64.999	-

E2 | TH 1981-1991.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	5.905	0,685%
	Broj stanova | Number of apartments	8.858	0,547%
	Površina (m^2) | Surface (m^2)	1.035.435	0,635%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	89.498	0,454%
	Unapređenje 1 | Improvement 1	33.184	-
	Unapređenje 2 | Improvement 2	25.138	-

A3 | MH do 1945. godine | up to 1945

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	450	0,052%
	Broj stanova | Number of apartments	2.264	0,1398%
	Površina (m^2) | Surface (m^2)	168.460	0,1034%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	17.488	0,089%
	Unapređenje 1 | Improvement 1	6.396	-
	Unapređenje 2 | Improvement 2	4.489	-

B3 | MH 1946-1960.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	2.462	0,2856%
	Broj stanova | Number of apartments	27.894	1,7227%
	Površina (m^2) | Surface (m^2)	1.639.913	1,006%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	195.151	0,0996%
	Unapređenje 1 | Improvement 1	60.137	-
	Unapređenje 2 | Improvement 2	42.805	-

C3 | MH 1961-1970.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	3.012	0,349%
	Broj stanova | Number of apartments	50.541	3,12%
	Površina (m^2) | Surface (m^2)	3.184.346	1,954%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	327.081	1,669%
	Unapređenje 1 | Improvement 1	117.788	-
	Unapređenje 2 | Improvement 2	74.939	-

D3 | MH 1971-1980.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	2.203	0,255%
	Broj stanova | Number of apartments	52.872	3,265%
	Površina (m^2) | Surface (m^2)	3.587.596	2,20%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	189.255	0,9659%
	Unapređenje 1 | Improvement 1	68.938	-
	Unapređenje 2 | Improvement 2	45.615	-

E3 | MH 1981-1991.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	1.116	0,1295%
	Broj stanova | Number of apartments	12.053	0,744%
	Površina (m^2) | Surface (m^2)	1.048.335	0,6434%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	115.571	0,898%
	Unapređenje 1 | Improvement 1	35.099	-
	Unapređenje 2 | Improvement 2	24.709	-

F3 | MH 1992-2014.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	2.725	0,316%
	Broj stanova | Number of apartments	58.588	3,618%
	Površina (m^2) | Surface (m^2)	4.666.418	2,864%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	116.191	0,593%
	Unapređenje 1 | Improvement 1	76.753	-
	Unapređenje 2 | Improvement 2	55.952	-

A4 | AB1 do 1945. godine | up to 1945

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	218	0,025%
	Broj stanova | Number of apartments	3.285	0,0203%
	Površina (m^2) | Surface (m^2)	193.882	0,119%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	20.151	0,103%
	Unapređenje 1 | Improvement 1	6.433	-
	Unapređenje 2 | Improvement 2	4.607	-

B4 | AB1 1946-1960.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	851	0,0987%
	Broj stanova | Number of apartments	9.667	0,597%
	Površina (m^2) | Surface (m^2)	697.074	0,428%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	58.365	0,298%
	Unapređenje 1 | Improvement 1	15.687	-
	Unapređenje 2 | Improvement 2	10.349	-

C4 | AB1 1961-1970.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	1.429	0,1658%
	Broj stanova | Number of apartments	17.648	1,089%
	Površina (m^2) | Surface (m^2)	1.192.969	0,732%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	80.437	0,410%
	Unapređenje 1 | Improvement 1	23.982	-
	Unapređenje 2 | Improvement 2	15.706	-

E4 | AB1 1981-1991.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	88	0,010%
	Broj stanova | Number of apartments	1.976	0,122%
	Površina (m^2) | Surface (m^2)	56.310	0,035%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	3.022	0,015%
	Unapređenje 1 | Improvement 1	1.003	-
	Unapređenje 2 | Improvement 2	743	-

F4 | AB1 1992-2014.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	707	0,082%
	Broj stanova | Number of apartments	13.447	0,083%
	Površina (m^2) | Surface (m^2)	846.958	0,519%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	35.918	0,183%
	Unapređenje 1 | Improvement 1	20.680	-
	Unapređenje 2 | Improvement 2	15.706	-

B5 | AB2 1946-1960.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	328	0,038%
	Broj stanova | Number of apartments	16.653	1,028%
	Površina (m^2) | Surface (m^2)	353.420	0,217%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	24.688	0,1259%
	Unapređenje 1 | Improvement 1	7.130	-
	Unapređenje 2 | Improvement 2	4.484	-

C5 | AB2 1961-1970.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	660	0,076%
	Broj stanova | Number of apartments	46.061	2,844%
	Površina (m^2) | Surface (m^2)	3.122.201	1,916%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	284.792	1,45%
	Unapređenje 1 | Improvement 1	88.851	-
	Unapređenje 2 | Improvement 2	54.343	-

D5 | AB2 1971-1980.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	1.419	0,1646%
	Broj stanova | Number of apartments	99.245	6,129%
	Površina (m^2) | Surface (m^2)	8.758.838	5,356%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	662.681	3,38%
	Unapređenje 1 | Improvement 1	263.950	-
	Unapređenje 2 | Improvement 2	205.413	-

E5 | AB2 1981-1991.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	876	0,102%
	Broj stanova | Number of apartments	39.797	2,458%
	Površina (m^2) | Surface (m^2)	3.280.277	2,013%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	191.170	0,956%
	Unapređenje 1 | Improvement 1	90.838	-
	Unapređenje 2 | Improvement 2	49.840	-

F5 | AB2 1992-2014.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	1.040	0,121%
	Broj stanova | Number of apartments	57.918	3,577%
	Površina (m^2) | Surface (m^2)	3.200.171	0,0196%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	105.050	0,536%
	Unapređenje 1 | Improvement 1	62.961	-
	Unapređenje 2 | Improvement 2	48.720	-

C6 | H 1961-1970.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	75	0,0087%
	Broj stanova | Number of apartments	5.224	0,3226%
	Površina (m^2) | Surface (m^2)	485.596	0,298%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	58.326	0,2976%
	Unapređenje 1 | Improvement 1	14.632	-
	Unapređenje 2 | Improvement 2	9.444	-

D6 | H 1971-1980.

Zastupljenost tipa | Type share	Broj zgrada | Number of buildings	84	0,0097%
	Broj stanova | Number of apartments	5.738	0,354%
	Površina (m^2) | Surface (m^2)	489.698	0,300%
Energija potrebna za grijanje (MWh/god.) | Energy need for heating (MWh/a)	Postojeće stanje | Current baseline	34.574	0,176%
	Unapređenje 1 | Improvement 1	10.927	-
	Unapređenje 2 | Improvement 2	6.252	-

TIPOLOGIJA STAMBENIH ZGRADA BOSNE I HERCEGOVINE: TIPIČNI OBJEKTI | RESIDENTIAL BUILDING TYPOLOGY OF BIH: TYPICAL OBJECTS

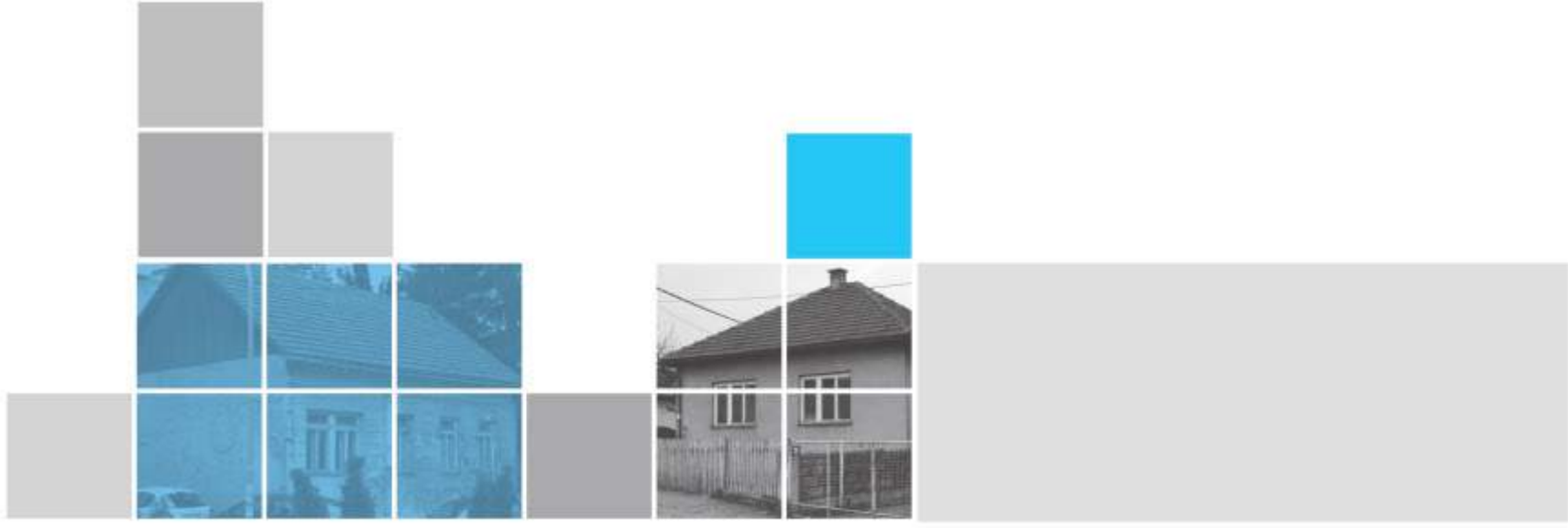




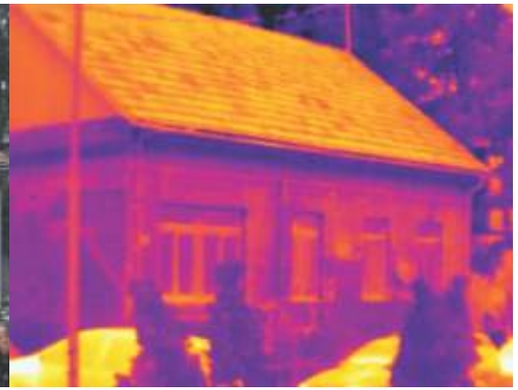

individualno stanovanje
single-family housing

kolektivno stanovanje
collective housing

SLOBODNOSTOJEĆE KUĆE
SINGLE-FAMILY HOUSES



<1945 | 1946-1960 | 1961-1970 | 1971-1980 | 1981-1991 | 1992-2014



OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

A1

Kategorija objekta Building category	**SLOBODNOSTOJEĆA KUĆA** **SINGLE-FAMILY HOUSE**
Godina izgradnje Built in	**1904.**
Broj etaža Number of floors	**1**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**91,67**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**68,14**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**213,44**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,91**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**452,34**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**638,59**

Slobodnostojeća porodična zgrada izgrađena je 1904. godine i zaštićena kao spomenik kulture. Zgrada je kompaktne osnove, spratnosti prizemlje. Krov je dvovodni, klasične drvene konstrukcije s crijepom kao krovnim pokrivačem. Tavanski prostor se ne koristi za stanovanje. Spoljašnji zidovi su od opeke, debljine 45cm i obostrano malterisani, a ulična fasada s dekorativnom plastikom je u vrlo lošem stanju. Međuspratna konstrukcija prema tavanu je drvena, s plafonom izvedenim od maltera na sloju trske. Prozori su dvostruki, drveni i zastakljeni jednostrukim staklom.

Slobodnostojeća porodična kuća je masivnih zidova od opeke, bez termičke izolacije. Fasadni malter je u lošem stanju, kao i fasadna stolarija. U trenutku snimanja kuća se nije koristila, što znači da se nije ni grijala te snimci nisu relevantni. U dijelu prozorskih otvora vidljivi su veći gubici toplote na mjestima prozorskih otvora. Snimanjem je registrovano zagrijavanje u zoni krova koje potiče od sunčevog zračenja.

Single-family house built in 1904, and protected as cultural heritage. It is of compact footprint, ground floor only. The roof is traditional, wooden, gable roof, with clay roof tiles. Attic is not used for residential purposes. External walls are made of 45cm clay brick with plaster on both sides, and the facade is decorative elements is in very bad condition. Construction towards the attic is wooden, and the ceiling is made of plastered cane. Double windows, wooden framing, single glazing.

Single-family house is made of massive brick walls, without any thermal insulation. Facade plaster is in bad condition, as well as the framings. At the moment of recording, the house was not being used, so since it was not heated, the images are irrelevant. There is indication of higher level of heat loss at the window openings. Some heat was recorded at the roof, as a result of sun radiation.

Mjere se ne odnose na predstavljenu tipičnu zgradu, koja je zaštićena kao spomenik kulture i koja prema entitetskoj regulativi ne podliježe obavezi energetske sanacije. Predložene mjere se odnose na ostale zgrade koje pripadaju ovom periodu i tehnologiji građenja.

The measures do not concern the presented typical building, which is protected as cultural heritage, and according to the Entity laws, it is not subject to mandatory energy-efficiency improvement. Proposed measures concern other buildings from this period sharing the same construction technology.

OPIS UNAPREĐENJA | IMPROVEMENT MEASURES DESCRIPTION

UNAPREĐENJE 1 | IMPROVEMENT 1

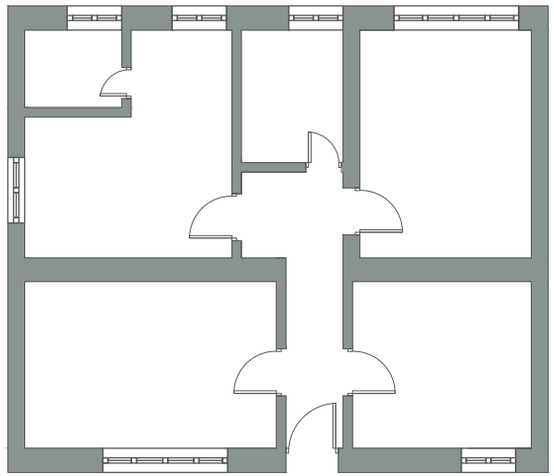
Izolovanje spoljašnjeg zida termoizolacionim slojem debljine 10cm (λ=0,041 W/mK), izvedenim u sistemu kontaktne fasade. Izolovanje međuspratne konstrukcije ka tavanu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK) (s gornje strane). Ugradnja novih prozora U=1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izolovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

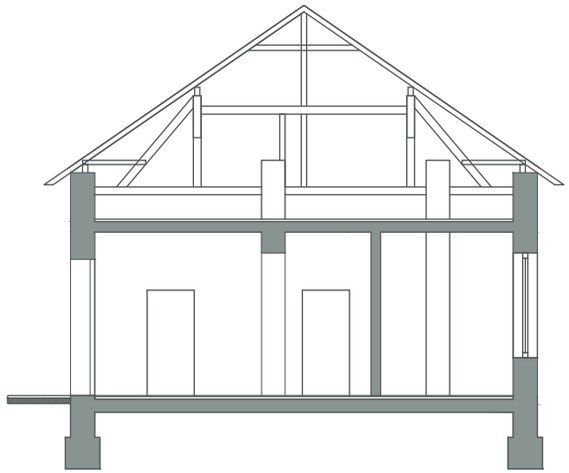
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the ground floor and the unheated attic (on the upper side) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U=1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

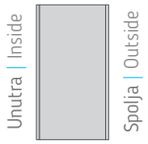
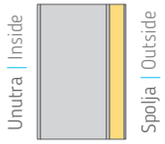
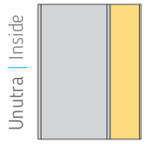
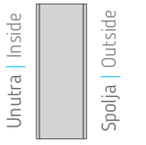
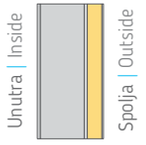
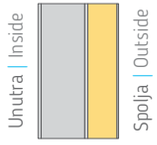
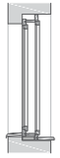
UNAPREĐENJE 2 | IMPROVEMENT 2

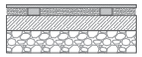
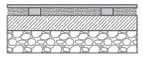
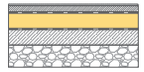
Izolovanje spoljašnjeg zida termoizolacionim slojem debljine 20cm (λ=0,041 W/mK), izvedenim u sistemu kontaktne fasade. Izolovanje međuspratne konstrukcije ka tavanu termoizolacionim slojem debljine 20cm (λ=0,041 W/mK) (s gornje strane). Izolovanje poda na tlu, termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora s U=1,0 W/m^{2}K (g=0,48). Ugradnja novih ulaznih vrata s U=2,0 W/m^{2}K. • Instalacija sistema centralnog grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the ground floor and the unheated attic (on the upper side) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). Installing of new entrance door with U =2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.





	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 45cm, malter 2cm plaster 2cm, brick wall 45cm, plaster 2cm	 malter 2cm, puna opeka 45cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 45cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 45cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 45cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,10 W/m^2/K	U = 0,29 W/m^2/K	U = 0,17 W/m^2/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 30cm, malter 2cm plaster 2cm, brick wall 30cm, plaster 2cm	 malter 2cm, puna opeka 30cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 30cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 30cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 30cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,48 W/m^2/K	U = 0,32 W/m^2/K	U = 0,18 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s razmaknutim krilima i jednostrukim staklom wooden, double frame, double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,50 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
POD NA TLU GROUND FLOOR	Unutra | Inside  Spolja | Outside drvene daske 2cm, potpatosnice u pijesku 5cm, betonska ploča 10cm, šljunak 15cm wooden floor 2cm, sleepers in ash bedding 5cm, concrete slab 10cm, gravel 15cm	Unutra | Inside  Spolja | Outside NEMA IZMJENA NO CHANGES	Unutra | Inside  Spolja | Outside parket 1cm, cementni estrih 4cm, PE folija, termoizolacija 10cm, hidroizolacija 1cm, betonska ploča 10cm, šljunak 15cm parquet 1cm, cement screed 4cm, PE foil, thermal insulation 10cm, waterproofing 1cm, concrete slab 10cm, gravel 15 cm
U (W/m^2/K)	U = 2,14 W/m^2/K	U = 2,14 W/m^2/K	U = 0,35 W/m^2/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside drvena tavanica 20cm, drvene daske 2cm, malter na trsci 2,5cm wooden rafters 14/20cm at 80cm distance / air layer 20cm, wooden planks 2cm, straw-plaster ceiling 2.5cm	Spolja | Outside  Unutra | Inside drvena tavanica 20cm, termoizolacija 10cm, parna brana, drvene daske 2cm, malter na trsci 2,5cm wooden rafters 14/20cm at 80cm distance / air layer 20cm, thermal insulation 10cm, vapor barrier, wooden planks 2cm, straw-plaster ceiling 2.5cm	Spolja | Outside  Unutra | Inside drvena tavanica 20cm, termoizolacija 20cm, parna brana, drvene daske 2cm, malter na trsci 2,5cm wooden rafters 14/20cm at 80cm distance / air layer 20cm, thermal insulation 20cm, vapor barrier, wooden planks 2cm, straw-plaster ceiling 2.5cm
U (W/m^2/K)	U = 2,52 W/m^2/K	U = 0,35 W/m^2/K	U = 0,19 W/m^2/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

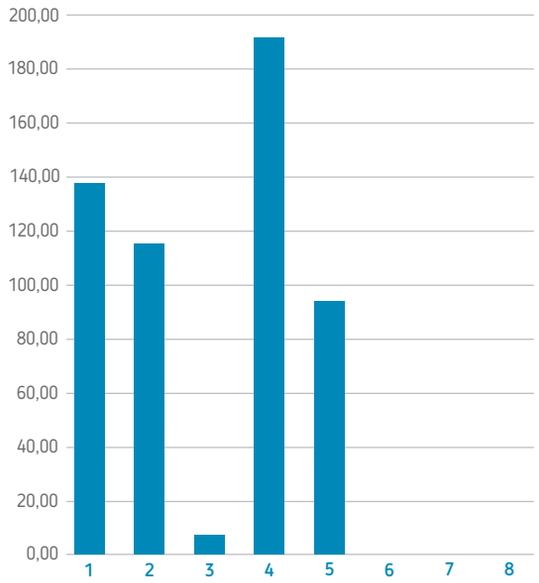
UNAPREĐENJE 2 | IMPROVEMENT 2

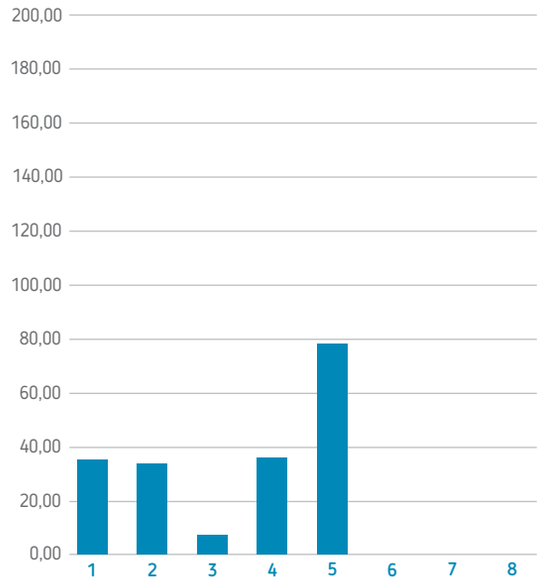
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

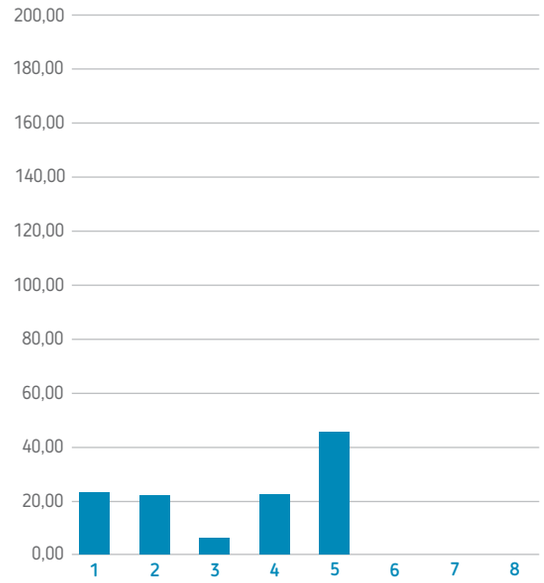
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - Floor on the ground

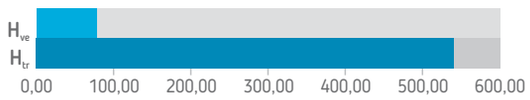


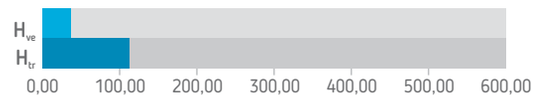




ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)

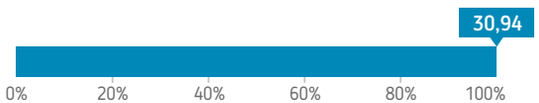


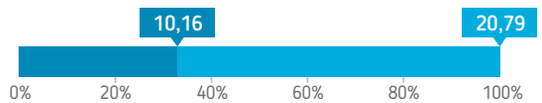


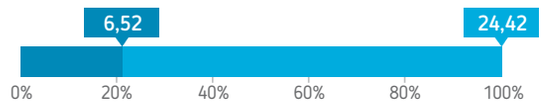
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

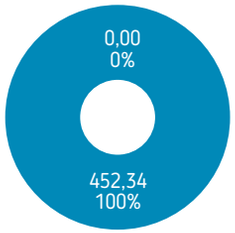
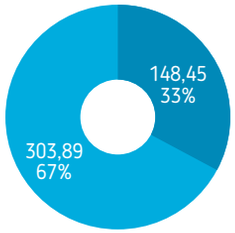
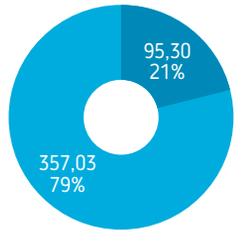
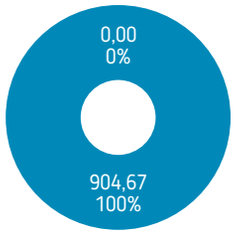
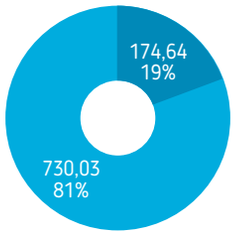
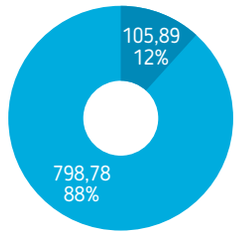
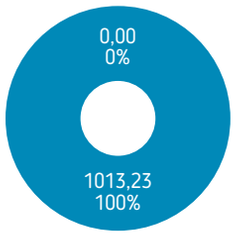
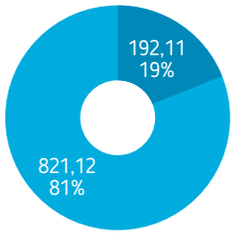
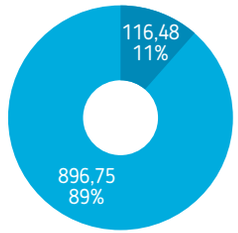
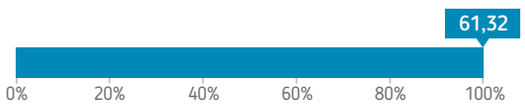
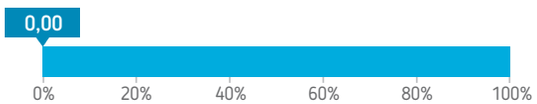
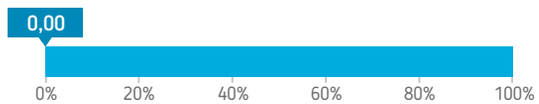
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

B1

Kategorija objekta Building category	**SLOBODNOSTOJEĆA KUĆA** **SINGLE-FAMILY HOUSE**
Godina izgradnje Built in	**1946-1960.**
Broj etaža Number of floors	**1**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**53,86**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**43,24**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**98,15**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**1,49**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**473,96**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**602,16**

Slobodnostojeća prizemna porodična kuća izdužene pravougaone osnove, s malo otvora na fasadi. Ulazna vrata su uvučena u odnosu na fasadnu ravan, te je formiran natkriveni predulazni prostor. Krov je klasičan, drveni, na dvije vode, dosta plitak s crijepom kao krovnim pokrivačem. Tavanski prostor se ne koristi za stanovanje. Spoljašnji zidovi su izvedeni od pune opeke, debljine 25cm, bez termoizolacije i obostrano malterisani. Međuspratna konstrukcija prema tavanu je drvena, a plafon je izveden od maltera na podlozi od trske. Prozori su dvostruki, s drvenim okvirima i jednostrukim zastakljenjem.

Spoljašnji zidovi slobodnostojeće kuće su od pune opeke, bez termoizolacije i obostrano malterisani. Termovizijski snimak pokazuje da postoje termički mostovi na mjestima veze horizontalne međuspratne konstrukcije i spoljašnjeg zida, kao i na mjestima promjene geometrije osnove zgrade, tj. u ulaznom dijelu. Termički mostovi su zabilježeni i u dijelovima fasadnih otvora, prozora i vrata koji su u lošem stanju.

Single-family house is a single floor family house of extended rectangular footprint, with a few facade openings. Entrance doors are receded compared to the facade plane, with a covered entrance area. The roof is traditional, wooden, quite shallow gable roof, with clay roof tiles. Attic is not used for residential purposes. External walls made of solid 25cm brick, without thermal insulation, and with plaster finish on both sides. Construction towards the attic is wooden, and the ceiling is made of plastered cane. Double windows, wooden single-glazing frames.

Free-standing house, external walls made of solid brick, without thermal insulation, and with plaster finish on both sides. Thermovision image shows prominent thermal bridges where the construction between floors meets external walls, as well as in the areas where the building changes its shape, that is, at the entrance. Thermal bridges are registered at parts of facade openings, doors and windows in poor condition.

UNAPREĐENJE 1 | IMPROVEMENT 1

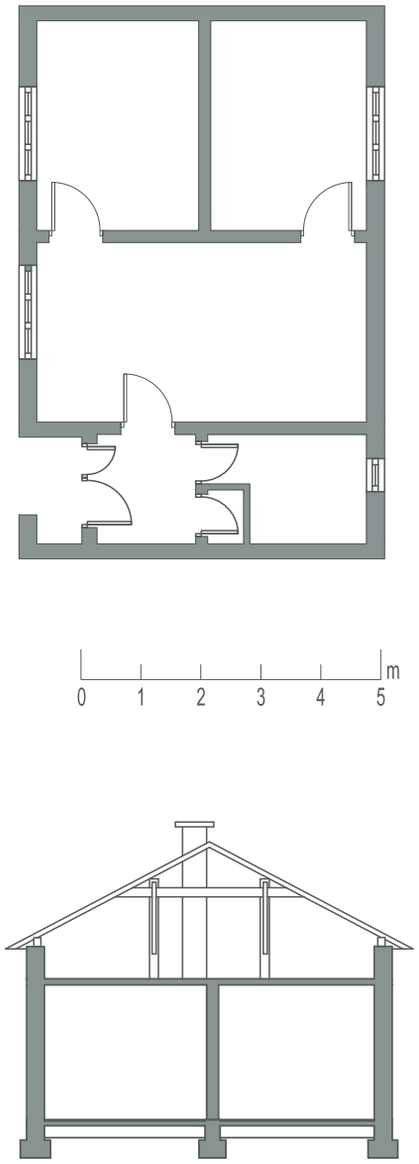
Izolovanje spoljašnjeg zida slojem termoizolacije debljine 10cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Zamjena starih prozora novim s U =1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

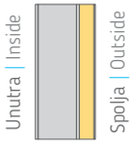
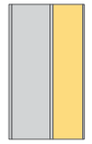
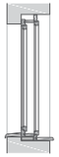
Insulation of external wall with thermal insulation layer of 10cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida slojem termoizolacije debljine 20cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu slojem termoizolacije debljine 10cm (λ=0,041 W/mK). Zamjena postojećih prozora novim s U =1,0 W/m^{2}K (g=0,61). Ugradnja novih ulaznih vrata s U = 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

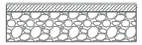
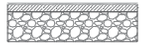
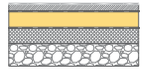
Insulation of external wall with thermal insulation layer of 20cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.0 W/m^{2}K (g=0.61). Installing of new entrance door with U =2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 25cm, malter 2cm plaster 2cm, brick wall 25cm, plaster 2cm	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,70 W/m^2/K	U = 0,32 W/m^2/K	U = 0,18 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s razmaknutim krilima i jednostrukim staklom wooden, double frame, double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,09 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

ELEMENTI UNAPREĐENJA OMOTAČA | BUILDING ENVELOPE IMPROVEMENTS ELEMENTS

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
POD NA TLU GROUND FLOOR	Unutra | Inside  Spolja | Outside keramičke pločice 1cm, betonska ploča 5cm, šljunak 20cm ceramic tiles 1cm, concrete 5cm, rammed earth 20cm	Unutra | Inside  Spolja | Outside NEMA IZMJENA NO CHANGES	Unutra | Inside  Spolja | Outside keramičke pločice 1cm, cementni estrih 4cm, PE folija, termoizolacija 10cm, hidroizolacija 1cm, AB ploča 10cm, šljunak 15cm ceramic tiles 1cm, cement screed 4cm, PE foil, thermal insulation 10cm, waterproofing 1cm, ferroconcrete 10cm, gravel 15cm
U (W/m^2/K)	U = 4,74 W/m^2/K	U = 4,74 W/m^2/K	U = 0,35 W/m^2/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside Unutra | Inside drvene daske 2cm, malter na trsci 2,5cm wooden planks 2cm, straw-plaster ceiling 2.5cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, parna brana, drvene daske 2cm, malter na trsci 2,5cm thermal insulation 10cm,vapor barrier, wooden planks 2cm, straw-plaster ceiling 2.5cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, parna brana, drvene daske 2cm, malter na trsci 2,5cm thermal insulation 20cm,vapor barrier, wooden planks 2cm, straw-plaster ceiling 2.5cm
U (W/m^2/K)	U = 2,52 W/m^2/K	U = 0,35 W/m^2/K	U = 0,19 W/m^2/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

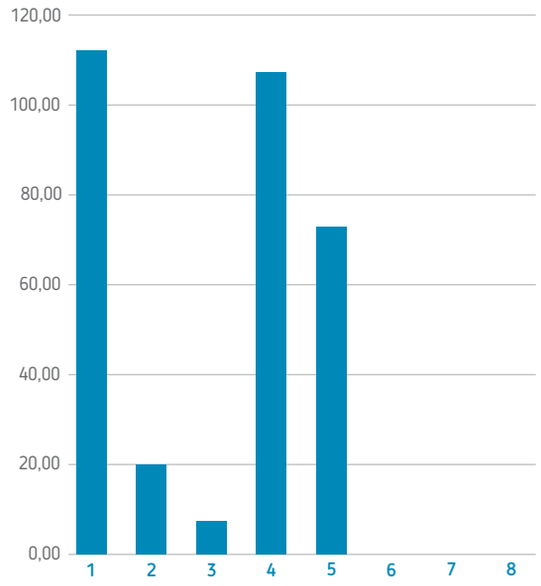
UNAPREĐENJE 2 | IMPROVEMENT 2

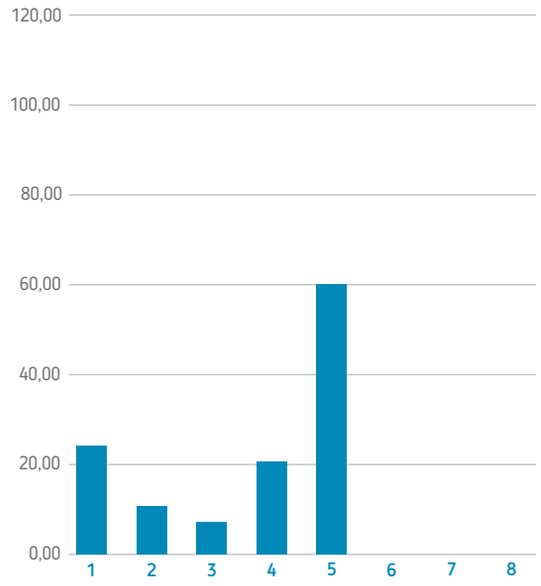
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

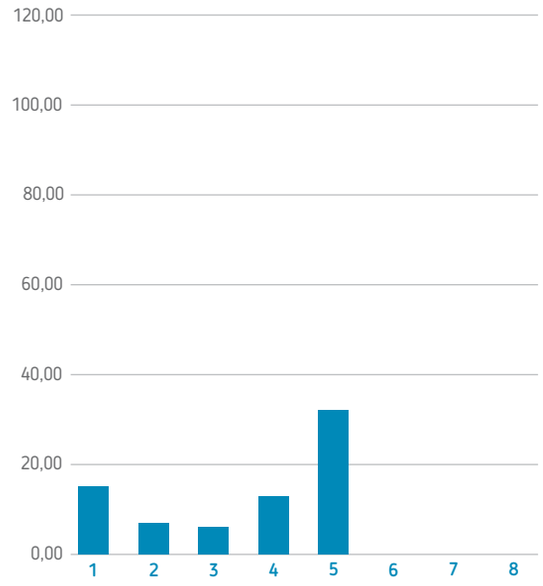
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - Floor on the ground

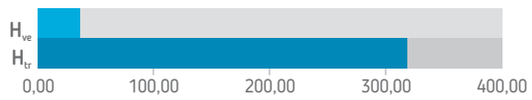






ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

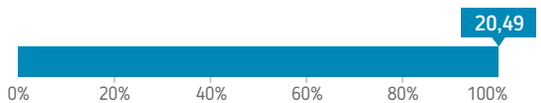
(W/K)

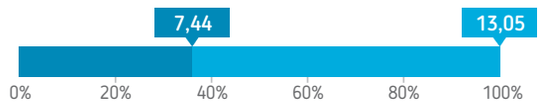


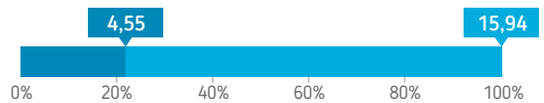
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

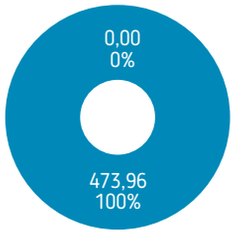
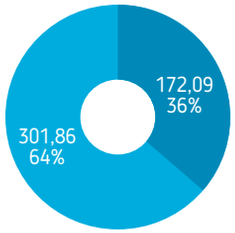
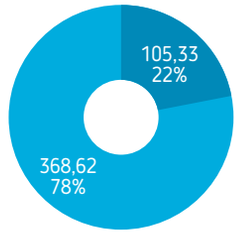
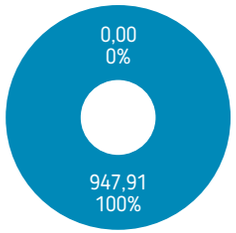
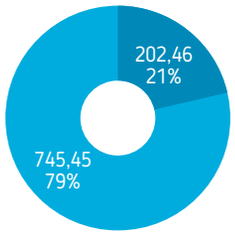
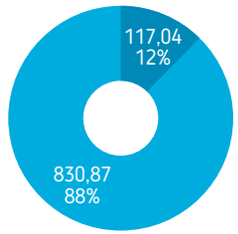
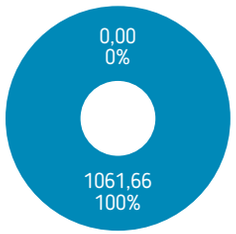
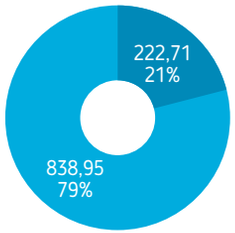
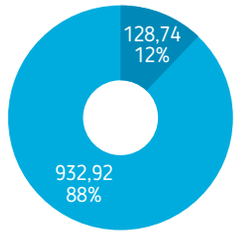
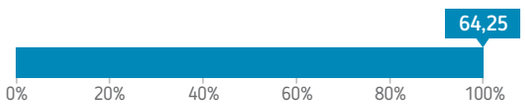
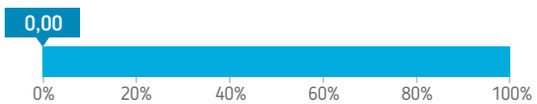
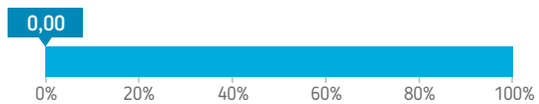
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

C1

Kategorija objekta Building category	**SLOBODNOSTOJEĆA KUĆA** **SINGLE-FAMILY HOUSE**
Godina izgradnje Built in	**1961-1970.**
Broj etaža Number of floors	**1**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**69,11**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**55,65**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**139,13**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**1,36**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**464,90**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**582,31**

Slobodnostojeća porodična kuća kompaktne osnove, skoro kvadratne, s malo otvora na fasadi. Krov je klasičan, na četiri vode, plitak, s crijepom kao krovnim pokrivačem. Tavanski prostor se ne koristi za stanovanje. Spoljašnji zidovi su izvedeni od pune opeke, debljine 25cm, bez termoizolacije i obostrano su malterisani. Konstrukcija prema tavanu je drvena, a plafon je izveden od maltera na podlozi od trske. Prozori su dvostruki, s drvenim okvirima i jednostrukim zastakljenjem.

Termovizijski snimak je registrovao velike toplotne gubitke kroz spoljašnje zidove, koji nisu termički izolovani. Postojanje termičkih mostova na spoljašnjim zidovima se uočavaju u području natprozornih greda, kao i na mjestima horizontalnih serklaža. Postoje veći gubici u dijelovima fasadne stolarije, koji ukazuju na loše stanje okvira prozora ali i zastakljenja.

Single-family house is of compact, almost square footprint, with a few facade openings. The roof is traditional shallow hip roof, with roof tiles. Attic is not used for residential purposes. External walls made of solid 25cm brick, without thermal insulation, and with plaster finish on both sides. Construction towards the attic is wooden, and the ceiling is made of plastered cane. Double windows, wooden single-glazing frames.

Thermovision image shows significant loss of heat through the external walls due to the lack of thermal insulation. Thermal bridges on external walls are registered at the beams above windows and along horizontal ring beams. There is significant loss of heat in the area of facade framings indicative of poor condition of the framing and glazing.

UNAPREĐENJE 1 | IMPROVEMENT 1

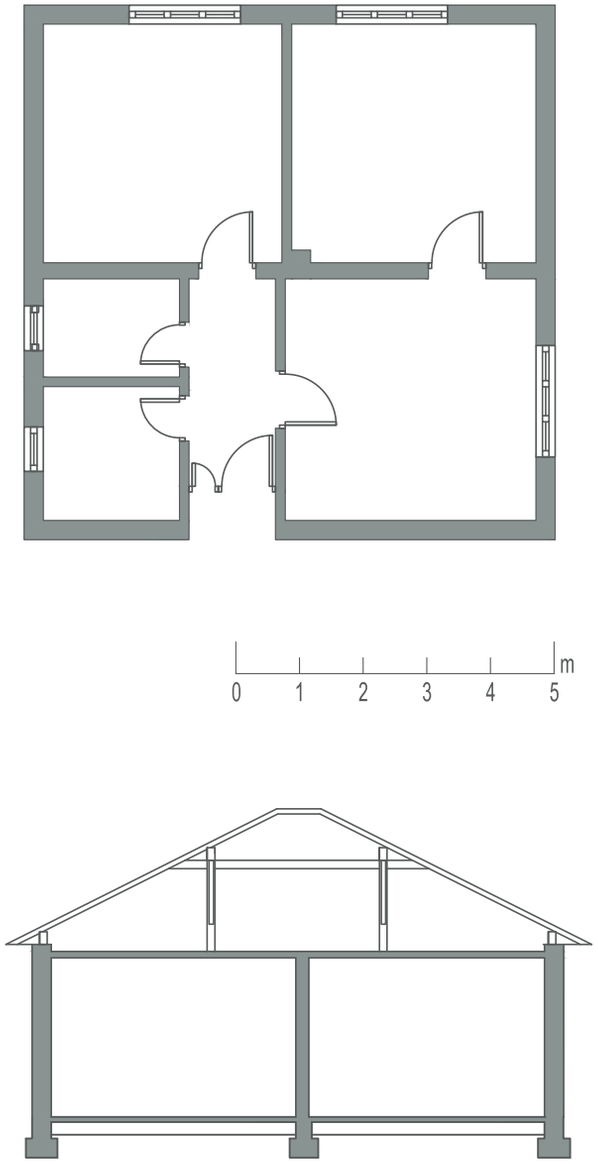
Izolovanje spoljašnjeg zida slojem termoizolacije debljine 10cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Zamjena postojećih prozora novim s U =1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

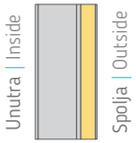
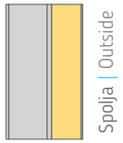
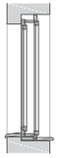
Insulation of external wall with thermal insulation layer of 10cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

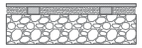
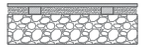
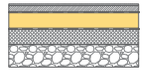
UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida slojem termoizolacije debljine 20cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu slojem termoizolacije debljine 10cm (λ=0,041 W/mK). Zamjena postojećih prozora novim, s U =1,0 W/m^{2}K (g=0,61). Ugradnja novih ulaznih vrata s U = 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with thermal insulation layer of 20cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.0 W/m^{2}K (g=0.61). Installing of new entrance door with U =2.0 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 25cm, malter 3cm plaster 2cm, brick wall 25cm, plaster 3cm	 malter 2cm, puna opeka 25cm, malter 3cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 3cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 25cm, malter 3cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 3cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,70 W/m^2/K	U = 0,32 W/m^2/K	U = 0,18 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s razmaknutim krilima i jednostrukim staklom wooden, double frame, double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,00 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
POD NA TLU GROUND FLOOR	Unutra | Inside  Spolja | Outside drvene daske 2cm, potpatosnice u pijesku 5cm, šljunak 20cm wooden planks 2cm, sleepers in ash bedding 5cm, rammed earth 20cm	Unutra | Inside  Spolja | Outside NEMA IZMJENA NO CHANGES	Unutra | Inside  Spolja | Outside parket 1cm, cementni estrih 4cm, PE folija, termoizolacija 10cm, hidroizolacija 1cm, armirani beton 10cm, šljunak 15cm parquet 1cm, cement screed 4cm, PE foil, thermal insulation 10cm, waterproofing 1cm, reinforced concrete 10cm, gravel 15cm
U (W/m^2/K)	U = 2,45 W/m^2/K	U = 2,45 W/m^2/K	U = 0,35 W/m^2/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside Unutra | Inside drvene daske 2cm, malter na trsci 2,5cm wooden planks 2cm, straw-plaster ceiling 2.5cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, parna brana, drvene daske 2cm, malter na trsci 2,5cm thermal insulation 10cm,vapor barrier, wooden planks 2cm, straw-plaster ceiling 2.5cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, parna brana, drvene daske 2cm, malter na trsci 2,5cm thermal insulation 20cm,vapor barrier, wooden planks 2cm, straw-plaster ceiling 2.5cm
U (W/m^2/K)	U = 2,52 W/m^2/K	U = 0,35 W/m^2/K	U = 0,19 W/m^2/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

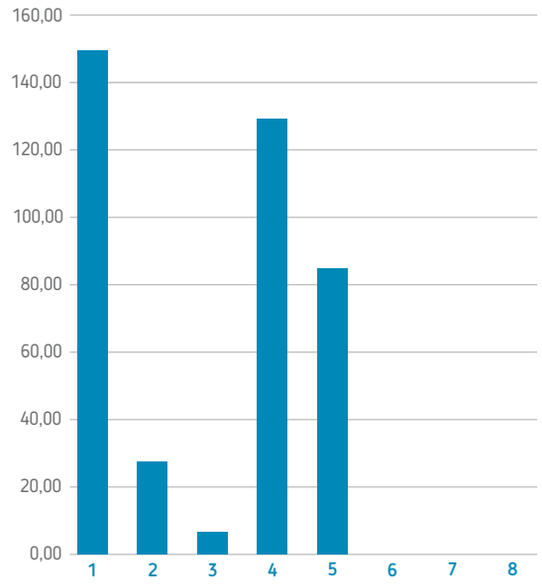
UNAPREĐENJE 2 | IMPROVEMENT 2

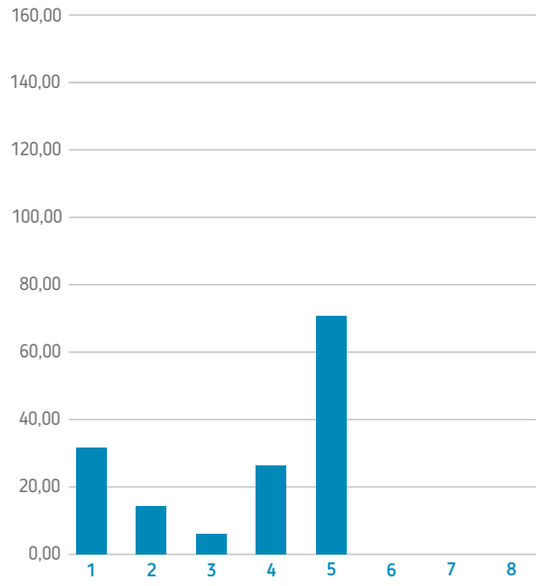
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

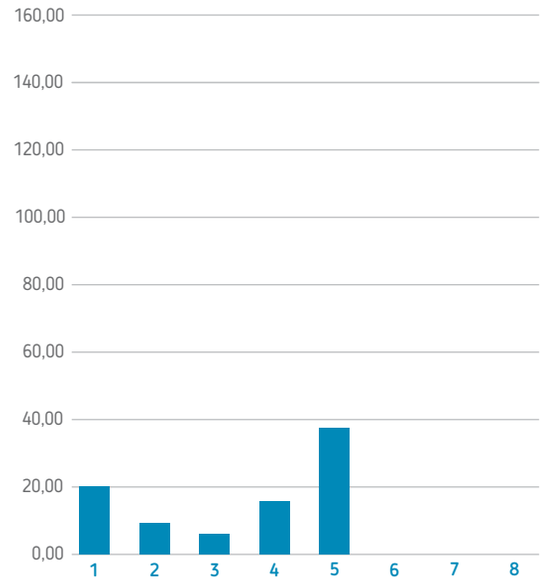
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - Floor on the ground

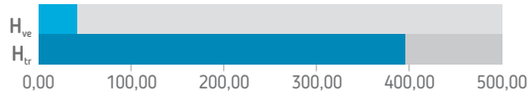


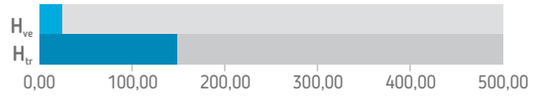


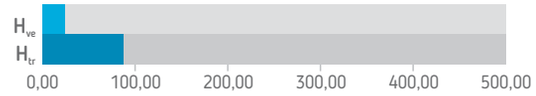


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



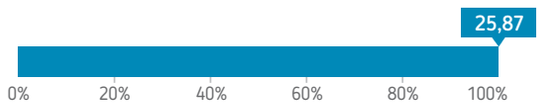


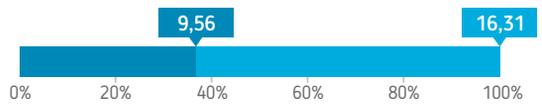


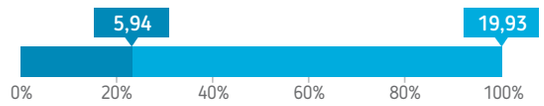
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

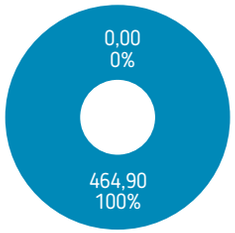
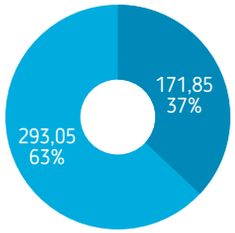
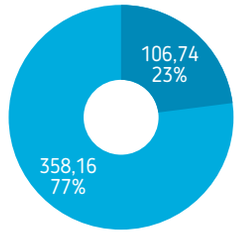
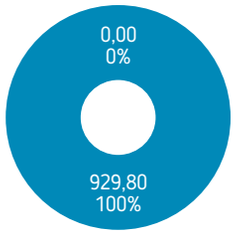
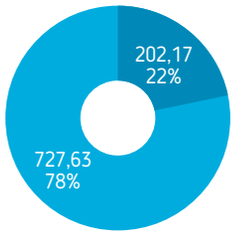
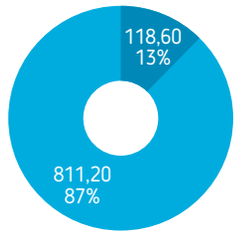
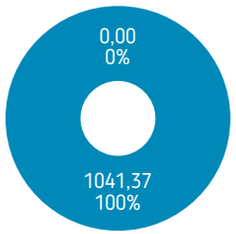
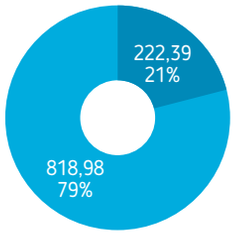
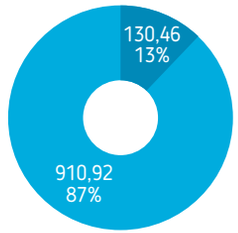
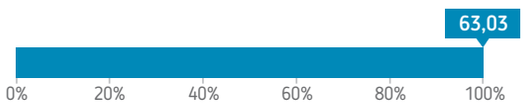
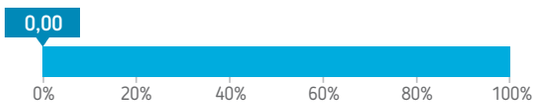
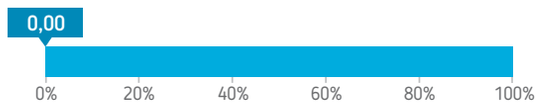
(MWh/god) | (MWh/year)

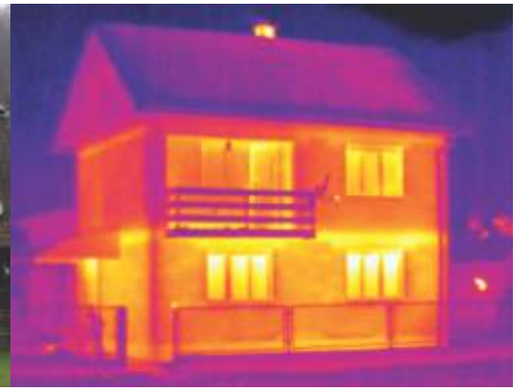
Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			



OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

D1

Kategorija objekta Building category	**SLOBODNOSTOJEĆA KUĆA** **SINGLE-FAMILY HOUSE**
Godina izgradnje Built in	**1971-1980.**
Broj etaža Number of floors	**2**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**43,60**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**67,83**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**149,23**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**1,04**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**381,59**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**484,58**

Slobodnostojeća spratna porodična kuća kompaktne osnove. Krov je klasičan, drveni, na dvije vode, s crijepom kao krovnim pokrivačem. Tavanski prostor se ne koristi za stanovanje. Spoljašnji zidovi su izvedeni od pune opeke, debljine 25cm, bez termoizolacije i obostrano malterisani. Međuspratna konstrukcija prema tavanu je poluprefabrikovana, tipa TM3, sa šupljim opekarskim elementima i armirano-betonskom pločom preko njih. Prozori su dvostruki, s drvenim okvirima i jednostrukim zastakljenjem.

Termovizijski snimak pokazuje da postoje izraziti termički mostovi na mjestima veze međuspratne konstrukcije i spo-ljašnjih zidova, kao i na dijelu sokla. Na termovizijskom snimku spoljašnjeg zida mogu se uočiti fuge u strukturi zida. Snimak pokazuje izrazite toplotne gubitke na dijelovima fasadnih otvora, a nešto manje na krovnim površinama.

Single-family house of compact footprint. The roof is traditional, wooden, gable roof, with clay roof tiles. Attic is not used for residential purposes. External walls made of solid 25cm brick, without thermal insulation, and with plaster finish on both sides. The layer between the second floor and the attic is partially prefabricated, type TM3, with hollow brick elements and RC slab on top. Double windows, wooden single-glazing frames.

Thermovision image shows prominent thermal bridges where the construction between floors meets external walls, as well as along the plinth. Thermovision image of the external wall shows joints in the wall structure. The image shows major heat loss at openings on the facade, and somewhat smaller loss at the roof.

UNAPREĐENJE 1 | IMPROVEMENT 1

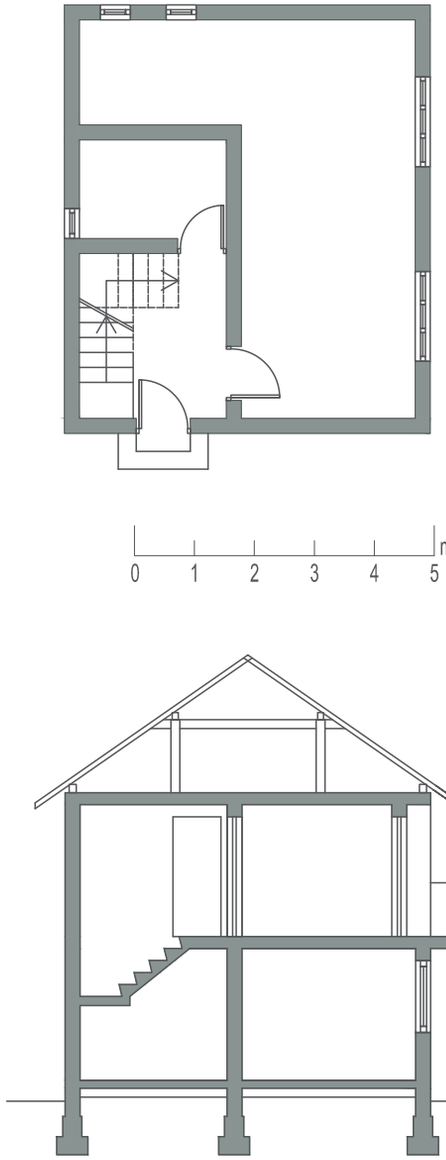
Izolovanje spoljašnjeg zida slojem termoizolacije debljine 10cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (sa gornje strane) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Zamjena postojećih prozora novim, s U =1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

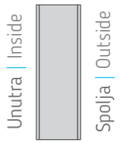
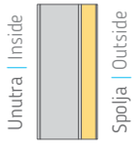
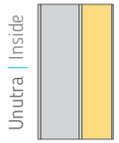
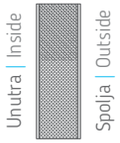
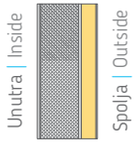
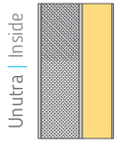
Insulation of external wall with thermal insulation layer of 10cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

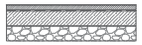
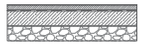
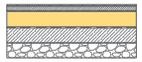
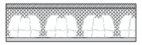
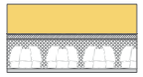
UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida slojem termoizolacije debljine 20cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu slojem termoizolacije debljine 10cm (λ=0,041 W/mK). Zamjena postojećih prozora novim, s U =1,0 W/m^{2}K (g=0,61). Ugradnja novih ulaznih vrata s U = 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i priprema potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with thermal insulation layer of 20cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new entrance door with U =2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 25cm, malter 2cm plaster 2cm, brick wall 25cm, plaster 2cm	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,64 W/m^2/K	U = 0,32 W/m^2/K	U = 0,18 W/m^2/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, AB zid 25cm, malter 2cm plaster 2cm, reinforced concrete wall 25cm, plaster 2cm	 malter 2cm, AB zid 25cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 25cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, AB zid 25cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 25cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 3,07 W/m^2/K	U = 0,36 W/m^2/K	U = 0,19 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki sa spojenim krilima i jednostrukim staklom wooden, single frame, connected double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,00 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
POD NA TLU - F1 GROUND FLOOR - F2	Unutra | Inside  Spolja | Outside vinaz 0,2cm, cementna košuljica 3cm, hidroizolacija, betonska ploča 10cm, šljunak 10cm vinyl 0.2cm, cement screed 3cm, waterproofing, concrete 10cm, gravel 10cm	Unutra | Inside  Spolja | Outside NEMA IZMJENA NO CHANGES	Unutra | Inside  Spolja | Outside parket 1cm, cementna košuljica 3cm, PE folija, termoizolacija 10cm, hidroizolacija, betonska ploča 10cm, šljunak 10cm parquet 1cm, cement screed 3cm, PE foil, thermal insulation 10cm, waterproofing 1cm, concrete 10cm, gravel 10cm
U (W/m²/K)	U = 3,63 W/m²/K	U = 3,63 W/m²/K	U = 0,36 W/m²/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside cementna košuljica 3cm, TM3 konstrukcija 20cm, malter 2cm cement screed 3cm, TM3 slab with hollow clay block 20cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, parna brana, cementna košuljica 3cm, TM3 konstrukcija 20cm, malter 2cm thermal insulation 10cm, vapor barrier, cement screed 3cm, TM3 slab with hollow clay block 20cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, parna brana, cementna košuljica 3cm, TM3 konstrukcija 20cm, malter 2cm thermal insulation 20cm, vapor barrier, cement screed 3cm, TM3 slab with hollow clay block 20cm, plaster 2cm
U (W/m²/K)	U = 1,75 W/m²/K	U = 0,33 W/m²/K	U = 0,18 W/m²/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

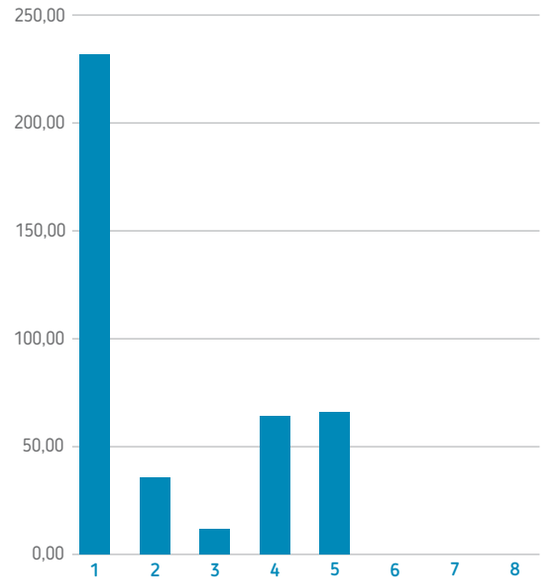
UNAPREĐENJE 2 | IMPROVEMENT 2

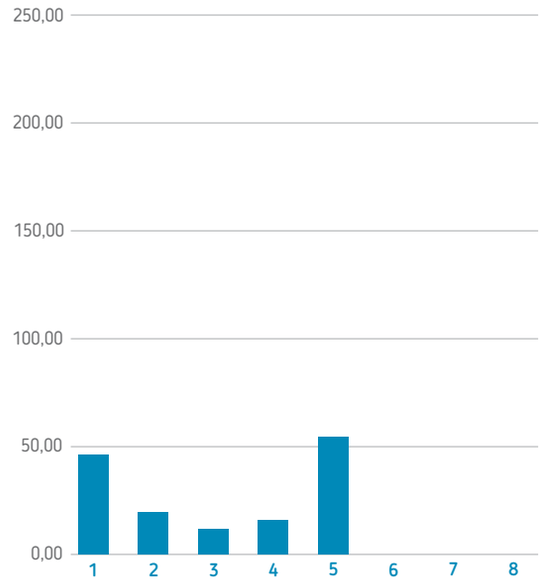
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

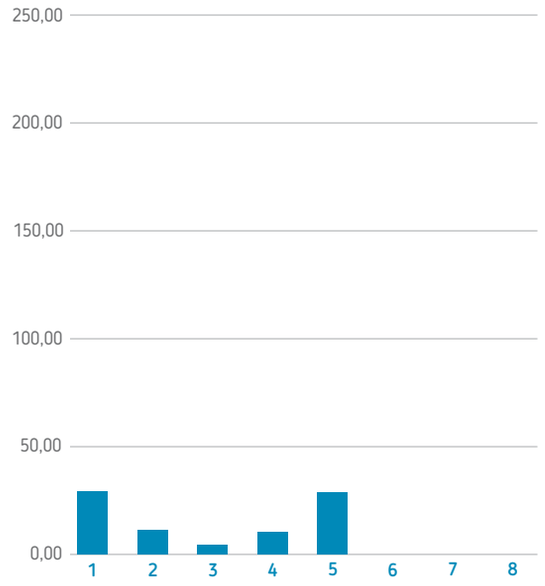
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - Floor on the ground

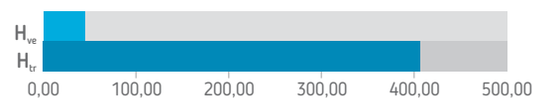


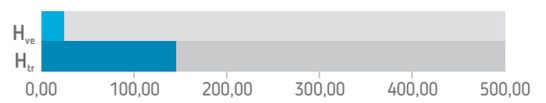


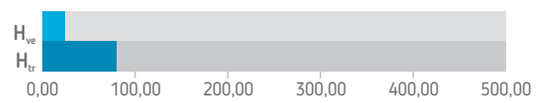


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



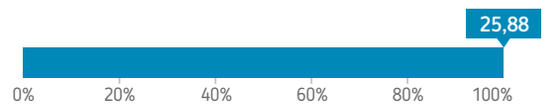


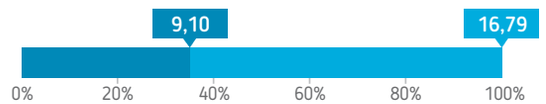


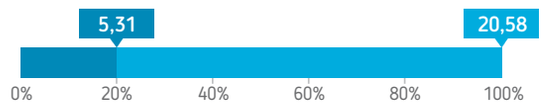
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

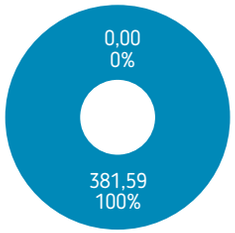
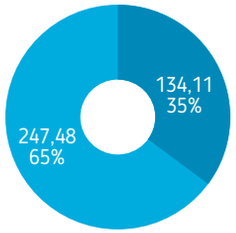
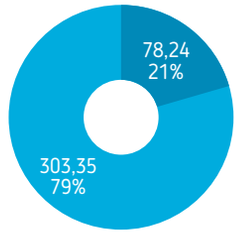
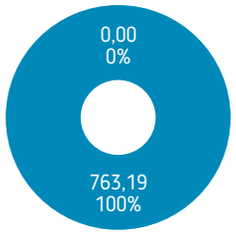
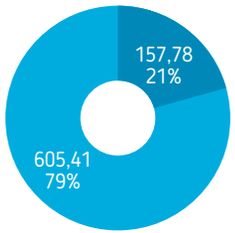
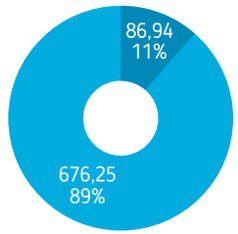
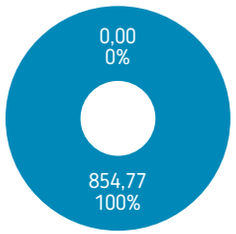
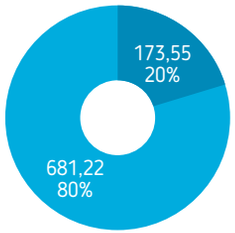
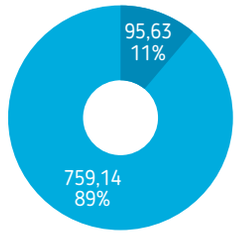
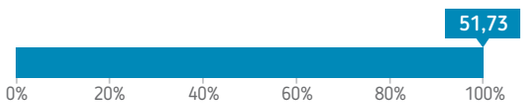
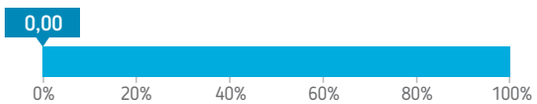
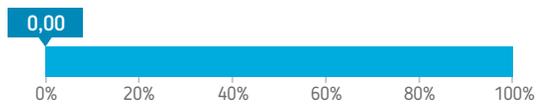
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

E1

Kategorija objekta Building category	**SLOBODNOSTOJEĆA KUĆA** **SINGLE-FAMILY HOUSE**
Godina izgradnje Built in	**1981-1990.**
Broj etaža Number of floors	**2**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**69,66**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**101,44**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**250,15**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,83**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ (kWh/m^2/god) Specific energy need for intermitted heating $Q_{H,nd,interm}$ (kWh/m^2/year)	**135,93**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ (kWh/m^2/god) Specific energy need for continuous heating $Q_{H,nd,cont}$ (kWh/m^2/year)	**176,45**

Slobodnostojeća porodična kuća, spratnosti prizemlje i potkrovlje koje se koristi za stanovanje. Krov je klasičan, drveni, na dvije vode, s crijepom kao krovnim pokrivačem. Spoljašnji zidovi su izvedeni od šupljih opekarskih blokova, debljine 29cm, sa slojem termoizolacije od 5cm u sistemu kontaktne fasade. Međuspratne konstrukcije su tipa TM3, poluprefabrikovane, sa šupljim opekarskim elementima i armiranobetonskom pločom. Prema tavanu međuspratna konstrukcija je izolovana termoizolacijom debljine 5cm. Prozori su dvostruki, s drvenim okvirima i jednostrukim zastakljenjem.

Porodična kuća spratnosti P+Pk s konstrukcijom spoljašnjih zidova od šupljih opekarskih blokova, s termoizolacionim slojem i obostrano su malterisani. Termovizijski snimak pokazuje da postoje izraziti termički mostovi na mjestima armiranobetonskih serklaža (horizontalnih i vertikalnih), i pored postojanja sloja termoizolacije zbog različitih karakteristika materijala. Snimak pokazuje toplotne gubitke na dijelovima fasadnih otvora, što ukazuje na njihovo loše stanje.

Single-family house with ground floor and attic used for residential purposes. The roof is traditional, wooden, gable roof, with clay roof tiles. External walls are made of 29cm hollow clay bricks, with 5cm thermal insulation layer in the contact facade system. Floors are separated by TM3, semi-prefabricated elements with hollow clay elements and RC slab. The attic floor is insulated with a 5cm thick thermal insulation layer. Double windows, wooden single-glazing frames.

Family home with ground floor + attic features external walls made of hollow clay blocks, with thermal insulation, and plaster on both sides. Thermovision image shows prominent thermal bridges along horizontal and vertical RC ring beams, despite the thermal insulation layer, due to different characteristics of the material. The image shows major heat loss at openings on the facade indicating their poor condition.

UNAPREĐENJE 1 | IMPROVEMENT 1

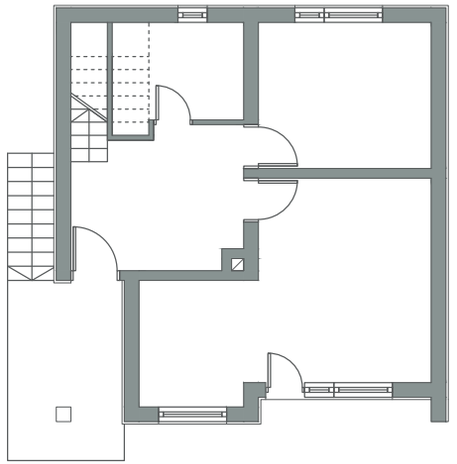
Izolovanje spoljašnjeg zida slojem termoizolacije debljine 10cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Zamjena postojećih prozora novim, s U =1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

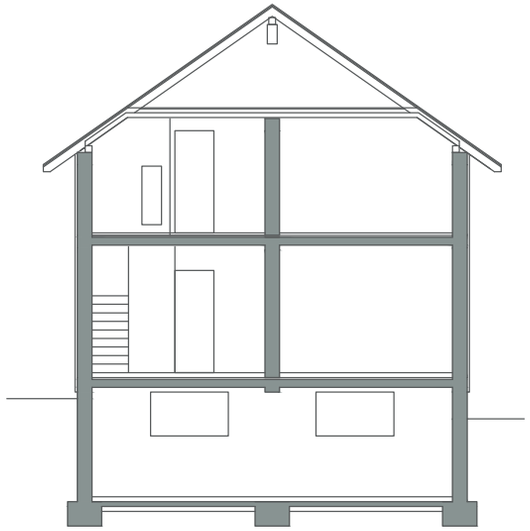
Insulation of external wall with thermal insulation layer of 10cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

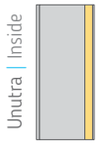
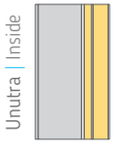
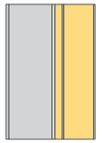
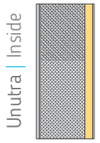
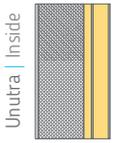
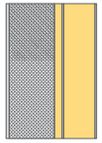
UNAPREĐENJE 2 | IMPROVEMENT 2

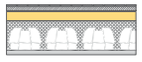
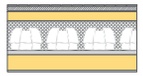
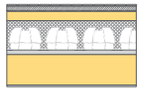
Izolovanje spoljašnjeg zida slojem termoizolacije debljine 20cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu slojem termoizolacije debljine 10cm (λ=0,041 W/mK). Zamjena postojećih prozora novim, s U =1,0 W/m^{2}K (g=0,61). Ugradnja novih ulaznih vrata s U = 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i priprema potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with thermal insulation layer of 20cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.0 W/m^{2}K (g=0.61). Installing of new entrance door with U =2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.





	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 29cm, termoizolacija 5cm, fasadni malter 1cm plaster 2cm, clay block wall 29cm, thermal insulation 5cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 29cm, malter 2cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, clay block wall 29cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 29cm, malter 2cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, clay block wall 29cm, thermal insulation 5cm,facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 0,50 W/m^2/K	U = 0,22 W/m^2/K	U = 0,15 W/m^2/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, AB zid 29cm, termoizolacija 5cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 29cm, thermal insulation 5cm, facade plaster 1cm	 malter 2cm, AB zid 29cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 29cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, AB zid 29cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 29cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 0,64 W/m^2/K	U = 0,25 W/m^2/K	U = 0,16 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki sa spojenim krilima i jednostrukim staklom wooden, single frame, connected double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 2,93 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	Unutra | Inside  Spolja | Outside parket 1cm, cementni estrih 3cm, PVC folija, termoizolacija 5cm, TM3 konstrukcija 20cm, malter 3cm parquet 1cm, cement screed 3cm, PVC foil, thermal insulation 5cm, TM3 slab with hollow clay block 20cm, plaster 3cm	Unutra | Inside  Spolja | Outside parket 1cm, cementni estrih 3cm, PVC folija, termoizolacija 5cm, TM3 konstrukcija 20cm, malter 3cm, termoizolacija 10cm, malter 1cm parquet 1cm, cement screed 3cm, PVC foil, thermal insulation 5cm, TM3 slab with hollow clay block 20cm, plaster 3cm, thermal insulation 10cm, plaster 1cm	Unutra | Inside  Spolja | Outside parket 1cm, cementni estrih 3cm, PVC folija, termoizolacija 5cm, TM3 konstrukcija 20cm, malter 3cm, termoizolacija 20cm, malter 1cm parquet 1cm, cement screed 3cm, PVC foil, thermal insulation 5cm, TM3 slab with hollow clay block 20cm, plaster 3cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 0,43 W/m^2/K	U = 0,21 W/m^2/K	U = 0,14 W/m^2/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside drvene daske 2cm, vazduh 6cm, termoizolacija 10cm, PE folija, drvena lamperija 2cm, wooden planks 2cm, air 6cm, thermal insulation 10cm, PE foil, wood paneling 2cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, termoizolacija 10cm, parna brana, drvena lamperija 2cm thermal insulation 10cm, thermal insulation 10cm, vapor barrier, wood paneling 2cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, termoizolacija 10cm, parna brana, drvena lamperija 2cm, thermal insulation 20cm, thermal insulation 10cm, vapor barrier, wood paneling 2cm
U (W/m^2/K)	U = 0,34 W/m^2/K	U = 0,19 W/m^2/K	U = 0,13 W/m^2/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

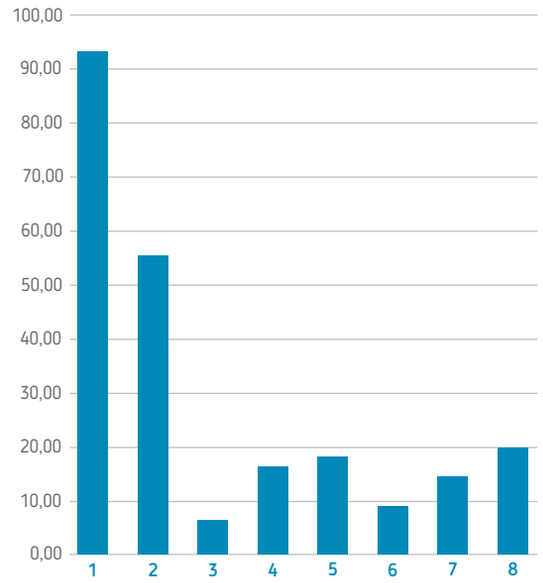
UNAPREĐENJE 2 | IMPROVEMENT 2

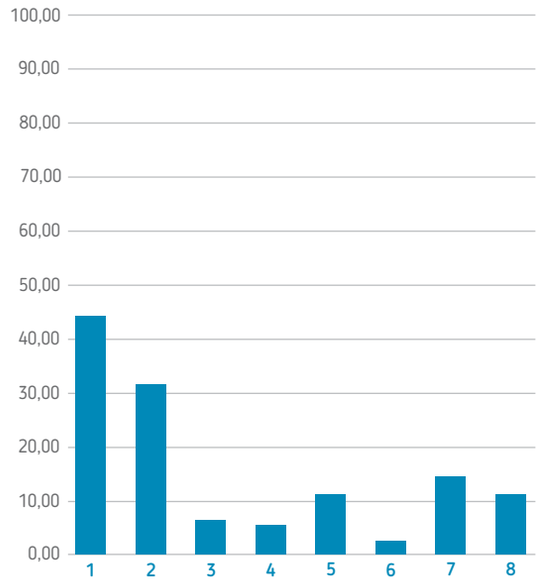
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

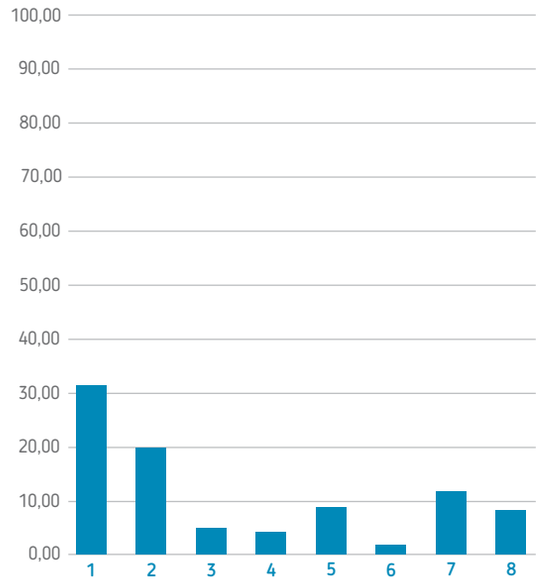
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Kosi krov
5 - Gubici prema negrijanom tavanu
6 - Strop prema okolini
7 - Pod na tlu
8 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - Shed roof
5 - To the unheated attic
6 - Ceiling to the surroundings
7 - Floor on the ground
8 - Through the unheated basement

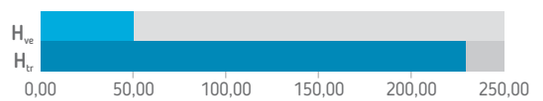


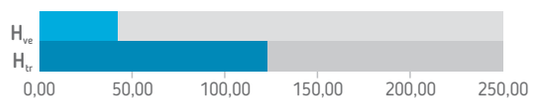


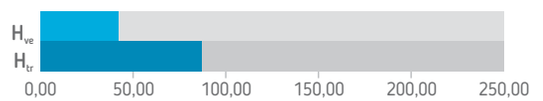


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



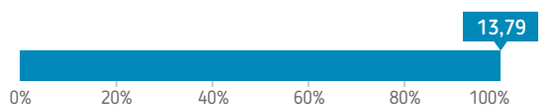


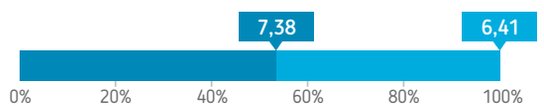


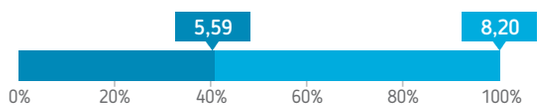
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

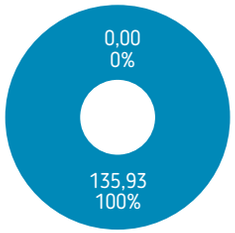
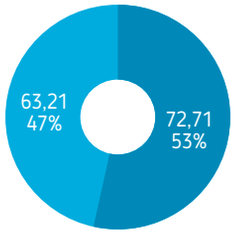
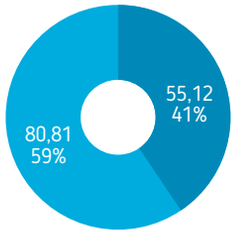
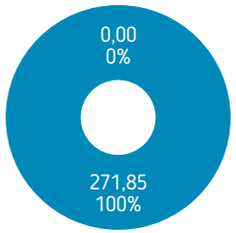
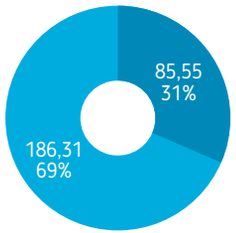
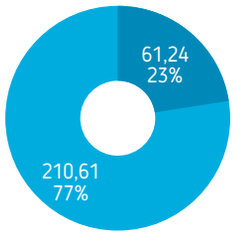
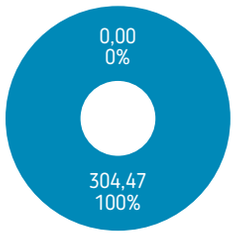
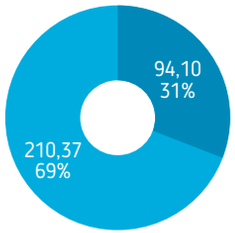
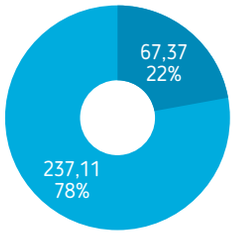
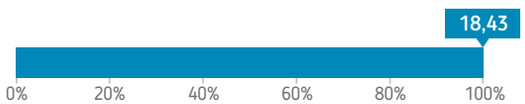
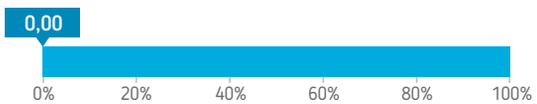
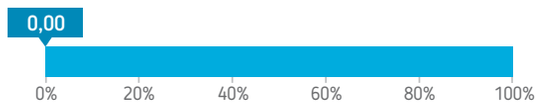
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

F1

Kategorija objekta Building category	**SLOBODNOSTOJEĆA KUĆA** **SINGLE-FAMILY HOUSE**
Godina izgradnje Built in	**1991-2014.**
Broj etaža Number of floors	**2**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**75,20**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**121,10**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**298,76**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,92**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**127,61**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**149,89**

Slobodnostojeća porodična kuća, spratnosti prizemlje i sprat. Krov je klasičan, drveni, na dvije vode, s crijepom kao krovnim pokrivačem. Spoljašnji zidovi su izvedeni od šupljih opekarskih blokova, debljine 29cm, sa slojem termoizolacije od 5cm u sistemu kontaktne fasade. Međuspratne konstrukcije su tipa TM3, a prema tavanskom prostoru postavljen je sloj termoizolacije debljine 10cm. Prozori su jednostruki, s termoizolacionim staklom.

Porodična kuća spratnosti P+1 s konstrukcijom spoljašnjih zidova od šupljih opekarskih blokova, s termoizolacionim slojem i obostrano su malterisani. Termovizijski snimak pokazuje da ne postoje termički mostovi na mjestima armirano-betonskih serklaža (horizontalnih i vertikalnih), što znači da je pravilno izveden termoizolacioni sloj. Snimak pokazuje toplotne gubitke na dijelovima fasadnih otvora, posebno u području okvira što ukazuje na njihove loše karakteristike.

Single-family house with ground floor + 1. The roof is traditional, wooden, gable roof, with clay roof tiles. External walls are made of 29cm hollow clay bricks, with 5cm thermal insulation layer in the contact facade system. Floors are separated by TM3, with 10cm thermal insulation layer towards the attic. Single, single-glazed windows.

Family home with ground floor + 1 features external walls made of hollow clay blocks, with thermal insulation, and plaster on both sides. Thermovision image shows no thermal bridges along horizontal and vertical RC ring beams, indicating properly installed insulation. The image shows major heat loss at openings on the facade, especially along framings, indicating their poor condition.

UNAPREĐENJE 1 | IMPROVEMENT 1

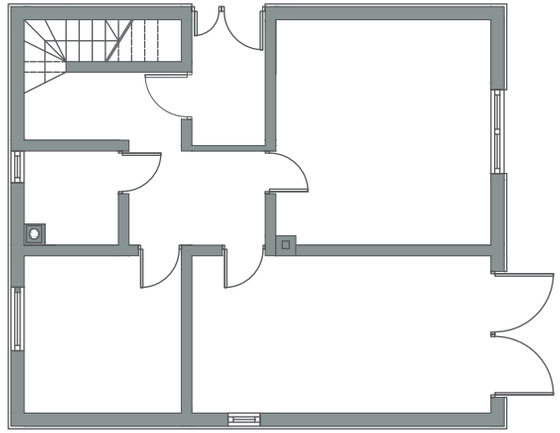
Izolovanje spoljašnjeg zida slojem termoizolacije debljine 10cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Zamjena starih prozora novim, s U =1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izolovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

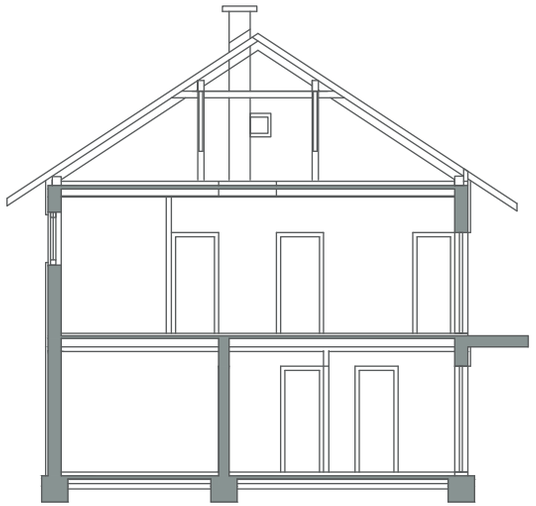
Insulation of external wall with thermal insulation layer of 10cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida slojem termoizolacije debljine 20cm (λ=0,041 W/mK), sa svim ostalim slojevima karakterističnim za kontaktne fasade. Izolovanje međuspratne konstrukcije prema negrijanom tavanu (s gornje strane) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu slojem termoizolacije debljine 10cm (λ=0,041 W/mK). Zamjena starih prozora novim s U =1,0 W/m^{2}K (g=0,61). Ugradnja novih ulaznih vrata s U = 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

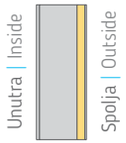
Insulation of external wall with thermal insulation layer of 20cm (λ=0.041 W/mK), including all layers typical of contact facade. Insulation of construction between the floors towards the unheated attic (on the upper side) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Replacing the windows with new ones with U =1.0 W/m^{2}K (g=0.61). Installing of new entrance door with U =2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.





POSTOJEĆE STANJE | CURRENT CONDITION

SPOLJAŠNJI ZID
EXTERNAL WALL

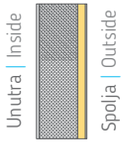


malter 2cm, šuplji opekarski blok 25cm, termoizolacija 5cm, fasadni malter 1cm
plaster 2cm, clay block wall 25cm, thermal insulation 5cm, facade plaster 1cm

U (W/m^2/K)

U = 0,52 W/m^2/K

SPOLJAŠNJI ZID
EXTERNAL WALL



malter 2cm, AB zid 25cm, termoizolacija 5cm, fasadni malter 1cm
plaster 2cm, reinforced concrete wall 25cm, thermal insulation 5cm, facade plaster 1cm

U (W/m^2/K)

U = 0,65 W/m^2/K

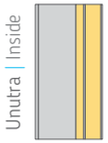
PROZORI
WINDOWS

drveni prozor s dvostrukim staklom
wooden, single frame with double glazing

U (W/m^2/K)

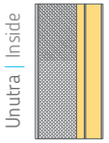
U = 2,85 W/m^2/K

UNAPREĐENJE 1 | IMPROVEMENT 1



malter 2cm, šuplji opekarski blok 25cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm
plaster 2cm, clay block wall 25cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm

U = 0,22 W/m^2/K



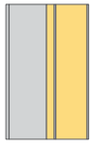
malter 2cm, AB zid 25cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm
plaster 2cm, reinforced concrete wall 25cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm

U = 0,25 W/m^2/K

prozor s dvostrukim staklom
windows with double glazing

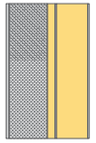
U = 1,60 W/m^2/K

UNAPREĐENJE 2 | IMPROVEMENT 2



malter 2cm, šuplji opekarski blok 25cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm
plaster 2cm, clay block wall 25cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm

U = 0,14 W/m^2/K

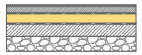
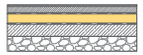
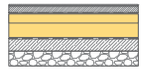
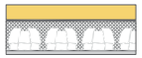
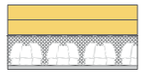
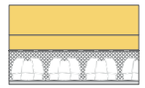


malter 2cm, AB zid 25cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm
plaster 2cm, reinforced concrete wall 25cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm

U = 0,15 W/m^2/K

prozor s trostrukim staklom
windows with triple glazing

U = 1,00 W/m^2/K

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
POD NA TLU GROUND FLOOR	Unutra | Inside  Spolja | Outside keramičke pločice 1cm, estrih 4cm, PVC folija, termoizolacija 6cm, hidroizolacija, betonska ploča 10cm, šljunak 10cm ceramic tiles 1cm, cement screed 4cm, PVC foil, thermal insulation 6cm, waterproofing, concrete 10cm, gravel 10cm	Unutra | Inside  Spolja | Outside NEMA IZMJENA NO CHANGES	Unutra | Inside  Spolja | Outside keramičke pločice 1cm, estrih 4cm, PE folija, termoizolacija 10cm, termoizolacija 6cm, hidroizolacija, betonska ploča 10cm, šljunak 10cm ceramic tiles 1cm, cement screed 4cm, PE foil, thermal insulation 10cm, thermal insulation 6cm, waterproofing, concrete 10cm, gravel 10cm
U (W/m²/K)	U = 4,74 W/m²/K	U = 4,74 W/m²/K	U = 0,23 W/m²/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside termoizolacija 10cm, PVC folija, TM3 konstrukcija 20cm, malter 2cm thermal insulation 10cm, PVC foil, TM3 slab with hollow clay block 20cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, termoizolacija 10cm, parna brana, TM3 konstrukcija 20cm, malter 2cm thermal insulation 10cm, thermal insulation 10cm, vapor barrier, TM3 slab with hollow clay block 20cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, termoizolacija 10cm, parna brana, TM3 konstrukcija 20cm, malter 2cm thermal insulation 20cm, thermal insulation 10cm, vapor barrier, TM3 slab with hollow clay block 20cm, plaster 2cm
U (W/m²/K)	U = 0,34 W/m²/K	U = 0,18 W/m²/K	U = 0,12 W/m²/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

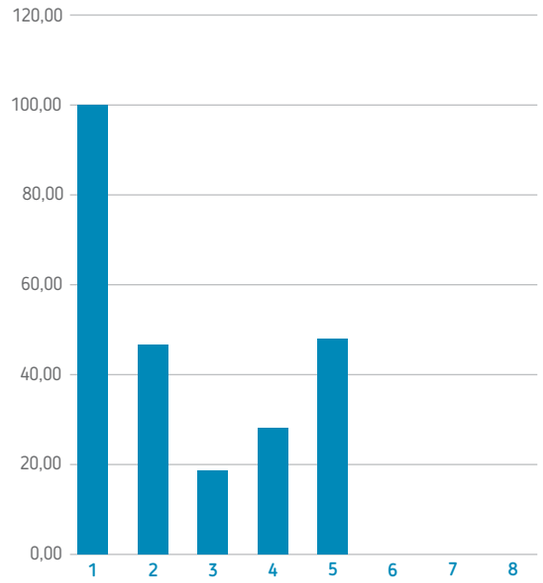
UNAPREĐENJE 2 | IMPROVEMENT 2

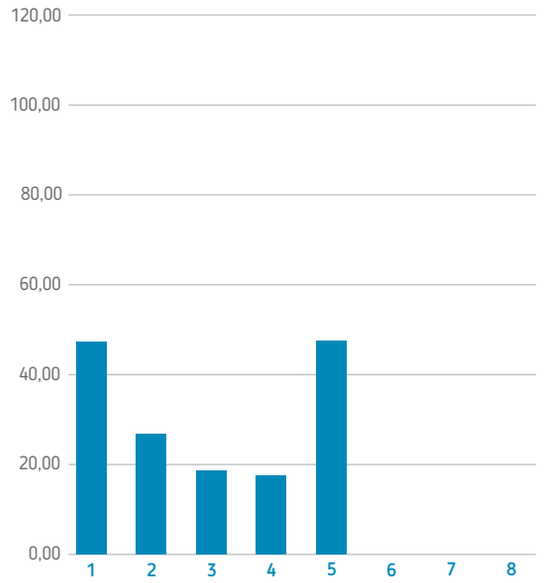
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

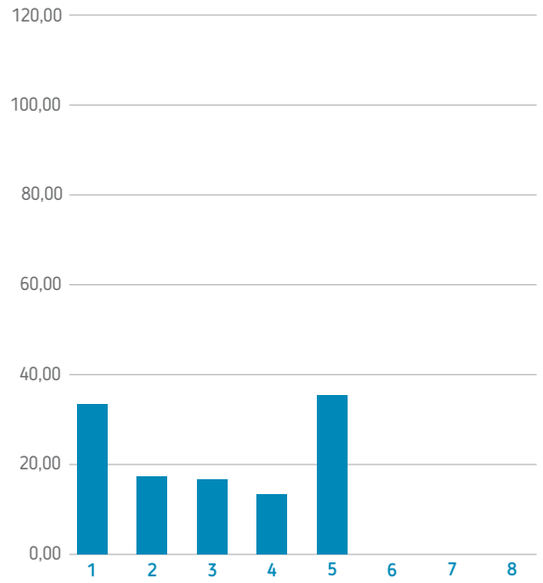
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - Floor on the ground

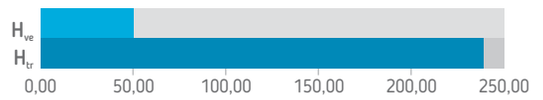


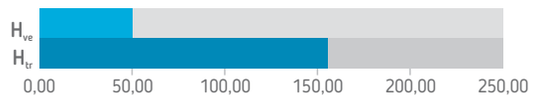


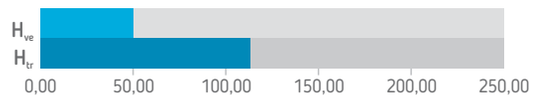


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



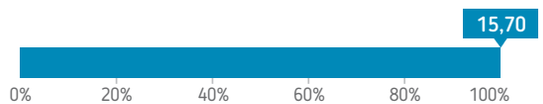


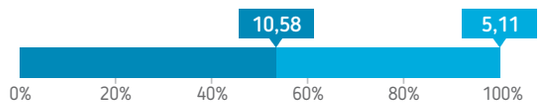


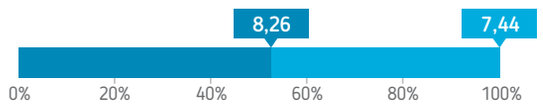
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

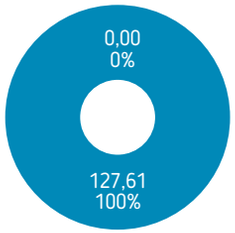
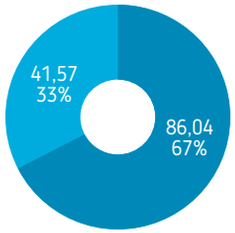
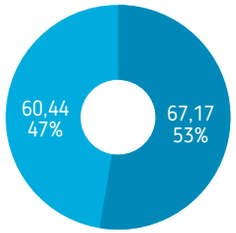
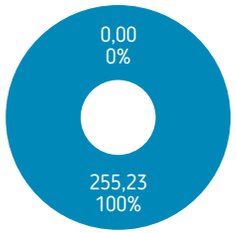
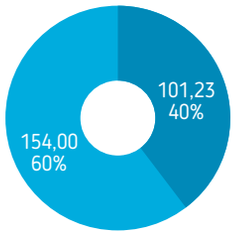
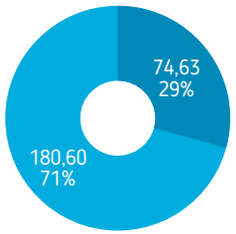
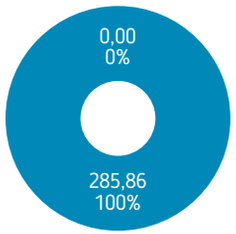
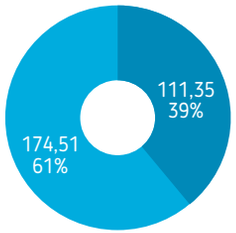
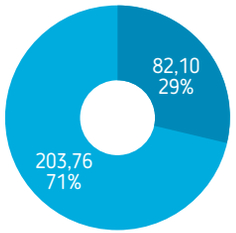
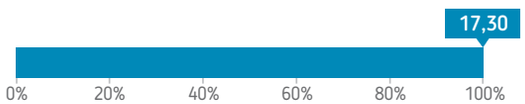
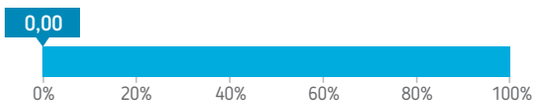
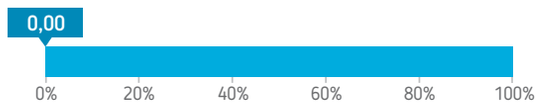
(MWh/god) | (MWh/year)

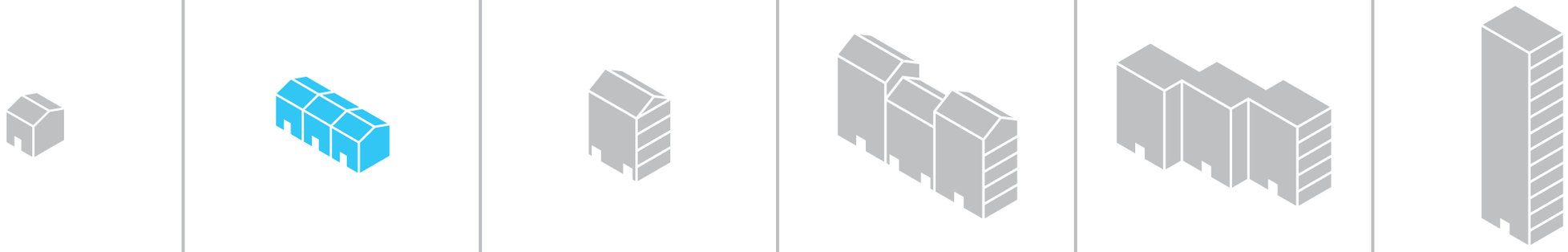
Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			



individualno stanovanje
single-family housing

kolektivno stanovanje
collective housing

KUĆE U NIZU
TERRACED HOUSES

<1945 | 1946-1960 | 1961-1970 | 1971-1980 | 1981-1991 | 1992-2014

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

A2

Kategorija objekta Building category	**KUĆA U NIZU** **TERRACED HOUSE**
Godina izgradnje Built in	**do 1945. | up to 1945**
Broj etaža Number of floors	**2**
Broj stanova Number of apartments	**2**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**106,85**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**135,88**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**407,64**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,71**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**183,16**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**256,46**

Kuća u nizu je izgrađena na zasebnoj parceli u okviru niza objekata i aproksimativno je kvadratne osnove s dvovodnim krovom. Najčešća spratnost objekata iz ove kategorije je P i P+1. Tehnologije građenja i materijali su istovjetni kao kod slobodnostojećih kuća koje su građene u istom periodu. Konstruktivni zidovi su masivni, s debljinom koja varira od 30 do 70cm i rađeni su od opeke austrijskog formata. Objekat nema podruma, a međuspratna konstrukcijaje je izrađena od drvenih greda s daščanim pokovom, dok tavanska konstrukcija ne posjeduje termoizolaciju. Krov je dvovodni, s drvenom konstrukcijom i pokrovom od crijepa. Na homogenom fasadnom omotaču nema termoizolacije, a završna obrada je malter s reljefnim dekorativnim elementima prema uličnoj fasadi. Prozori su drveni, dvostruki, s razmaknutim krilima i jednostrukim staklom. Tavanski i stepenišni prostori su negrijani.

Termovizijski snimak ukazuje na razlike u toplotnim gubicima na vanjskim zidovima objekta uslijed različite debljine spoljnih prizemnih i spratnih zidova. Na snimku se ne mogu locirati termički mostovi jer su vrijednosti temperaturnih očitanja ravnomjerno raspoređeni po površini zidova. Stolarija na objektu je loših termičkih karakteristika tako da su evidentirani visoki toplotni gubici.

The terraced house is built on a separate lot within a system of buildings; it features approximately square footprint and gable roof. Buildings in this category are usually ground floor or GF + 1. Construction technology and materials are identical to those of free-standing houses from the same period. Construction walls are massive, 30 to 70cm, built using Austrian brick. The building does not feature a basement, and floors are separated by wooden beams plated with wood boards, while the attic construction does not include any thermal insulation. Gable roof is supported by wooden beams and covered with roof tiles. Homogenous facade envelope does not include thermal insulation, and the finish is made with plaster, and decorative relief installed on the facade facing the street. Double single-glazed wood windows, with space between wings. The attic and the stairway are left unheated.

The thermovision image of external walls shows different levels of heat loss depending on the thickness of external walls on the ground floor and upper floors. The image does not show thermal bridges since the temperature is evenly distributed over the wall surface. Framing of doors and windows shows high rate of heat loss which is indicative of poor thermal characteristics.

UNAPREĐENJE 1 | IMPROVEMENT 1

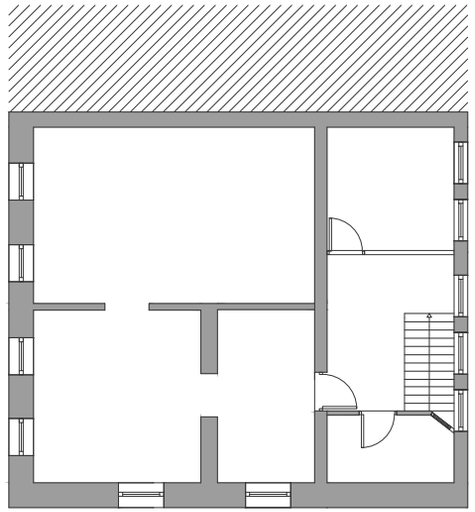
Izolovanje fasadnog zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija toplotne pumpe vazduh-vazduh s vršnim električnim grijačem s jednom vanjskom i više unutrašnjih jedinica. Centralna priprema potrošne tople vode povezana s toplotnom pumpom za period hlađenja. Sistem grijanja upravljan lokalno prema unutrašnjoj temperaturi prostora.

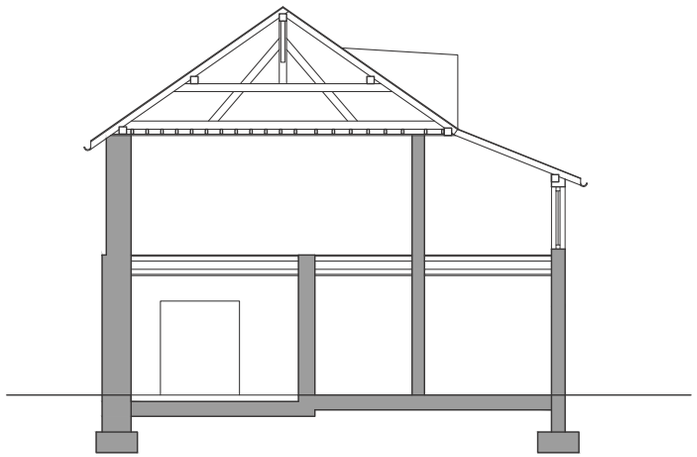
Insulation of the external facade wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of a heat pump air-air with peak load electric heater and one external, and several internal units. Central preparation of domestic hot water with heat pump for the cooling period. Heating system controlled locally according to the room temperature.

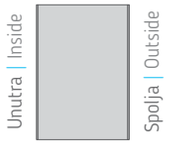
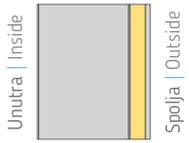
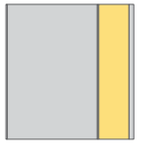
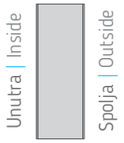
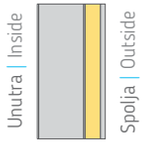
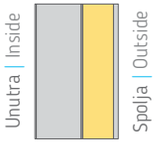
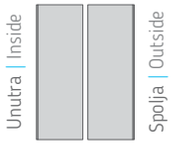
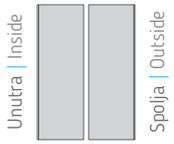
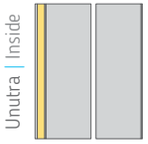
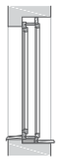
UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje fasadnog zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). Ugradnja novih ulaznih vrata kako bi se dostigao U-koeficijent od 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of the external facade wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of internal walls to unheated areas with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). Installing of new entrance door to reach U-coefficient of 2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolytic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.





	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 1cm, puna opeka 60cm, malter 1cm plaster 1cm, brick wall 60cm, plaster 1cm	 malter 1cm, puna opeka 60cm, malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 1cm, brick wall 60cm, plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 1cm, puna opeka 60cm, malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 1cm, brick wall 60cm, plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 0,93 W/m^2/K	U = 0,28 W/m^2/K	U = 0,17 W/m^2/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 1cm, puna opeka 30cm, malter 1cm plaster 1cm, brick wall 30cm, plaster 1cm	 malter 1cm, puna opeka 30cm, malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 1cm, brick wall 30cm, plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 1cm, puna opeka 30cm, malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 1cm, brick wall 30cm, plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,58 W/m^2/K	U = 0,32 W/m^2/K	U = 0,18 W/m^2/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 1cm, puna opeka 30cm,vazduh (dilatacija) 3cm, puna opeka 30cm, malter 1cm plaster 1cm, brick wall 30cm,air (dilatation) 3cm, brick wall 30cm, plaster 1cm	 NEMA IZMJENA NO CHANGES	 gips-kartonske ploče 1,25cm, termoizolacija 5cm, malter 1cm, zid od pune opeke 30cm, vazduh (dilatacija) 3cm, puna opeka 30cm, malter 1cm gypsum plasterboard 1.25cm, thermal insulation 5cm, plaster 1cm, full brick wall 30cm, air (dilatation) 3cm, brick wall 30cm, plaster 1cm
U (W/m^2/K)	U = 1,56 W/m^2/K	U = 1,56 W/m^2/K	U = 0,52 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s razmaknutim krilima i jednostrukim staklom wooden, double frame, double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 5,20 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	 Unutra | Inside Spolja | Outside drvene daske 2cm, drvene grede/vazduh 20cm, drvene daske 2cm, malter 2cm wooden planks 2cm, wooden beamers/air 20cm, wooden planks 2cm, plaster 2cm	 Unutra | Inside Spolja | Outside termoizolacija 10cm, parna brana, drvene daske 2cm, drvene grede/vazduh 20cm, drvene daske 2cm, malter 2cm thermal insulation 10cm, vapour barrier, wooden planks 2cm, wooden beamers/air 20cm, wooden planks 2cm, plaster 2cm	 Unutra | Inside Spolja | Outside termoizolacija 20cm, parna brana, drvene daske 2cm, drvene grede/vazduh 20cm, drvene daske 2cm, malter 2cm thermal insulation 20cm, vapour barrier, wooden planks 2cm, wooden beamers/air 20cm, wooden planks 2cm, plaster 2cm
U (W/m^2/K)	U = 0,55 W/m^2/K	U = 0,24 W/m^2/K	U = 0,15 W/m^2/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Električne peći (grijalice + TA peći) Electric heaters (heaters + electric thermal storage heaters)	 Toplotna pumpa vazduh-vazduh s vršnim električnim grijačem Heat pump air-air with peak load electric heater	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	0,98	3	0,9
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

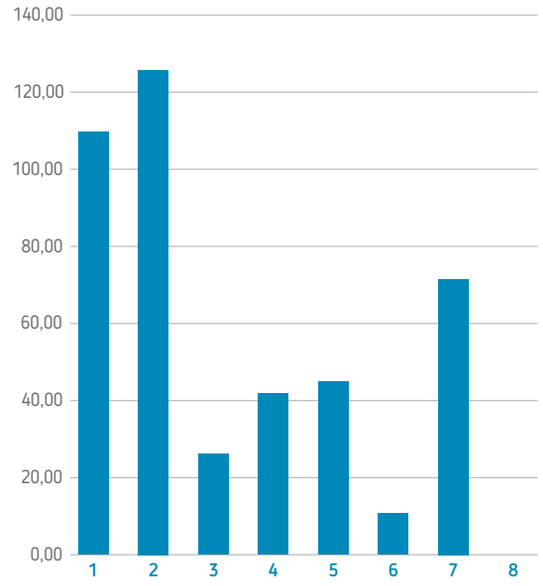
UNAPREĐENJE 2 | IMPROVEMENT 2

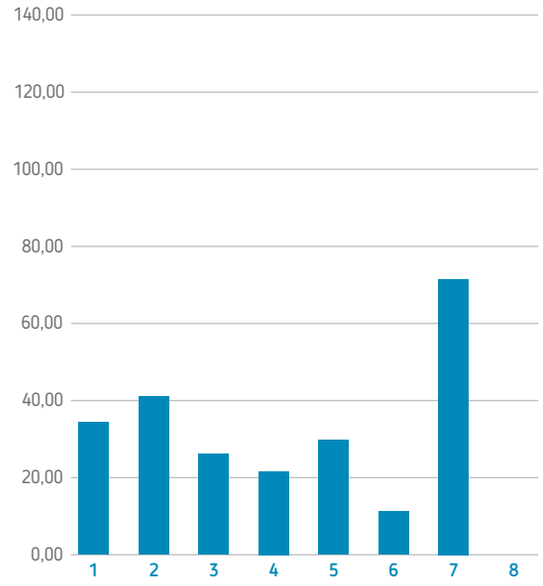
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

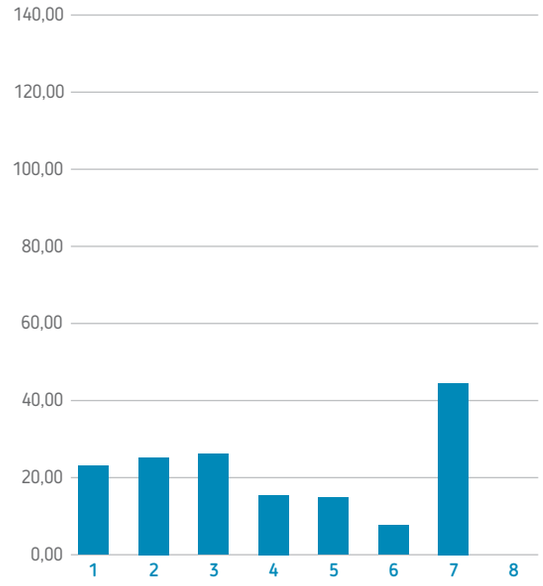
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Gubici prema negrijanom stepeništu
6 - Zid ka susjednom objektu
7 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - To the unheated staircase
6 - Wall to the adjacent building
7 - Floor on the ground

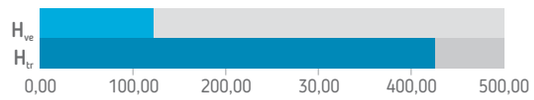


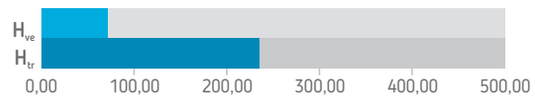




ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)

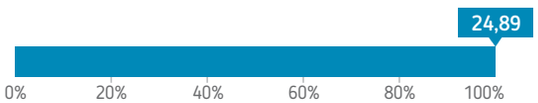


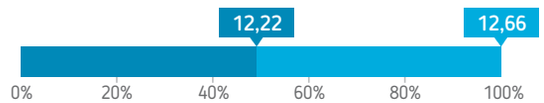


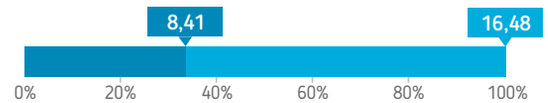
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

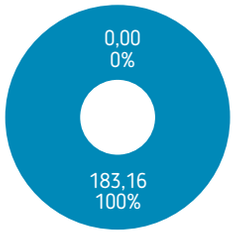
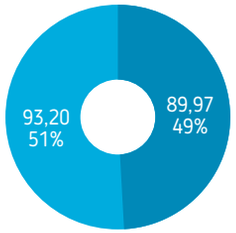
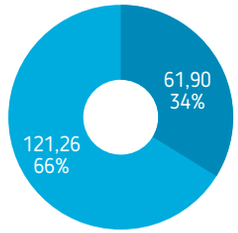
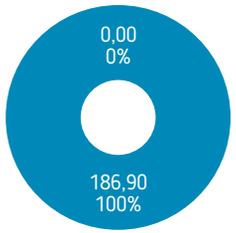
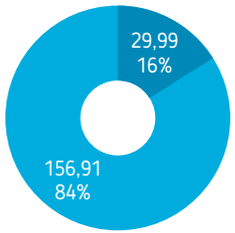
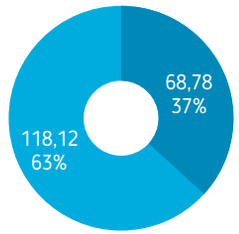
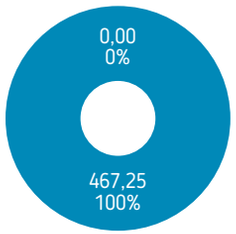
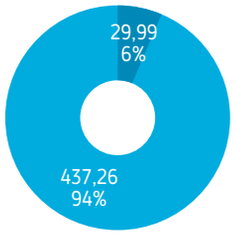
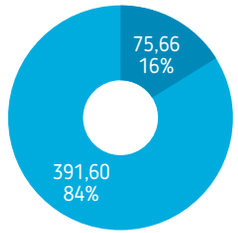
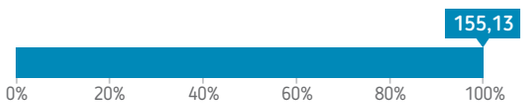
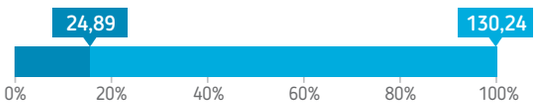
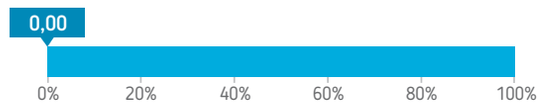
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	ELEKTRIČNA ENERGIJA ELECTRIC POWER	OBNOVLJIVI IZVOR ENERGIJE RENEWABLE ENERGY SOURCES	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

KUĆE U NIZU
TERRACED HOUSES

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

B2

Kategorija objekta Building category	**KUĆA U NIZU** **TERRACED HOUSE**
Godina izgradnje Built in	**1946-1960.**
Broj etaža Number of floors	**1**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**47,47**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**36,4**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**93,18**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**1,36**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**321,27**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**449,45**

Kuća u nizu, graniči sa susjednim objektom, pravougaone je osnove i ima dvovodni krov. Najčešća spratnost objekata iz ove kategorije je P i P+1. Tehnologije građenja i materijali su istovjetni kao kod slobodnostojećih kuća koje su građene u istom periodu. Konstruktivni zidovi su masivni, od pune opeke debljine 25cm, sa završnom obradom od maltera. Objekat nema podruma i izgrađen je bez horizontalnih i vertikalnih armiranobetonskih serklaža, dok su drvene grede ujedno natprozornici i nadvratnici. Strop je izrađen od drvenih greda, sa slojem trstike i oblogom od maltera, bez termoizolacije prema tavanu. Konstrukcija krova je drvena, s pokrovom od crijepa. Tavanski prostor se ne koristi za stanovanje i negrijan je. Prozori su drveni, dvostruki, s razmaknutim krilima i jednostrukim staklom i imaju izraženo velike gubitke.

Termovizijski snimak pokazuje visoke gubitke po cijeloj površini omotača registrovane kroz svjetlije boje koje definišu viša temperaturna očitanja. Drvene grede na mjestima natprozornika i nadvratnika predstavljaju mjesta velikih i neravnomjernih toplotnih gubitaka kroz kompletni omotač objekta. Vidljiva su velika temperaturna očitanja na vanjskim zidovima, kako u stambenom dijelu tako i tavanskom prostoru. Stropna konstrukcija nema termoizolacioni sloj uslijed čega se toplota prenosi u tavanski dio.

Terraced house, borders with the adjacent building, of rectangular footprint, with gable roof. Buildings in this category are usually ground floor or GF + 1. Construction technology and materials are identical to those of free-standing houses from the same period. Construction walls are massive, full 25cm brick, with plaster finish. The building does not feature a basement, it is built without horizontal or vertical RC ring beams, while wooden beams serve the purpose of both the window and door arches. The ceiling is made of wooden beams covered with cane and plaster finish, without any thermal insulation towards the attic. The roof is supported by wooden beams, and covered with roof tiles. Attic is not used for residential purposes, and is left unheated. The exterior features double single-glazed wood windows, with space between wings that show major heat loss.

Thermovision image shows great loss over the entire envelope which is presented by brighter colours indicative of high temperature readings. Wooden beams arching the windows and doors stand as areas of unevenly distributed heat loss occuring through the entire envelope of the building. High temperature readings are evident on external walls of both the residential and attic area. Ceiling constructions does not include thermal insulation so the heat is released into the attic space.

UNAPREĐENJE 1 | IMPROVEMENT 1

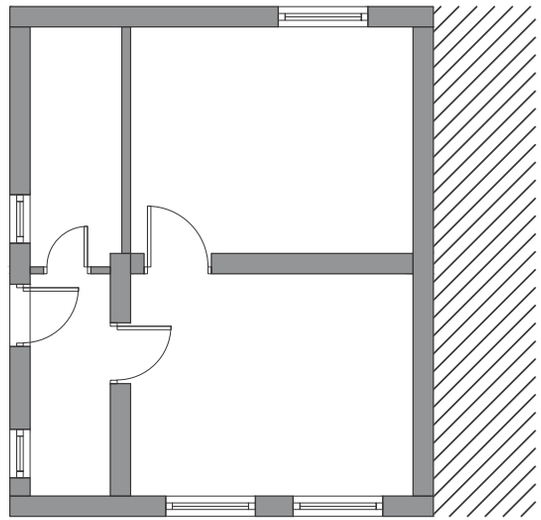
Izolovanje fasadnog zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izolovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

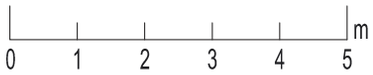
Insulation of the external facade wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

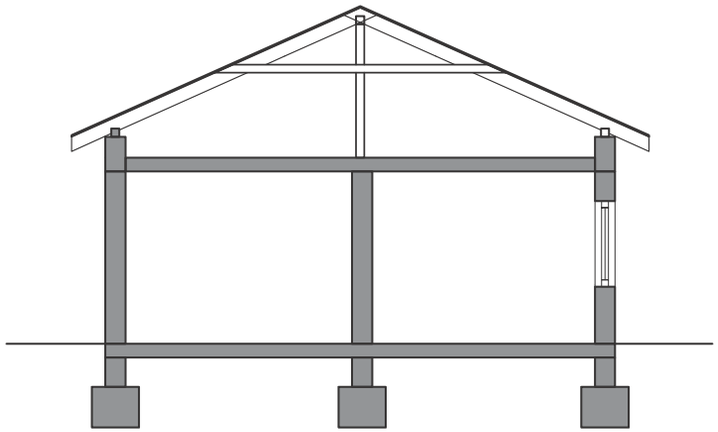
UNAPREĐENJE 2 | IMPROVEMENT 2

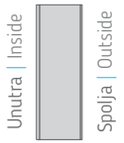
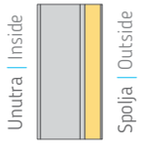
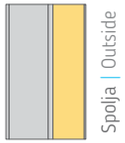
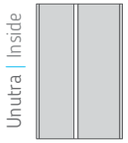
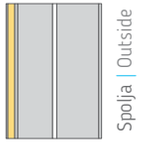
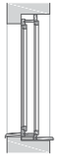
Izolovanje fasadnog zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). Ugradnja novih ulaznih vrata kako bi se dostigao U-koeficijent od 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of the external facade wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). Installing of new entrance door to reach U-coefficient of 2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 25cm, malter 1cm plaster 2cm, brick wall 25cm, plaster 1cm	 malter 2cm, puna opeka 25cm, malter 3cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 3cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 25cm, malter 3cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 3cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,87 W/m^2/K	U = 0,33 W/m^2/K	U = 0,18 W/m^2/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 2cm, puna opeka 25cm, vazduh (dilatacija) 3cm, puna opeka 30cm, malter 2cm plaster 2cm, brick wall 25cm, air (dilatation) 3cm, brick wall 30cm, plaster 1cm	 NEMA IZMJENA NO CHANGES	 gips-kartonske ploče 1,25cm, termoizolacija 5cm, malter 2cm, puna opeka 25cm, vazduh (dilatacija) 3cm, puna opeka 30cm, malter 2cm gypsum plasterboard 1.25cm, thermal insulation 5cm, plaster 2cm, brick wall 25cm, air (dilatation) 3cm, brick wall 30cm, plaster 2cm
U (W/m^2/K)	U = 1,53 W/m^2/K	U = 1,53 W/m^2/K	U = 0,52 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s razmaknutim krilima i jednostrukim staklom wooden, double frame, with double sash and single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,50 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside drvene daske 2cm, drvene grede/vazduh 7*14cm, drvene daske 2cm, ploče od drvenih vlakana 1cm, malter 2cm wooden planks 2cm, wooden beams/air 7*14cm, wooden planks 2cm, wood fibre boards 1cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, parna brana, drvene daske 2cm, drvene grede/vazduh 7*14cm, drvene daske 2cm, ploče od drvenih vlakana 1cm, malter 2cm thermal insulation 10cm, vapour barrier, wooden planks 2cm, wooden beams/air 7*14cm, wooden planks 2cm, wood fibre boards 1cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, parna brana, drvene daske 2cm, drvene grede/vazduh 7*14cm, drvene daske 2cm, ploče od drvenih vlakana 1cm, malter 2cm thermal insulation 20cm, vapour barrier, wooden planks 2cm, wooden beams/air 7*14cm, wooden planks 2cm, wood fibre boards 1cm, plaster 2cm
U (W/m^2/K)	U = 1,30 W/m^2/K	U = 0,30 W/m^2/K	U = 0,17 W/m^2/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

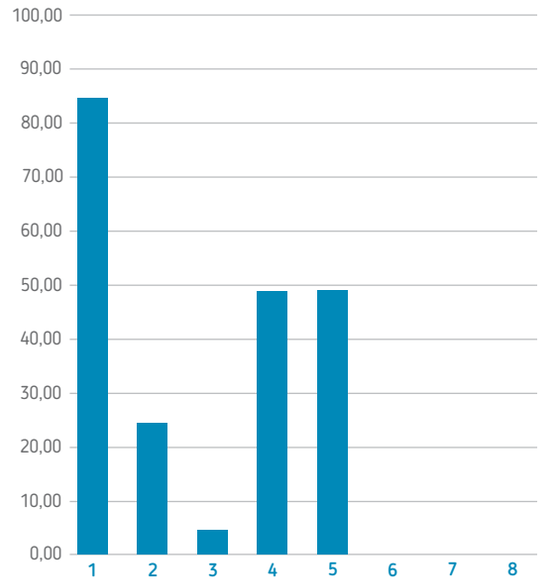
UNAPREĐENJE 2 | IMPROVEMENT 2

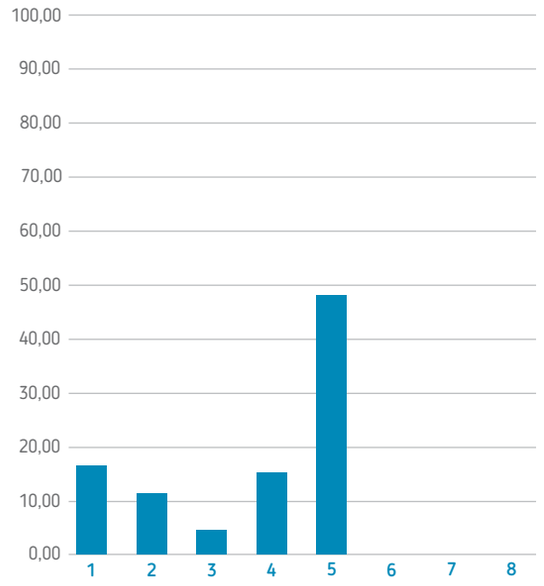
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

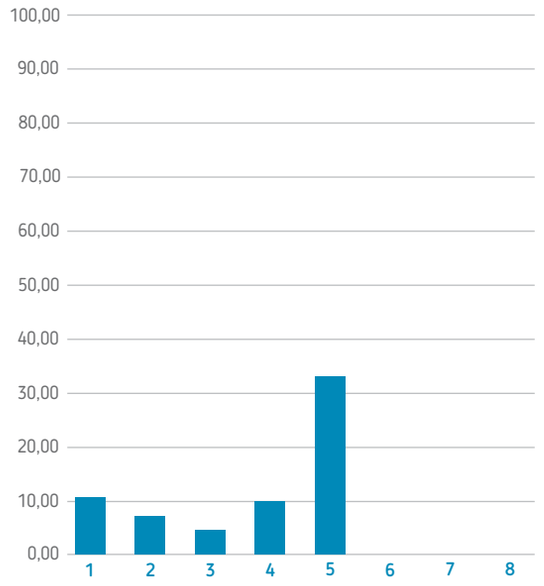
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - Floor on the ground

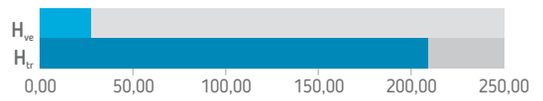


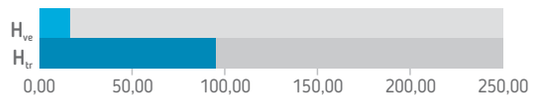


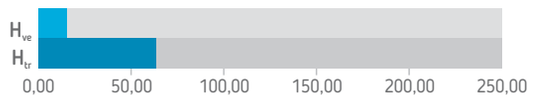


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



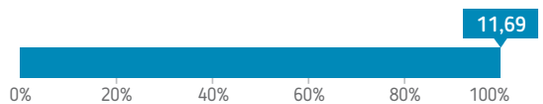


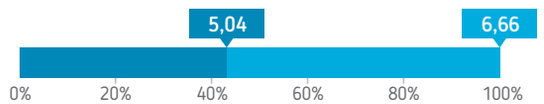


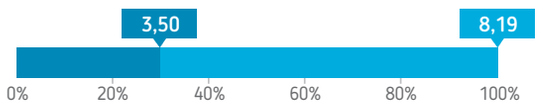
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

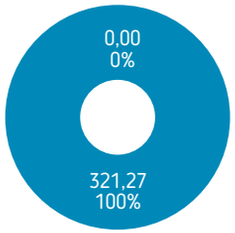
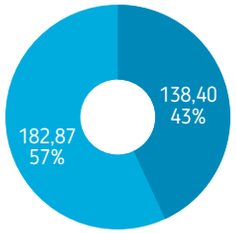
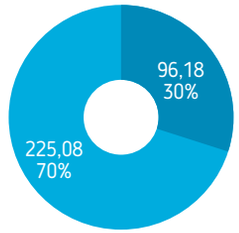
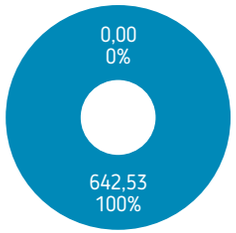
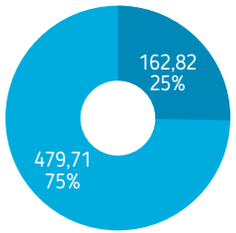
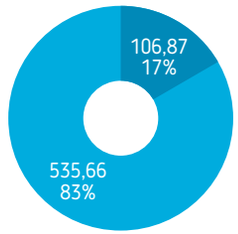
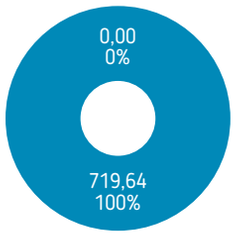
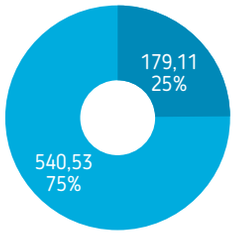
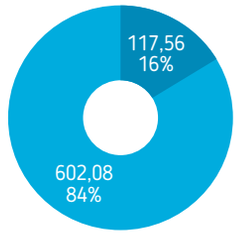
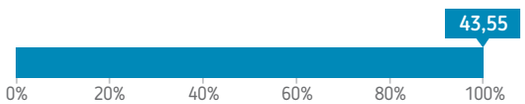
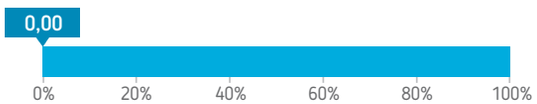
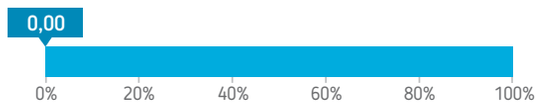
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

C2

Kategorija objekta Building category	**KUĆA U NIZU** **TERRACED HOUSE**
Godina izgradnje Built in	**1968.**
Broj etaža Number of floors	**2**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**84,00**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**118,78**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**285,83**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,69**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**196,42**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**253,97**

Stambena kuća u nizu je kompaktne pravougaone osnove s dvovodnim kosim krovom. Najčešća spratnost je P+1 (2 etaže). Karakteriše je klasična gradnja, masivni konstruktivni sistem. Konstruktivni i ujedno svi spoljašnji zidovi su od pune opeke, debljine 25cm, u oba pravca, obostrano omalterisani, samo s horizontalnim armiranobetonskim serklažima. Ove kuće u nizu imaju potpunu dilataciju bočnih spoljašnjih zidova, koji su za 1/3 duži od poprečnih/ulaznih spoljašnjih zidova. Međuspratne konstrukcije su armiranobetonske ploče s ispunom od opekarskih blokova, a javljaju se i pune ploče. U ovom periodu u omotaču nema termoizolacije. Prozori i balkonska vrata su dvostruka, razmaknuta drvena krila koja imaju dva obična jednostruka stakla. Kuće imaju negrijane prostore tavana i garaže, koja je u nivou terena.

Termovizijski snimak ukazuje da kuća u nizu, zbog nepostojanja termoizolacije, ima ravnomjerne toplotne gubitke na cijelom omotaču ali da su veći toplotni gubici na poziciji armiranobetonskih horizontalnih serklaža i natprozornika. Vidno je da su veliki površinski toplotni gubici u poziciji svih prozora, te kod međuspratne konstrukcije ispod tavanskog negrijanog prostora. Najveći toplotni gubici su na garažnim i ulaznim vratima.

The terraced house is of compact rectangular footprint with a gable roof. Buildings in this category are usually ground floor + 1 (two floors). Typical, massive construction. Construction walls are 25cm thick, made of solid brick, with plaster finish on both sides, with horizontal RC ring beams. These terraced houses have fully dilated side facade walls which are 1/3 longer than the cross/entrance external walls. Construction between the floors includes full reinforced concrete slabs, solid, or filled with bricks. Buildings from this period do not have thermal insulation on any section of the envelope. Windows and balcony doors are double, separated wooden frames, with regular single glazing. These houses include unheated attics and garages on the ground level.

Thermovision image of the house shows evenly distributed heat loss over the entire envelope due to the lack of thermal insulation, but higher values are registered along horizontal ring beams, window and door arches made of reinforced concrete. All window surfaces as well as constructions between floors below the unheated attic space show significant heat loss. The greatest loss is recorded at the garage door and entrance door.

UNAPREĐENJE 1 | IMPROVEMENT 1

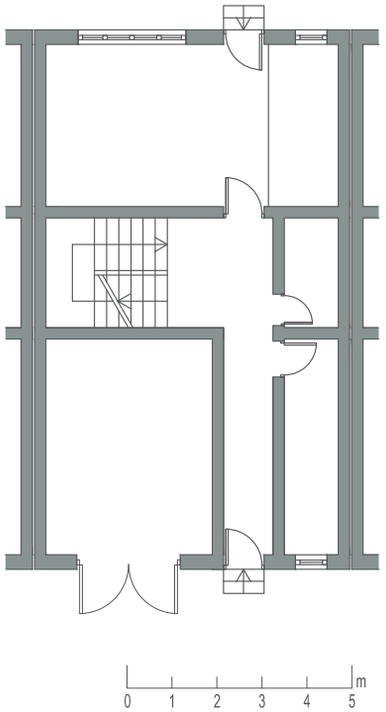
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

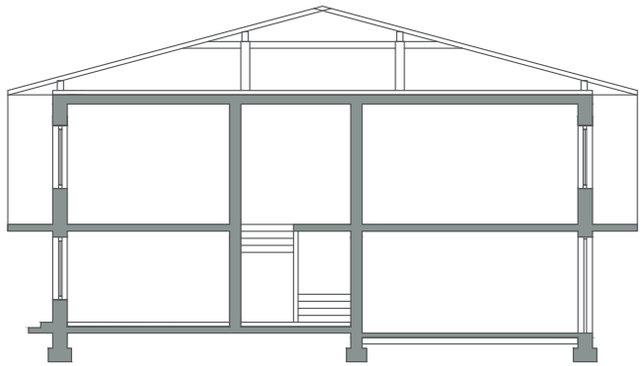
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

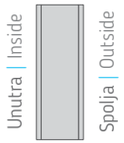
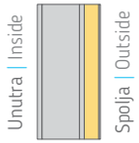
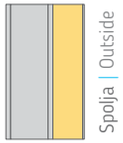
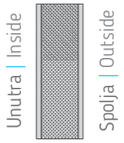
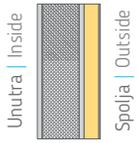
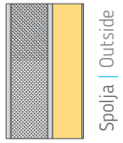
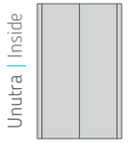
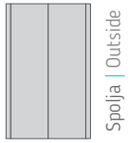
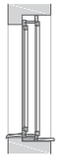
UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana), termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (garaža) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora sa dostizanjem U-koeficijenta od 1,0 W/m^{2}K (g=0,48). Ugradnja novih ulaznih vrata kako bi se dostigao U-koeficijent od 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of internal walls to unheated areas (garage) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). Installing of new entrance door to reach U-coefficient of 2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.

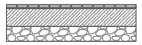
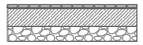
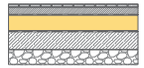
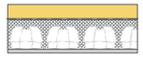
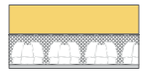




	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 3cm, puna opeka 25cm, malter 3cm plaster 3cm, brick wall 25cm, plaster 3cm	 malter 3cm, puna opeka 25cm, malter 3cm, termoizolacija 10cm, fasadni malter 1cm plaster 3cm, brick wall 25cm, plaster 3cm, thermal insulation 10cm, facade plaster 1cm	 malter 3cm, puna opeka 25cm, malter 3cm, termoizolacija 20cm, fasadni malter 1cm plaster 3cm, brick wall 25cm, plaster 3cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,58 W/m^2/K	U = 0,32 W/m^2/K	U = 0,18 W/m^2/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 3cm, AB zid 25cm, malter 3cm plaster 3cm, reinforced concrete wall 25cm, plaster 3cm	 malter 3cm, AB zid 25cm, malter 3cm, termoizolacija 10cm, fasadni malter 1cm plaster 3cm, reinforced concrete wall 25cm, plaster 3cm, thermal insulation 10cm, facade plaster 1cm	 malter 3cm, AB zid 25cm, malter 3cm, termoizolacija 20cm, fasadni malter 1cm plaster 3cm, reinforced concrete wall 25cm, plaster 3cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 2,86 W/m^2/K	U = 0,35 W/m^2/K	U = 0,19 W/m^2/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 3cm, puna opeka 25cm, puna opeka 25cm, malter 3cm plaster 3cm, brick wall 25cm, brick wall 25cm, plaster 3cm	 NEMA IZMJENA NO CHANGES	 NEMA IZMJENA NO CHANGES
U (W/m^2/K)	U = 0,89 W/m^2/K	U = 0,89 W/m^2/K	U = 0,89 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s razmaknutim krilima i jednostrukim staklom wooden, double frame, double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 2,90 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

ELEMENTI UNAPREĐENJA OMOTAČA | BUILDING ENVELOPE IMPROVEMENTS ELEMENTS

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
POD NA TLU GROUND FLOOR	Unutra | Inside  Spolja | Outside parket 2cm, hidroizolacija, betonska ploča 12cm, šljunak 10cm parquet 2cm, waterproofing, concrete 12cm, gravel 10 cm	Unutra | Inside  Spolja | Outside NEMA IZMJENA NO CHANGES	Unutra | Inside  Spolja | Outside parket 2cm, cementni estrih 5cm, PE folija, termoizolacija 10cm, hidroizolacija 1cm, betonska ploča 12cm, šljunak 10cm parquet 2cm, cement screed 5cm, PE foil, thermal insulation 10cm, waterproofing 1cm, concrete 12cm, gravel 10cm
U (W/m²/K)	U = 2,89 W/m²/K	U = 2,89 W/m²/K	U = 0,35 W/m²/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside TM3 konstrukcija 20cm, malter 2cm TM3 slab with hollow clay block 20cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, parna brana, TM3 konstrukcija 20cm, malter 2cm thermal insulation 10cm, vapor barrier, TM3 slab with hollow clay block 20cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, parna brana, TM3 konstrukcija 20cm, malter 2cm thermal insulation 20cm, vapor barrier, TM3 slab with hollow clay block 20cm, plaster 2cm
U (W/m²/K)	U = 1,82 W/m²/K	U = 0,33 W/m²/K	U = 0,18 W/m²/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	0,50	0,85	0,90
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

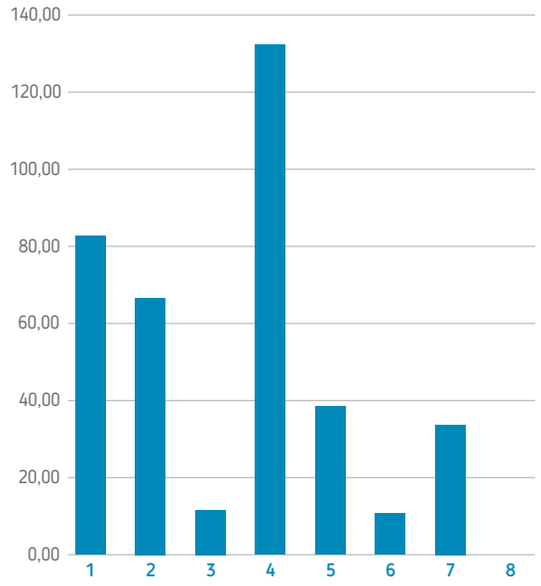
UNAPREĐENJE 2 | IMPROVEMENT 2

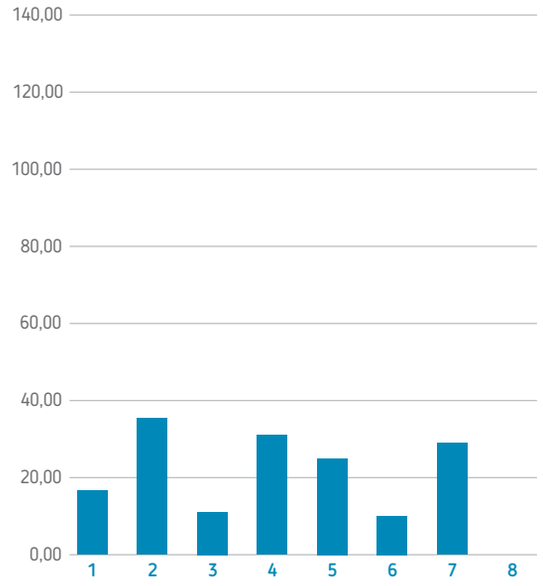
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

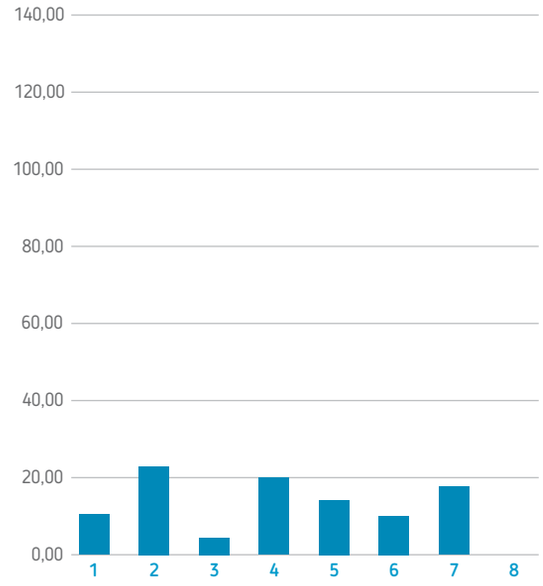
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Gubici prema negrijanom prostoru
6 - Zid ka susjednom objektu
7 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - To the unheated area
6 - Wall to the adjacent building
7 - Floor on the ground

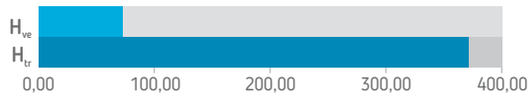


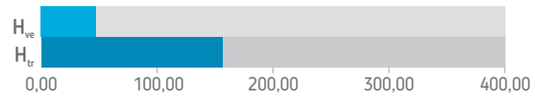




ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)

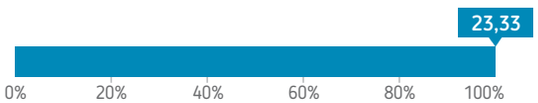


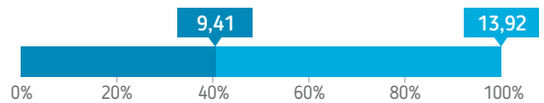


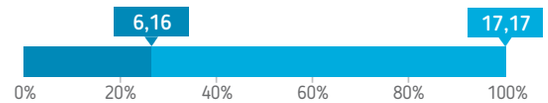
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

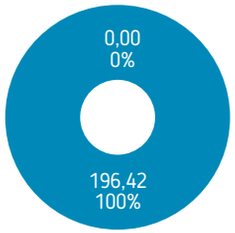
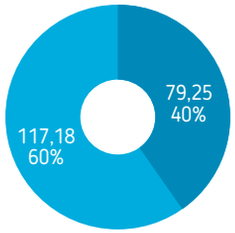
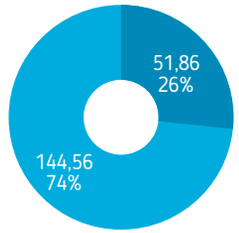
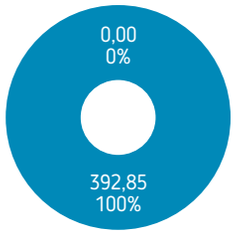
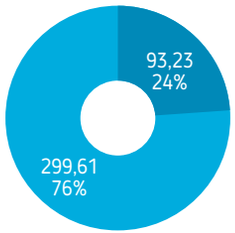
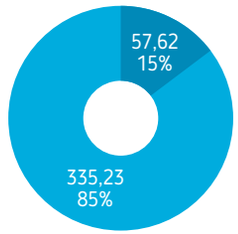
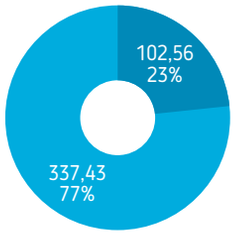
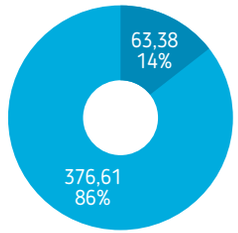
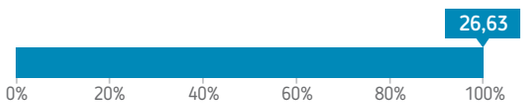
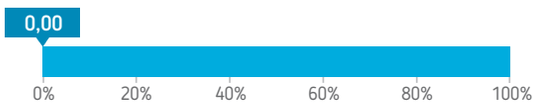
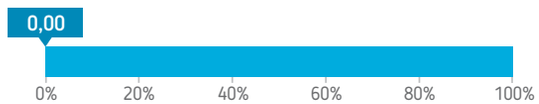
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

KUĆE U NIZU
TERRACED HOUSES

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

D2

Kategorija objekta Building category	**KUĆA U NIZU** **TERRACED HOUSE**
Godina izgradnje Built in	**1974.**
Broj etaža Number of floors	**2**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**82,72**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**131,17**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**328,40**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,91**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ (kWh/m^2/god) Specific energy need for intermitted heating $Q_{H,nd,interm}$ (kWh/m^2/year)	**199,04**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ (kWh/m^2/god) Specific energy need for continuous heating $Q_{H,nd,cont}$ (kWh/m^2/year)	**251,32**

Stambena kuća u nizu je kompaktne pravougaone osnove s dvovodnim kosim krovom. Najčešća spratnost je P+1 (2 etaže). Karakteriše je klasična gradnja, masivni konstruktivni sistem. Konstruktivni i fasadni zidovi su od opekarskog bloka, debljine 19 i 29cm, u oba pravca, obostrano omalterisani, s horizontalnim i vertikalnim armirano-betonskim serklažima. Ove kuće u nizu imaju potpunu dilataciju bočnih fasadnih zidova. Međuspratne konstrukcije su pune armirano-betonske ploče. U ovom periodu u omotaču spoljašnjeg zida i u podu na tlu nema termoizolacije, ali pojavljuje se 5cm termoizolacije na međuspratnoj konstrukciji ispod tavana. Prozori i balkonska vrata su dvostruka spojena drvena krila koja imaju dva obična jednostruka stakla. Kuće imaju negrijane prostore tavana i garaže, koja je u nivou terena.

Termovizijski snimak ukazuje da kuća u nizu ima ravnomjerne toplotne gubitke na cijelom omotaču zbog nepostojanja termoizolacije, ali da su veći toplotni gubici na poziciji armirano-betonskih horizontalnih serklaža, nadvratnika i natprozornika. Vidno je da su veliki površinski toplotni gubici u poziciji svih prozora, gdje se griju prostorije. Najveći toplotni gubici su na ulaznim vratima i na fasadnom zidu, armirano-betonu, ispod ploče lođe.

The terraced house is of compact rectangular footprint with a gable roof. Buildings in this category are usually ground floor + 1 (two floors). Typical massive construction. Construction and facade walls are made of clay block, 19 and 29cm thick, in both directions, with plaster on both sides, with horizontal and vertical RC ring beams. These townhouses have fully dilated side facade walls. Construction between the floors includes reinforced concrete slabs. This period of construction does not feature any thermal insulation on the ground floor or in the envelope, but there is a 5cm layer of thermal insulation between the top floor and the attic. Windows and balcony doors are double conjoined wooden frames, with regular single glazing. These houses include unheated attics and garages on the ground level.

The thermovision image of the town house shows evenly distributed heat loss over the entire envelope due to the lack of thermal insulation, but higher values are registered along horizontal ring beams, window and door arches made of reinforced concrete. All window surfaces of heated rooms show significant heat loss. The greatest loss is recorded at the entrance door and on the facade wall, reinforced concrete, and below the deep-set balcony.

UNAPREĐENJE 1 | IMPROVEMENT 1

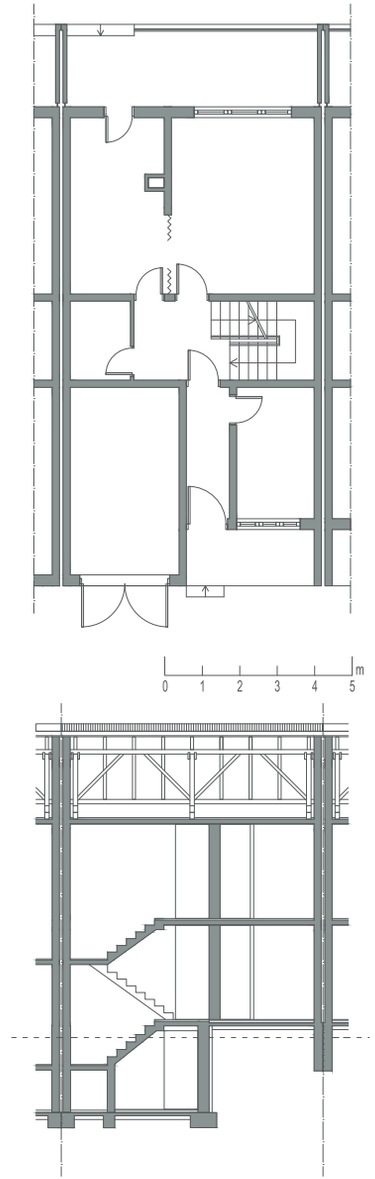
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

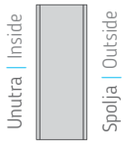
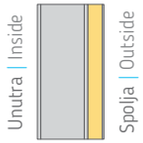
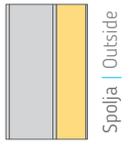
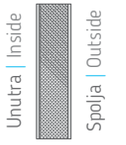
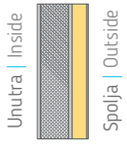
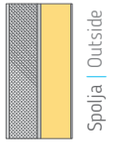
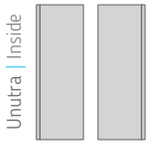
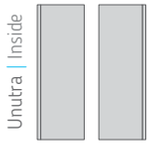
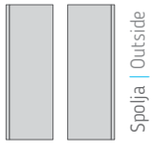
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolytic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu, termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (garaža) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). Ugradnja novih ulaznih vrata kako bi se dostigao U-koeficijent od 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

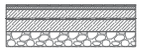
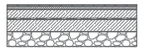
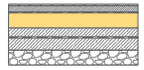
Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of internal walls to unheated areas (garage) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). Installing of new entrance door to reach U-coefficient of 2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolytic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 29cm, malter 3cm plaster 2cm, clay block wall 29cm, plaster 3cm	 malter 2cm, šuplji opekarski blok 29cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, clay block wall 29cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 29cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, clay block wall 29cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,29 W/m²/K	U = 0,31 W/m²/K	U = 0,18 W/m²/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, AB zid 19cm, malter 2cm plaster 2cm, reinforced concrete wall 19cm, plaster 2cm	 malter 2cm, AB zid 19cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 19cm, plaster 2cm, thermal insulation 10cm, facade plaster 1 cm	 malter 2cm, AB zid 19cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 19cm, plaster 2cm, thermal insulation 20cm, facade plaster 1 cm
U (W/m²/K)	U = 3,34 W/m²/K	U = 0,36 W/m²/K	U = 0,19 W/m²/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 2cm, šuplji opekarski blok 29cm, vazduh (dilatacija) 10cm, šuplji opekarski blok 29cm, malter 2cm plaster 2cm, clay block wall 29cm, air (dilatation) 10cm, clay block wall 29cm, plaster 2 cm	 NEMA IZMJENA NO CHANGES	 NEMA IZMJENA NO CHANGES
U (W/m²/K)	U = 1,29 W/m²/K	U = 1,29 W/m²/K	U = 1,29 W/m²/K
PROZORI WINDOWS	 drveni, dvostruki sa spojenim krilima i jednostrukim staklom wooden, single frame, connected double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m²/K)	U = 2,91 W/m²/K	U = 1,60 W/m²/K	U = 1,00 W/m²/K

ELEMENTI UNAPREĐENJA OMOTAČA | BUILDING ENVELOPE IMPROVEMENTS ELEMENTS

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
POD NA TLU GROUND FLOOR	Unutra | Inside  Spolja | Outside parket 1cm, cementna košuljica 2cm, beton 6cm, hidroizolacija, betonska ploča 8cm, šljunak 10cm parquet 1cm, cement screed 2cm, concrete 6cm, waterproofing, concrete 8cm, gravel 10cm	Unutra | Inside  Spolja | Outside NEMA IZMJENA NO CHANGES	Unutra | Inside  Spolja | Outside parket 1cm, cementna košuljica 4cm, PE folija, termoizolacija 10cm, beton 6cm, hidroizolacija, betonska ploča 8cm, šljunak 10cm parquet 1cm, cement screed 4cm, PE foil, thermal insulation 10cm, concrete 6cm, waterproofing, concrete 8cm, gravel 10cm
U (W/m^2/K)	U = 2,59 W/m^2/K	U = 2,59 W/m^2/K	U = 0,35 W/m^2/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside cementna košuljica 2cm, krovna ljepenka, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm cement screed 2cm, roofing felt, thermal insulation 3cm, reinforced concrete slab 12cm, plaster 1cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, parna brana, cementna košuljica 2cm, krovna ljepenka, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm thermal insulation 10cm, vapor barrier, cement screed 2cm, roofing felt, thermal insulation 3cm, reinforced concrete slab 12cm, plaster 1cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, parna brana, cementna košuljica 2cm, krovna ljepenka, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm thermal insulation 20cm, vapor barrier, cement screed 2cm, roofing felt, thermal insulation 3cm, reinforced concrete slab 12cm, plaster 1cm
U (W/m^2/K)	U = 0,97 W/m^2/K	U = 0,29 W/m^2/K	U = 0,17 W/m^2/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

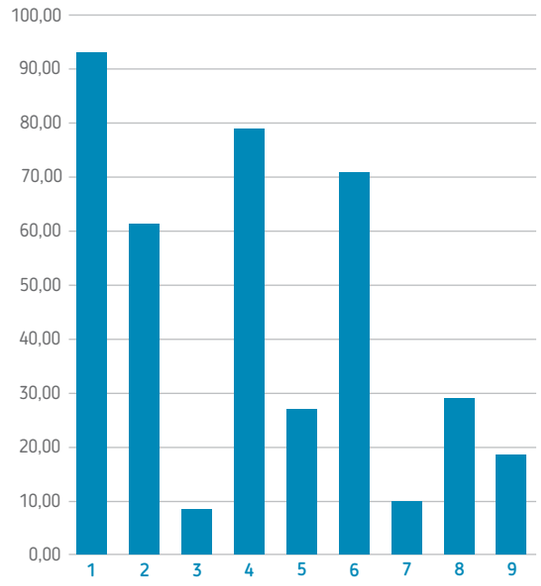
UNAPREĐENJE 2 | IMPROVEMENT 2

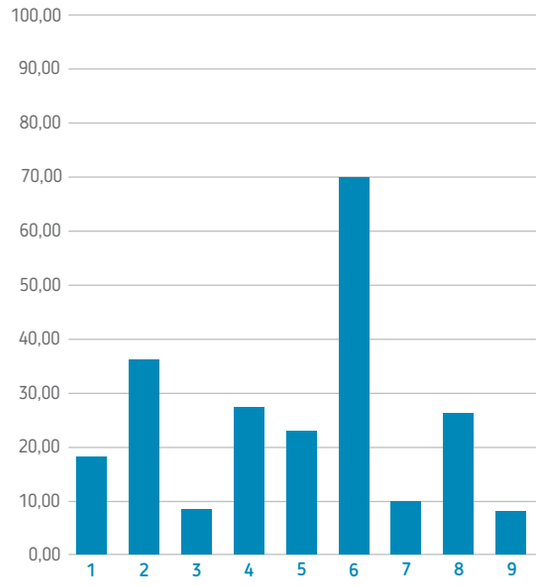
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

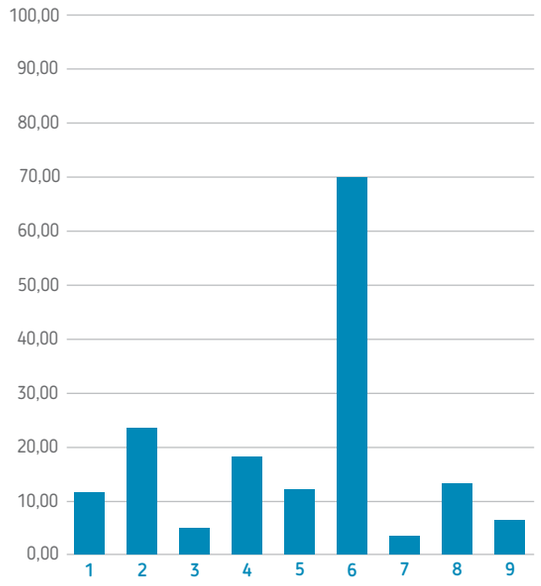
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Gubici prema negrijanom prostoru
6 - Zid ka susjednom objektu
7 - Gubici kroz grijani podrum
8 - Pod na tlu
9 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - To the unheated area
6 - Wall to the adjacent building
7 - Through the heated basement
8 - Floor on the ground
9 - Through the unheated basement

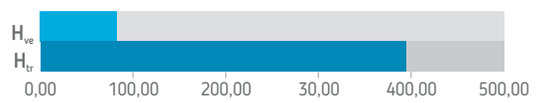


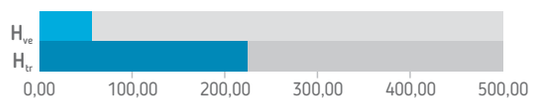


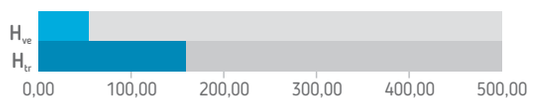


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



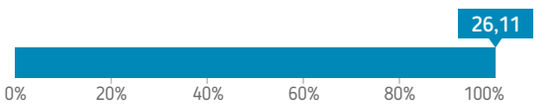


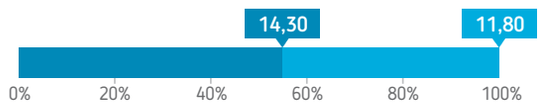


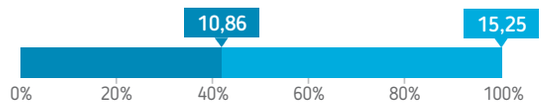
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

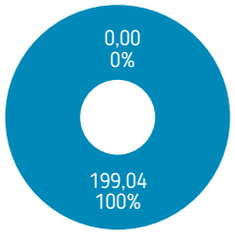
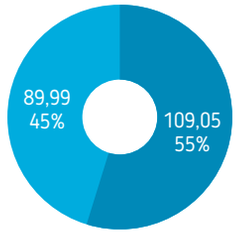
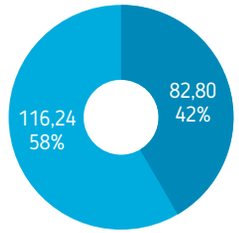
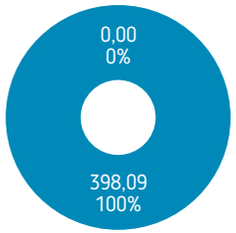
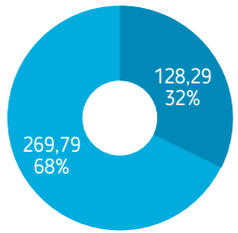
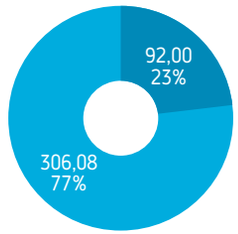
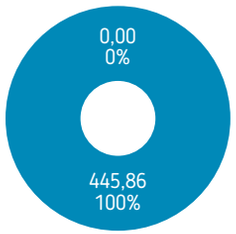
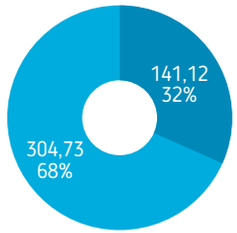
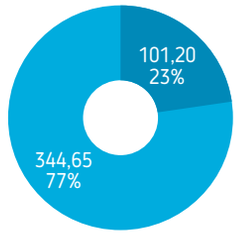
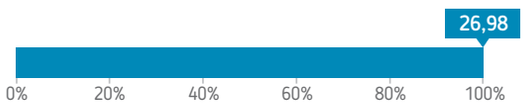
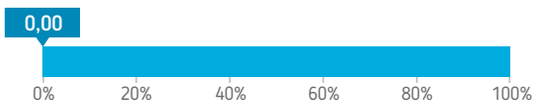
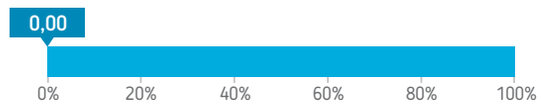
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

E2

Kategorija objekta Building category	**KUĆA U NIZU** **TERRACED HOUSE**
Godina izgradnje Built in	**1981-1991.**
Broj etaža Number of floors	**3**
Broj stanova Number of apartments	**1**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**53,96**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**81,05**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**205,04**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,95**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**219,2**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**294,01**

Kuća u nizu graniči sa susjednim objektom, pravougaone je osnove i ima dvovodni krov. Najčešća spratnost objekata iz ove kategorije je P, P+1 i P+2. Tehnologije građenja i materijali su istovjetni kao kod slobodnostojećih kuća koje su građene u istom periodu. Konstruktivni zidovi su masivni, od šuplje blok opeke debljine 25cm, sa završnom obradom od maltera. Suterenski prostor je nestambenog karaktera. Objekat je izgrađen s horizontalnim i vertikalnim armiranobetonskim serklažima, dok je stropna konstrukcija izvedena od armiranog betona. Dvovodni krov je izveden bez termoizolacije, s drvenom konstrukcijom i pokrovom od crijepa. Tavanski prostor i suterenski prostor ostave su negrijani i ne koriste se za stanovanje. Prozori su drveni, s dvostrukim staklom i izraženim toplotnim gubicima.

Termovizijski snimak porodične kuće u nizu, s masivnim vanjskim zidovima, pokazuje velike gubitke po cijeloj površini omotača, posebno na mjestima horizontalnih armiranobetonskih serklaža i natprozornika, kao i na promjeni geometrije objekta. Vanjska stolarija, prozori i vrata, je neodgovarajuća i pokazuje visoka temperaturna očitanja na okvirima i ostakljenim površinama.

The house borders with adjacent building are of rectangular footprint and gable roof. Buildings in this category are usually ground floor or GF + 1 and +2. The construction technology and materials are identical to those of free-standing houses from the same period. Construction walls are massive, 25cm hollow brick blocks, with plaster finish. Basement area is not of residential character. The building is constructed with horizontal and vertical RC ring beams, while the roof is constructed of reinforced concrete. Gable roof is without thermal insulation, supported by wooden beams and covered with roof tiles. Unheated attic space and basement area are used for storage, not for residential purposes. Windows are double-glazed wooden frames with high heat losses.

The thermovision image of the townhouse, with massive external walls, shows major losses all over the envelope, particularly along horizontal RC ring beams and window arches, as well as on changes of the building geometry. External framings, doors and windows, are inadequate, showing high temperature readings along the framework as well as on glass surfaces.

UNAPREĐENJE 1 | IMPROVEMENT 1

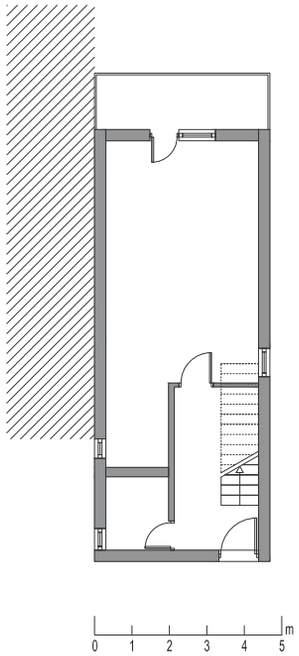
Izolovanje fasadnog zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma), termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

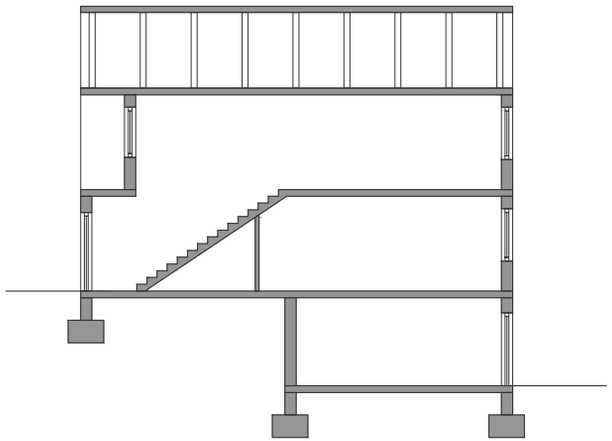
Insulation of the external facade wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolytic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

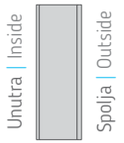
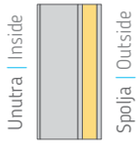
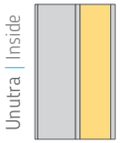
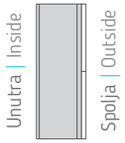
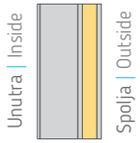
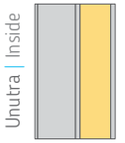
UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje fasadnog zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine10 cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). Ugradnja novih ulaznih vrata kako bi se dostigao U-koeficijent od 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Ugradnja ventila s termostatskim glavama na grijaća tijela.

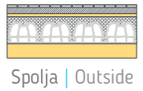
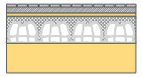
Insulation of the external facade wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). Installing of new entrance door to reach U-coefficient of 2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolytic boiler with heat accumulator. Installing of additional system for domestic hot water. Installation of thermostatic radiator valves.





	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,30 W/m²/K	U = 0,31 W/m²/K	U = 0,18 W/m²/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, kamene ploče 3cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, stone slabs 3cm	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,28 W/m²/K	U = 0,31 W/m²/K	U = 0,18 W/m²/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 2cm, šuplji opekarski blok 25cm, vazduh (dilatacija) 3cm, šuplji opekarski blok 25cm, malter 2cm plaster 2cm, hollow clay block 25cm, air (dilatation) 3cm, hollow clay block 25cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 gips-kartonske ploče 1,25cm, termoizolacija 5cm, malter 2cm, šuplji opekarski blok 25cm, vazduh (dilatacija) 3cm, šuplji opekarski blok 25cm, malter 2cm gypsum plasterboard 1.25cm, thermal insulation 5cm, plaster 2cm, hollow clay block 25cm, air (dilatation) 3cm, hollow clay block 25cm, plaster 2cm
U (W/m²/K)	U = 1,68 W/m²/K	U = 1,68 W/m²/K	U = 0,54 W/m²/K
PROZORI WINDOWS	 drveni, jednostruki s dvostrukim staklom wooden, single frame with double glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m²/K)	U = 3,00 W/m²/K	U = 1,60 W/m²/K	U = 1,00 W/m²/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 parket 2cm, cementni estrih 4cm, PVC folija, termoizolacija 2cm, beton 4cm, fert ispuna 14cm parquet 2cm, cement screed 4cm, PVC foil, thermal insulation 2cm, concrete 4cm, hollow clay block 14cm	 parket 2cm, cementni estrih 4cm, PVC folija, termoizolacija 2cm, beton 4cm, fert ispuna 14cm, termoizolacija 10cm, malter 1cm parquet 2cm, cement screed 4cm, PVC foil, thermal insulation 2cm, concrete 4cm, hollow clay block 14cm, thermal insulation 10cm, plaster 1cm	 parket 2cm, cementni estrih 4cm, PVC folija, termoizolacija 2cm, beton 4cm, fert ispuna 14cm, termoizolacija 20cm, malter 1cm parquet 2cm, cement screed 4cm, PVC foil, thermal insulation 2cm, concrete 4cm, hollow clay block 14cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 0,86 W/m^2/K	U = 0,28 W/m^2/K	U = 0,17 W/m^2/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	 AB konstrukcija 15cm, malter 2cm reinforced concrete floor 15cm, plaster 2cm	 termoizolacija 10cm, parna brana, AB konstrukcija 15cm, malter 2cm thermal insulation 10cm, vapor barrier, reinforced concrete floor 15cm, plaster 2cm	 termoizolacija 20cm, parna brana, AB konstrukcija 15cm, malter 2cm thermal insulation 20cm, vapor barrier, reinforced concrete floor 15cm, plaster 2cm
U (W/m^2/K)	U = 2,36 W/m^2/K	U = 0,35 W/m^2/K	U = 0,19 W/m^2/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote i termostatskim ventilima Central heating system - wood or wood pellet, with heat acummulation and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

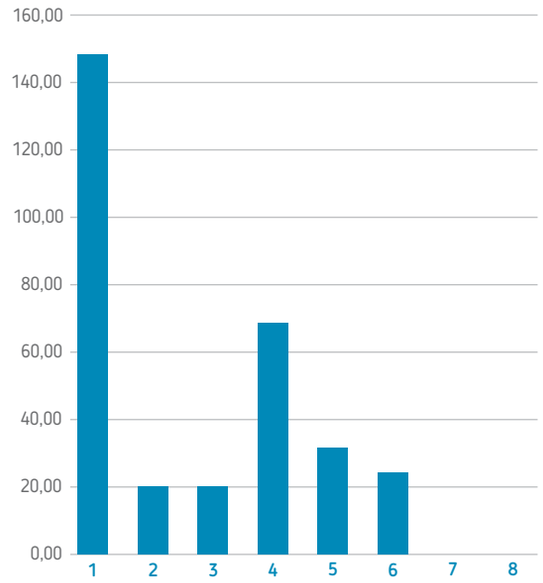
UNAPREĐENJE 2 | IMPROVEMENT 2

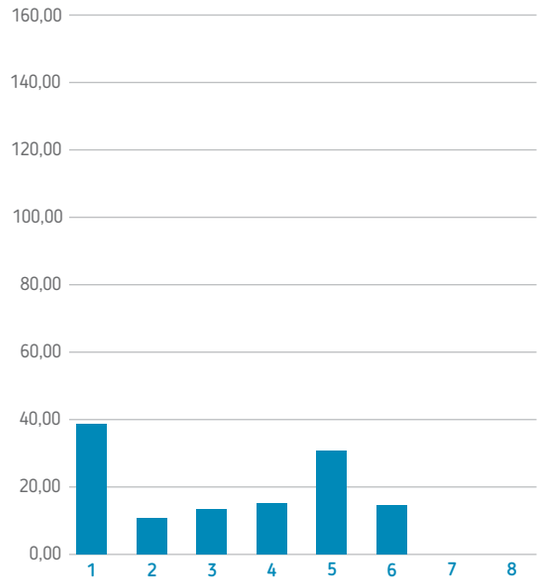
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

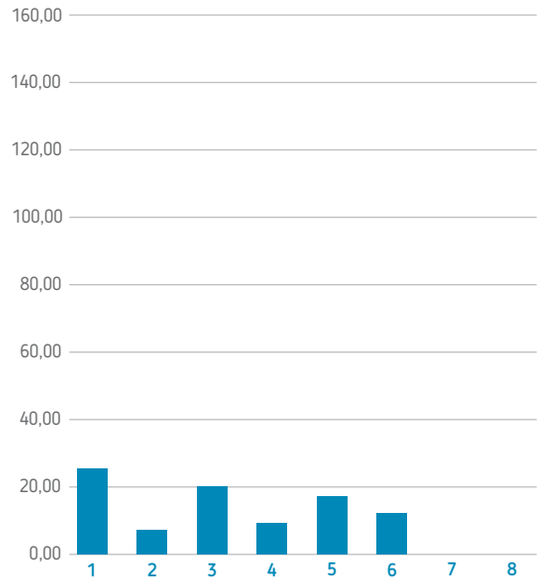
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Pod na tlu
6 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - To the unheated attic
5 - Floor on the ground
6 - Through the unheated basement

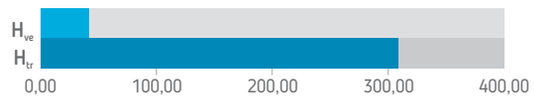


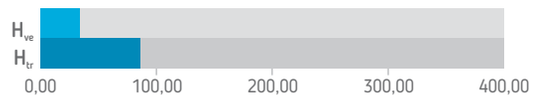




ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)

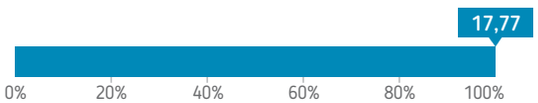


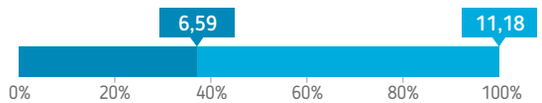


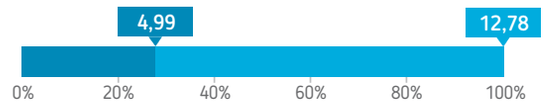
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

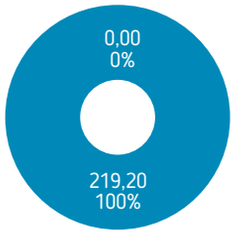
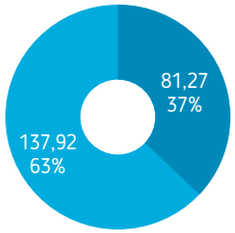
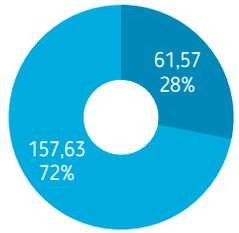
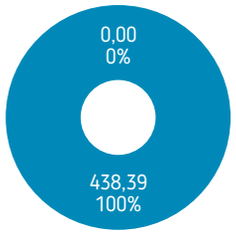
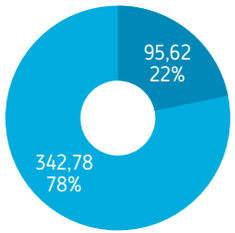
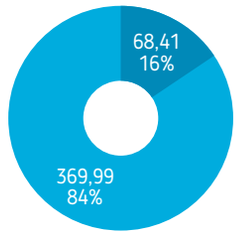
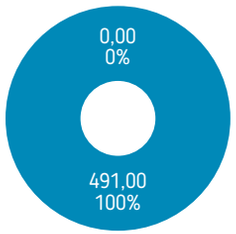
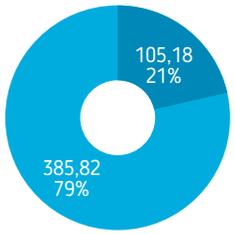
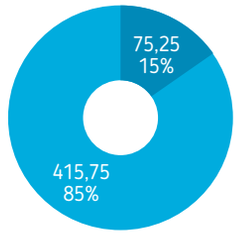
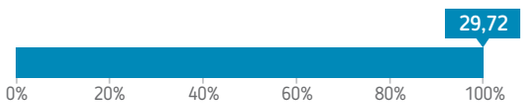
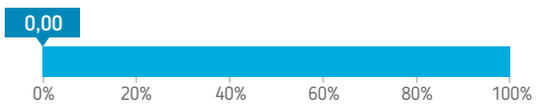
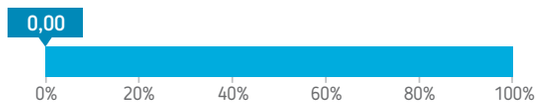
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings





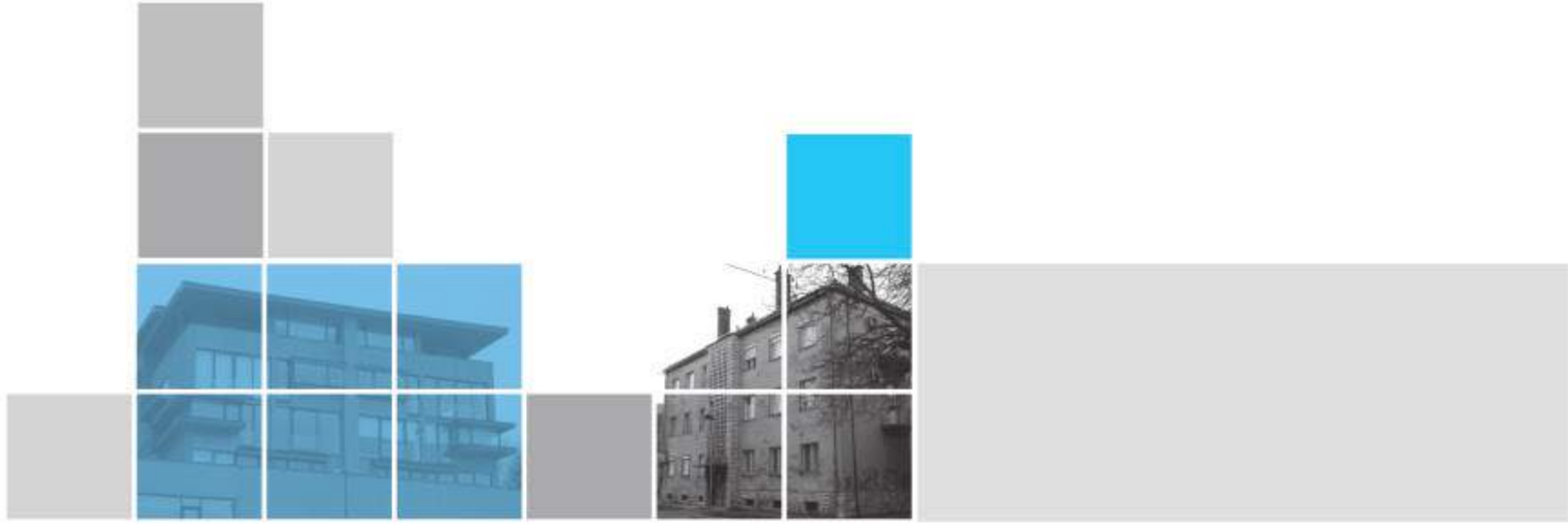


	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

individualno stanovanje
single-family housing

kolektivno stanovanje
collective housing

MANJE STAMBENE ZGRADE
MULTI-FAMILY HOUSES



OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

A3

Kategorija objekta Building category	**MANJA STAMBENA ZGRADA** **MULTI-FAMILY HOUSE**
Godina izgradnje Built in	**1932.**
Broj etaža Number of floors	**4**
Broj stanova Number of apartments	**6**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**246,64**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**492**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**1600**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,59**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**230,73**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**308,53**

Stambena slobodnostojeća zgrada je razuđene osnove, sa složenim kosim krovom. Najčešća spratnost joj je Po+P+2 (4 etaže). Karakteriše je masivni konstruktivni sistem. Konstruktivni zidovi od pune opeke, debljine 45cm, obostrano su omalterisani u oba pravca, samo s horizontalnim armiranobetonskim serklažima. Međuspratne konstrukcije su armiranobetonske sitnorebraste ploče, ali se javljaju i pune armiranobetonske ploče. U ovom periodu u omotaču nema termoizolacije. Prozori i balkonska vrata su dvostruka drvena razmaknuta krila koja imaju dva obična jednostruka stakla. Zgrade imaju negrijane prostore stepeništa, tavana i podrumske prostore. Podrumski prostori su poluukopani.

Termovizijski snimak ukazuje da stambena zgrada zbog nepostojanja termoizolacije ima ravnomjerne toplotne gubitke na cijelom omotaču, ali da su veći toplotni gubici na poziciji armiranobetonskih horizontalnih serklaža i natprozornika. Vidno je da su veliki površinski toplotni gubici u poziciji svih prozora, te najveći kod balkonskih vrata na posljednjoj etaži, te kod međuspratne konstrukcije ispod tavanskog negrijanog prostora. Gradacija temperature od najniže na prizemlju do najviše na posljednjoj etaži može ukazivati i na neuravnoteženu unutrašnju temperaturu u stanovima.

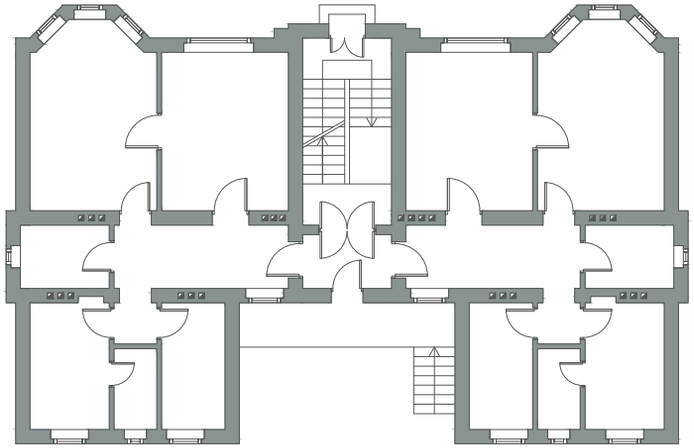
Multi Family House of somewhat discontinuous footprint with a complex shed roof. Buildings in this category are usually basement, ground floor + 2 (four floors). Typical massive construction. Construction walls are 45cm thick, made of solid brick, with plaster finish on both sides, with horizontal RC ring beams. Floors are separated by finely-ridged but also solid reinforced concrete slabs. Buildings from this period do not have thermal insulation on any section of the envelope. Windows and balcony doors are double separated wooden frames, with regular single glazing. The buildings feature unheated staircases, basement and attic area. Basement is partially underground.

Thermovision image of the residential building shows evenly distributed heat loss over the entire envelope due to the lack of thermal insulation, but higher values are registered along horizontal ring beams and window arches. All window surfaces show significant heat loss, but the greatest loss is recorded at the balcony doors on the top floor, as well as between floors below the unheated attic space. Temperature ranges from the lowest at the ground floor to the highest at the top floor, which might be indicative of disbalanced room temperature in the apartments.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

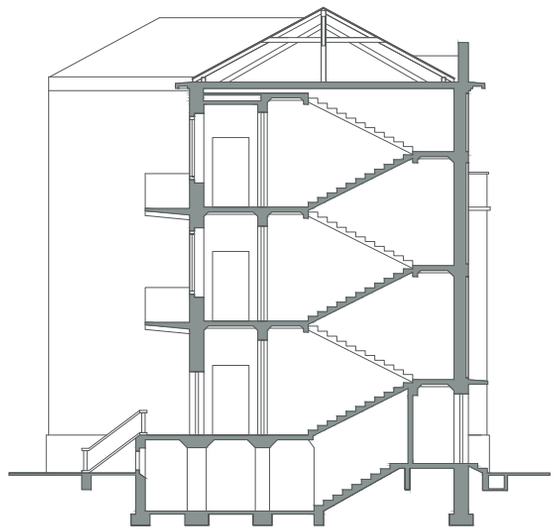
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

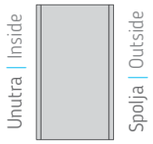
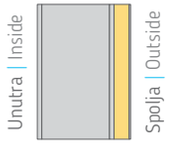
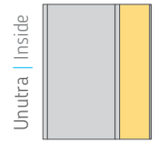
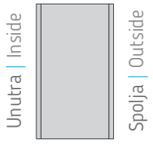
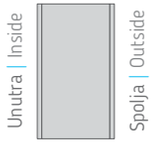
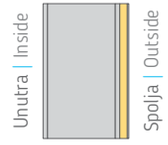
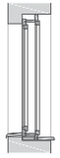
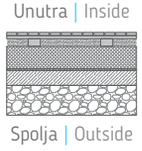
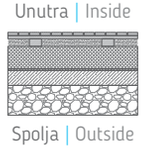
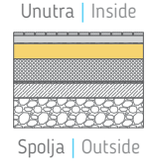


UNAPREĐENJE 2 | IMPROVEMENT 2

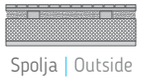
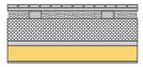
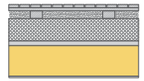
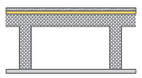
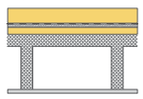
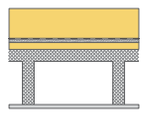
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (garaža), termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Instalacija ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls to unheated areas (garage) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 3cm, puna opeka 45cm, malter 3cm plaster 3cm, brick wall 45cm, plaster 3cm	 malter 3cm, puna opeka 45cm, malter 3cm, termoizolacija 10cm, fasadni malter 1cm plaster 3cm, brick wall 45cm, plaster 3cm, thermal insulation 10cm, facade plaster 1cm	 malter 3cm, puna opeka 45cm, malter 3cm, termoizolacija 20cm, fasadni malter 1cm plaster 3cm, brick wall 45cm, plaster 3cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,05 W/m^2/K	U = 0,29 W/m^2/K	U = 0,17 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 3cm, puna opeka 45cm, malter 3cm plaster 3cm, brick wall 45cm, plaster 3cm	 NEMA IZMJENA NO CHANGES	 malter 3cm, puna opeka 45cm, termoizolacija 5cm, malter 1cm plaster 3cm, brick wall 45cm, plaster 3cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 0,96 W/m^2/K	U = 0,96 W/m^2/K	U = 0,44 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s razmaknutim krilima i jednostrukim staklom wooden, double frame, double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,50 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K
POD NA TLU GROUND FLOOR	 parket 2cm, daščani slijepi pod 2,5cm, potpatosnice u pijesku 5cm, betonska ploča 15cm, bitumenska hidroizolacija, beton 10cm, šljunak 20cm parquet 2cm, wooden subfloor 2.5cm, sleepers in sand bedding 5cm, concrete slab 15cm, waterproofing, concrete 10cm, gravel 20cm	 NEMA IZMJENA NO CHANGES	 parket 2cm, cementni estrih 5cm, PE folija, termoizolacija 10cm, betonska ploča 15cm, bitumenska hidroizolacija, beton 10cm, šljunak 20cm parquet 2cm, cement screed 5cm, PE foil, thermal insulation 10cm, concrete slab 15cm, waterproofing 1cm, concrete 10cm, gravel 20cm
U (W/m^2/K)	U = 1,38 W/m^2/K	U = 1,38 W/m^2/K	U = 0,34 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IIZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 parket 2cm, drvene daske 2,5cm, potpatosnice u pijesku 5cm, AB konstrukcija 15cm, malter 3cm parquet 2cm, wooden subfloor 2.5cm, sleepers in sand bedding 5cm, concrete slab 15cm, plaster 3cm	 parket 2cm, drvene daske 2,5cm, potpatosnice u pijesku 5cm, AB konstrukcija 15cm, malter 3cm, termoizolacija 10cm, malter 1cm parquet 2cm, wooden subfloor 2.5cm, sleepers in sand bedding 5cm, concrete slab 15cm, plaster 3cm, thermal insulation 10cm, plaster 1cm	 parket 2cm, drvene daske 2,5cm, potpatosnice u pijesku 5cm, AB konstrukcija 15cm, malter 3cm, termoizolacija 20cm, malter 1cm parquet 2cm, wooden subfloor 2.5cm, sleepers in sand bedding 5cm, concrete slab 15cm, plaster 3cm, thermal insulation 20cm, plaster 1cm
U (W/m²/K)	U = 1,23 W/m²/K	U = 0,30 W/m²/K	U = 0,17 W/m²/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TOUNHEATED ATTIC	 pijesak 2cm, blato s pljevom 5cm, AB sitnorebrasta konstrukcija 35cm, malter na trsci 2,5cm sand 2cm, rammed earth with chaff 5cm, ribbed concrete slab 35cm, straw-plaster ceiling 2.5cm	 termoizolacija 10cm, parna brana, pijesak 2cm, blato s pljevom 5cm, AB sitnorebrasta konstrukcija 35cm, malter na trsci 2,5cm thermal insulation 10cm, vapor barrier, sand 2cm, rammed earth with chaff 5cm, ribbed concrete slab 35cm, straw-plaster ceiling 2.5cm	 termoizolacija 20cm, parna brana, pijesak 2cm, blato s pljevom 5cm, AB sitnorebrasta konstrukcija 35cm, malter na trsci 2,5cm thermal insulation 20cm, vapor barrier, sand 2cm, rammed earth with chaff 5cm, ribbed concrete slab 35cm, straw-plaster ceiling 2.5cm
U (W/m²/K)	U = 1,22 W/m²/K	U = 0,30 W/m²/K	U = 0,17 W/m²/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote, hidrauličkim balansiranjem mreže i termostatstkim ventilima Central heating system - wood or wood pellet, with heat accumulator, hydraulic system balance and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

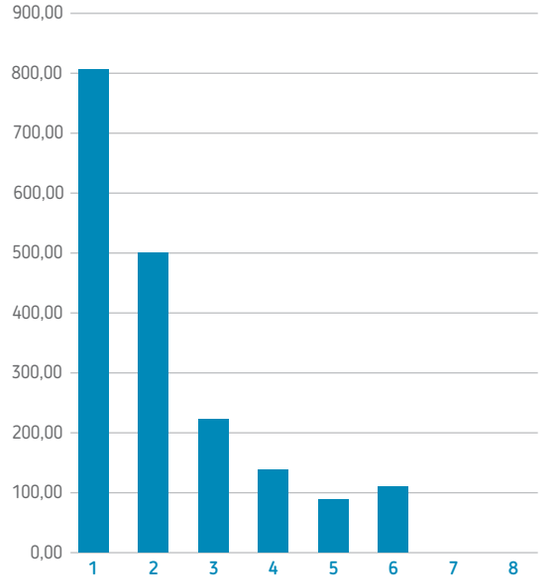
UNAPREĐENJE 2 | IMPROVEMENT 2

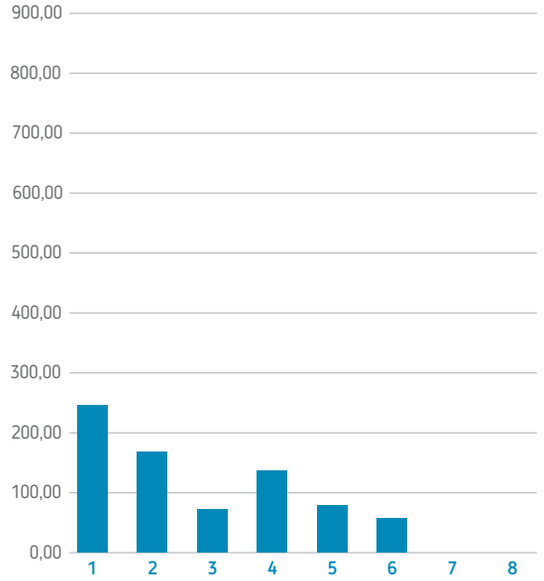
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

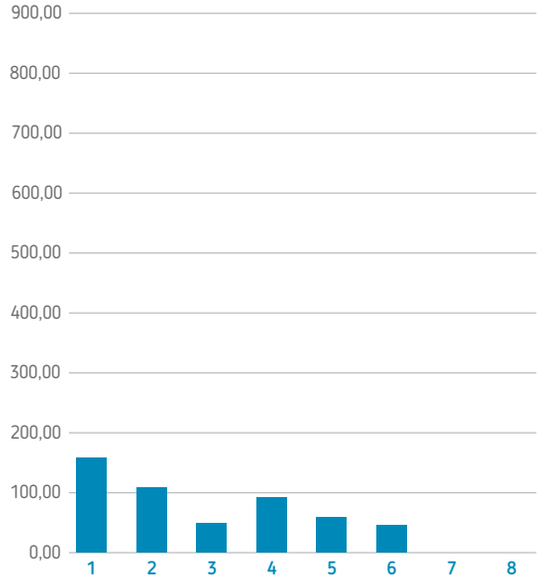
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Gubici prema negrijanom tavanu
4 - Gubici prema negrijanom stepeništu
5 - Pod na tlu
6 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - To the unheated attic
4 - To the unheated staircase
5 - Floor on the ground
6 - Through the unheated basement

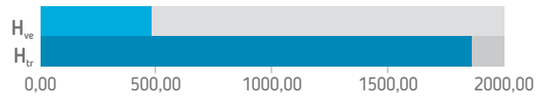


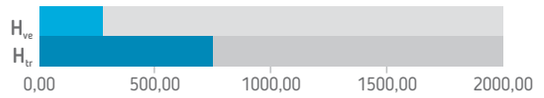


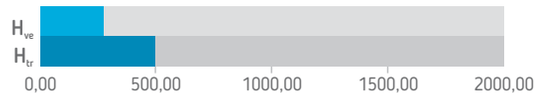


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



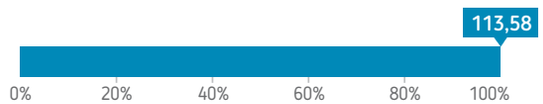


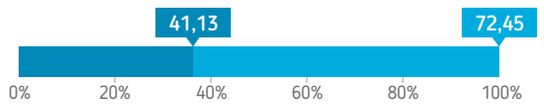


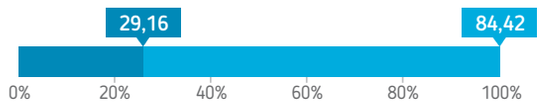
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

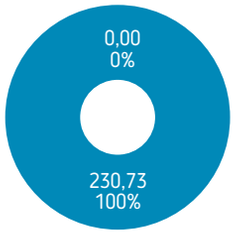
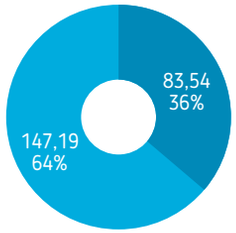
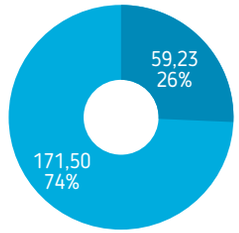
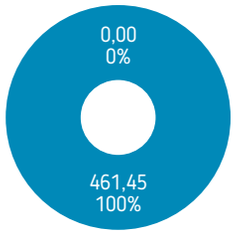
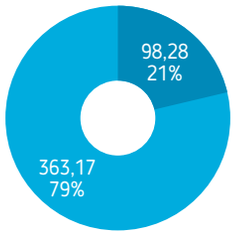
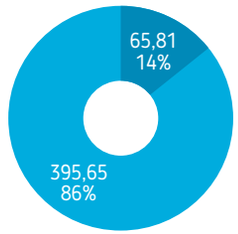
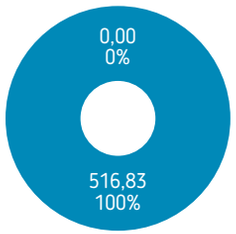
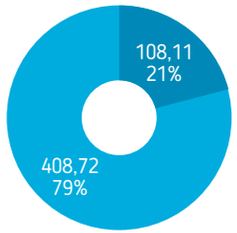
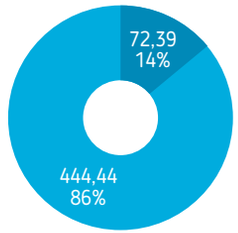
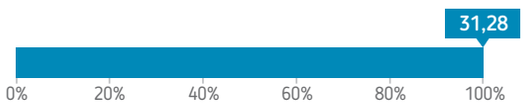
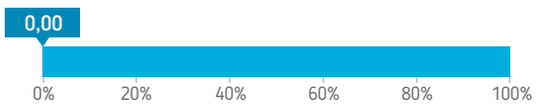
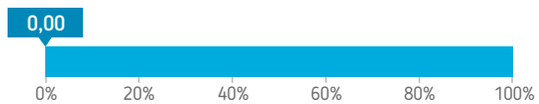
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

B3

Kategorija objekta Building category	**MANJA STAMBENA ZGRADA** **MULTI-FAMILY HOUSE**
Godina izgradnje Built in	**1958.**
Broj etaža Number of floors	**4**
Broj stanova Number of apartments	**9**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**203,00**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**451,83**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**1265,12**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,69**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**216,19**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**278,99**

Stambena slobodnostojeća zgrada je kompaktne pravougaone osnove s četverovodnim kosim krovom. Najčešća spratnost je Po+P+2 (4 etaže). Karakteriše je masivni konstruktivni sistem. Konstruktivni zidovi od šuplje opeke, debljine 25 i 38cm, su u oba pravca obostrano omalterisani, samo s horizontalnim armiranobetonskim serklažima. Međuspratne konstrukcije su armiranobetonske sitnorebraste i rebraste ploče. U ovom periodu u omotaču nema termoizolacije. Prozori i balkonska vrata su dvostruka, drvena krila koja imaju dva obična jednostruka stakla. Zgrade imaju negrijane prostore stepeništa, tavana i podrumske prostore. Podrumski prostori su poluukopani.

Termovizijski snimak ukazuje da stambena zgrada ima ravnomjerne toplotne gubitke na cijelom omotaču zbog nepostojanja termoizolacije, ali da su veći toplotni gubici na poziciji armiranobetonskih horizontalnih serklaža i natprozornika. Vidno je da su veliki površinski toplotni gubici u poziciji svih prozora, kod međuspratne konstrukcije ispod tavanskog negrijanog prostora. Najveći toplotni gubici su na bočnom fasadnom zidu kod prepuštenih betonskih ploča za terase. Na snimku se vidi da se pojedini stanovi i pojedine prostorije u stanovima ne griju.

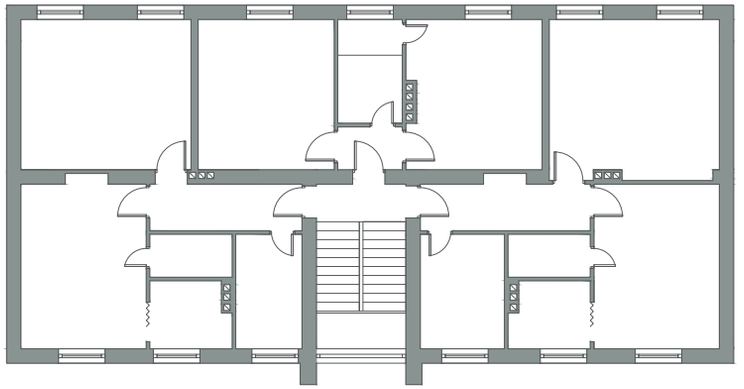
The multi-family house is of compact rectangular footprint with a hip roof. Buildings in this category are usually basement, ground floor + 2 (four floors). Typical massive construction. Construction walls are 25cm and 38cm thick, made of hollow brick, with plaster finish on both sides, with horizontal RC ring beams. Floors are separated by finely-ridged and ridged reinforced concrete slabs. Buildings from this period do not have thermal insulation on any section of the envelope. Windows and balcony doors are double, wooden frames, with regular single glazing. The buildings feature unheated staircases, basement and attic area. Basement is partially underground.

The thermovision image of the residential building shows evenly distributed heat loss over the entire envelope due to the lack of thermal insulation, but higher values are registered along horizontal ring beams and window arches. All window surfaces as well as constructions between floors below the unheated attic space show significant heat loss. The highest heat loss is recorded on the side facade wall near the nosing concrete terrace floors. The image shows that some apartments and rooms in the apartments are left unehated.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora sa dostizanjem U-koeficijenta od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom. Sistem grijanja je hidraulički balansiran po krugovima i vertikalama s balans ventilima. Instalacija ventila s termostatskim glavama na grijaća tijela.

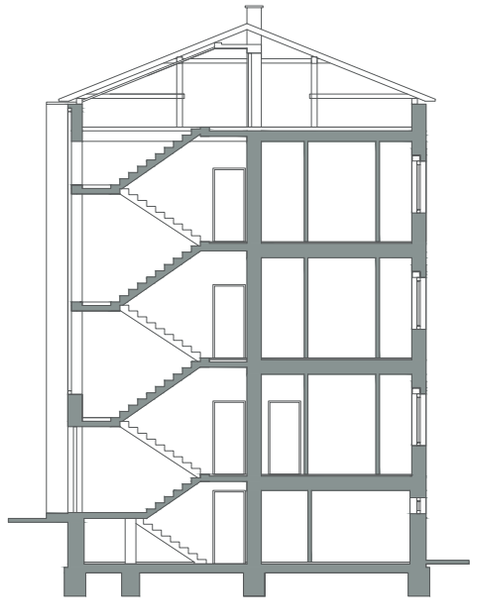
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer. Heating system is hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves.

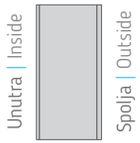
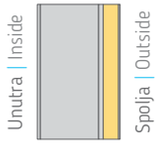
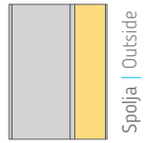
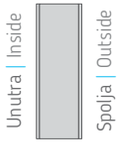
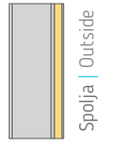
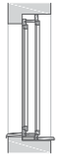


UNAPREĐENJE 2 | IMPROVEMENT 2

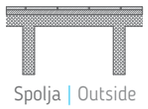
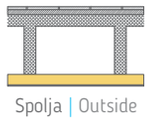
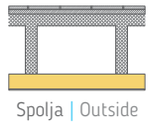
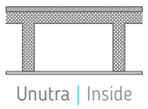
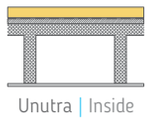
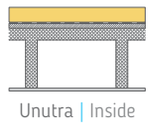
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije ispod negrijanog prostora (tavana) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (garaža) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). Ugradnja novih ulaznih vrata kako bi se dostigao U-koeficijent od 2,0 W/m^{2}K. • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Instalacija dopunskog sistema grijanja potrošne tople vode. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Instalacija ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors below the unheated space (attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls to unheated areas (garage) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). Installing of new entrance doors to reach U-coefficient of 2.0 W/m^{2}K. • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolitic boiler with heat accumulator. Installing of additional system for domestic hot water. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 38cm, malter 3cm plaster 3cm, brick wall 38cm, plaster 3cm	 malter 2cm, puna opeka 38cm, malter 3cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 38cm, plaster 3cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 38cm, malter 3cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 38cm, plaster 3cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,04 W/m^2/K	U = 0,29 W/m^2/K	U = 0,17 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, puna opeka 25cm, malter 2cm plaster 2cm, brick wall 25cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 0,96 W/m^2/K	U = 0,96 W/m^2/K	U = 0,44 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s razmaknutim krilima i jednostrukim staklom wooden, double frame, double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 5,27 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA U (W/m²/K)	 drveni pod 2cm, cementni estrih 3cm, AB konstrukcija HERBST sistema 40cm wooden floor 2cm, cement screed 3cm, ribbed concrete slab 40cm U = 1,65 W/m²/K	 drveni pod 2cm, cementni estrih 3cm, AB konstrukcija HERBST sistema 40cm, termoizolacija 10cm, malter 1cm wooden floor 2cm, cement screed 3cm, ribbed concrete slab 40cm, thermal insulation 10cm, plaster 1cm U = 0,32 W/m²/K	 drveni pod 2cm, cementni estrih 3cm, AB konstrukcija HERBST sistema 40cm, termoizolacija 20cm, malter 1cm wooden floor 2cm, cement screed 3cm, ribbed concrete slab 40cm, thermal insulation 20cm, plaster 1cm U = 0,18 W/m²/K
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC U (W/m²/K)	 cementni estrih 3cm, AB konstrukcija HERBST sistema 40cm, malter 2cm cement screed 3cm, ribbed concrete slab 40cm, plaster 2cm U = 2,21 W/m²/K	 termoizolacija 10cm, parna brana, cementni estrih 3cm, AB konstrukcija HERBST sistema 40cm, malter 2cm thermal insulation 10cm, vapor barrier, cement screed 3cm, ribbed concrete slab 40cm, plaster 2cm U = 0,34 W/m²/K	 termoizolacija 20cm, parna brana, cementni estrih 3cm, AB konstrukcija HERBST sistema 40cm, malter 2cm thermal insulation 20cm, vapor barrier, cement screed 3cm, ribbed concrete slab 40cm, plaster 2cm U = 0,18 W/m²/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Električne peći (grijalice + TA peći) Electric heaters (heaters + electric thermal storage heaters)	 Centralni sistem grijanja na drva ili pelet, sa akumulatorom toplote, hidrauličkim balansiranjem mreže i termostatskim ventilima Central heating system - wood or wood pellet, with heat accumulator, hydraulic system balance and thermostatic valves	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote, hidrauličkim balansiranjem mreže i termostatskim ventilima Central heating system - wood or wood pellet, with heat accumulator, hydraulic system balance and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

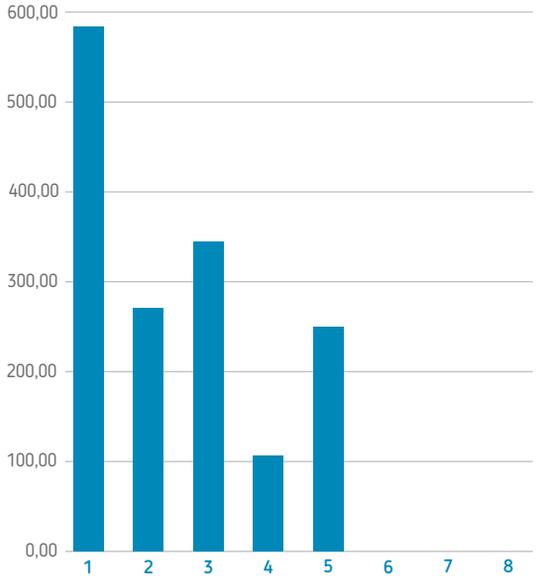
UNAPREĐENJE 2 | IMPROVEMENT 2

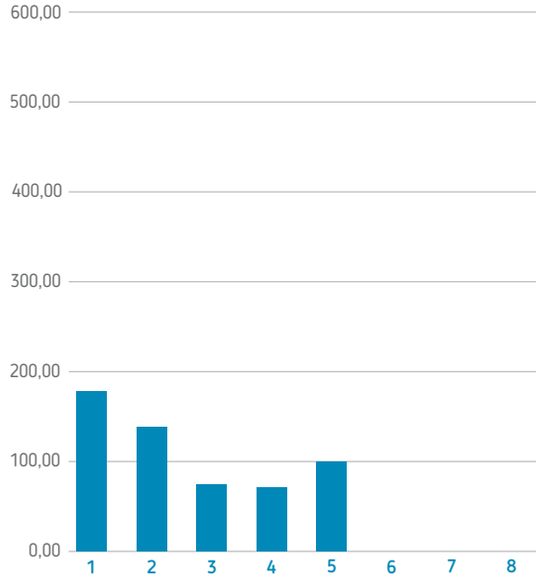
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

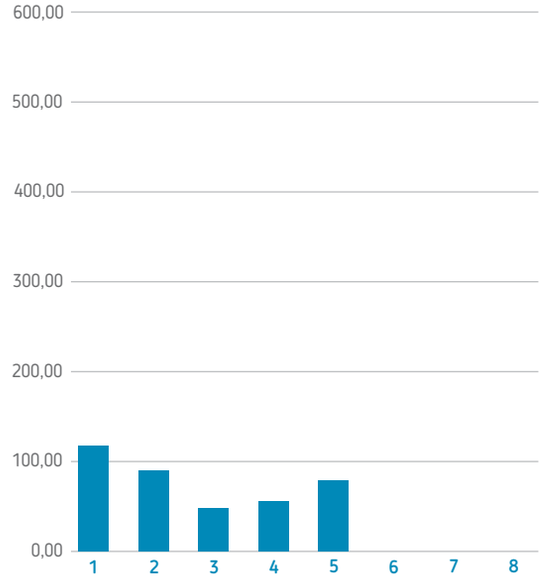
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Gubici prema negrijanom tavanu
4 - Gubici prema negrijanom stepeništu
5 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - To the unheated attic
4 - To the unheated staircase
5 - Through the unheated basement

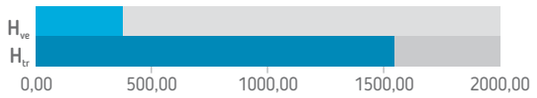


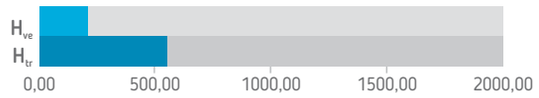


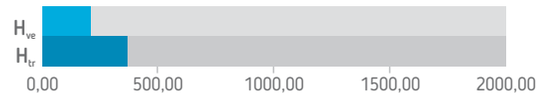


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



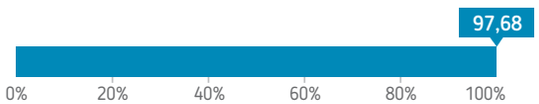


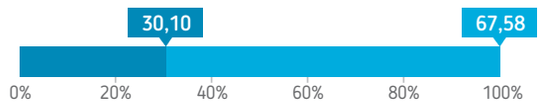


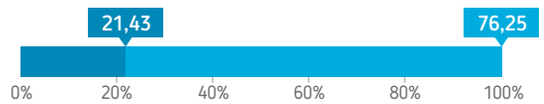
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

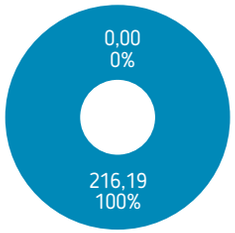
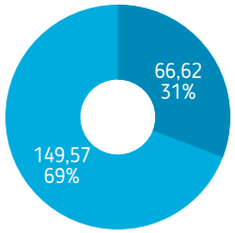
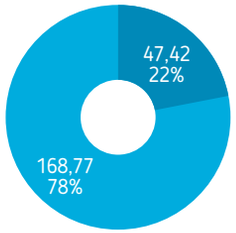
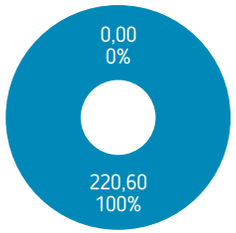
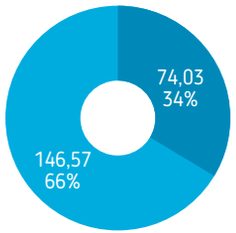
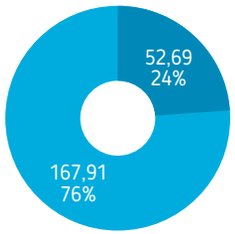
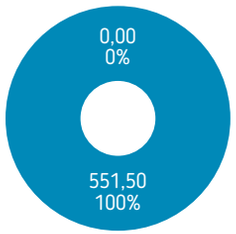
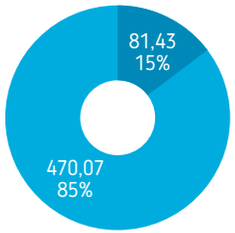
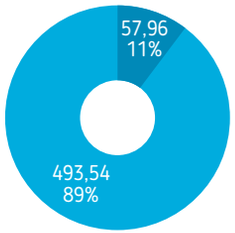
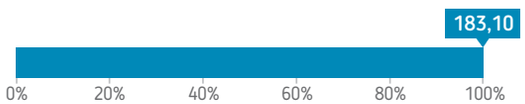
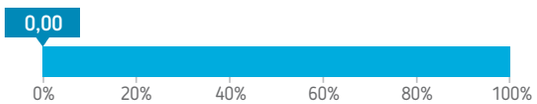
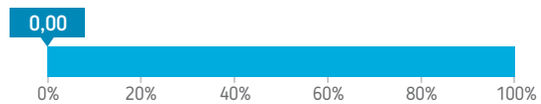
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	ELEKTRIČNA ENERGIJA ELECTRIC POWER	DRVO ILI PELETI WOOD OR PELLET	DRVO ILI PELETI WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

C3

Kategorija objekta Building category	**MANJA STAMBENA ZGRADA** **MULTI-FAMILY HOUSE**
Godina izgradnje Built in	**1961-1970.**
Broj etaža Number of floors	**4**
Broj stanova Number of apartments	**10**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**169,39**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**561,99**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**1404,97**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,71**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ (kWh/m^2/god) Specific energy need for intermitted heating $Q_{H,nd,interm}$ (kWh/m^2/year)	**188,44**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ (kWh/m^2/god) Specific energy need for continuous heating $Q_{H,nd,cont}$ (kWh/m^2/year)	**265,04**

Stambena zgrada je kompaktne pravougaone osnove s plitkim kosim krovom. Najčešća spratnost objekata iz ove kategorije je od P+1 do P+3. Objekte iz ove kategorije karakteriše masivni konstruktivni sistem s nosivim zidovima u oba pravca. Spoljašnji zidovi su izvedeni od pune opeke debljine 25cm bez vertikalnih armiranobetonskih serklaža. Objekat nema podruma, a međuspratna konstrukcija je izrađena od polumontažne betonske ploče debljine 20cm. Tavanski prostor je djelimično iskorišten za stanovanje, dok je suterenski prostor u potpunosti riješen kao stambeni. Kosi krov je četverovodan, bez termoizolacije, s drvenom konstrukcijom i pokrovom od valovitog salonita. Na fasadnom omotaču nema termoizolacije, a završna obrada je malter. Prozori su drveni, dvostruki sa spojenim krilima, jednostrukim staklom i ugradbenim roletnama. Stepenišni i nestambeni tavanski prostori su negrijani.

Termovizijski snimak fasade stambene zgrade s masivnim spoljašnjim zidovima pokazuje da je zgrada izgrađena bez termoizolacije i nehomogene je strukture. Mogu se uočiti toplotni gubici zbog različitih termičkih karakteristika materijala i prisutni su termički mostovi na armiranobetonskim horizontalnim serklažima i na promjenama geometrije objekta. Na vanjskoj stolariji, konstrukciji prozora i vrata, kao i na ostakljenim površinama, primjetni su toplotni gubici.

Free-standing residential building is of compact rectangular footprint with a shallow shed roof. Buildings in this category usually have ground floor + 1 to + 3 floors. Typical of this category is massive construction system with load-bearing walls in both directions. External walls made of solid 25cm brick, without vertical RC ring beams. The building does not feature a basement, and floors are separated by pre-fabricated 20cm concrete slabs. Attic space is partially used for residential purposes, while the basement area is completely residential. Hip roof is without thermal insulation, supported by wooden beams and covered with corrugated roof panels. The facade is without thermal insulation, with plaster finish. Windows are made of wood, double winged, with conjoined wings, single-glazed, and with built-in shades. The staircase and non-residential attic space are left unheated.

Thermovision image of the apartment building facade with massive external walls indicates that the building was built without thermal insulation, and that it is of heterogeneous structure. Heat losses are due to different thermal characteristics of the materials used. Thermal bridges can be detected along horizontal RC ring beams and where building geometry changes. External framings, windows and doors, as well as glass surfaces show heat loss.

UNAPREĐENJE 1 | IMPROVEMENT 1

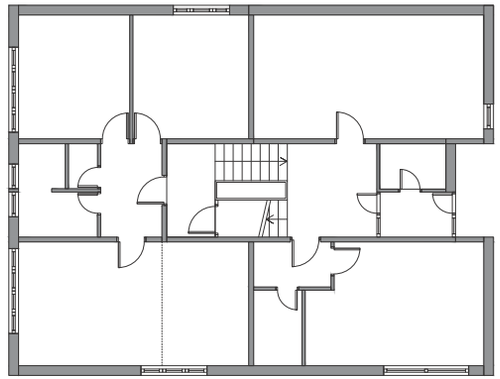
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave, stepenišni prostor i tavan) s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Na dijelu stambenog potkrovnog prostora izolovati kosi krov termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

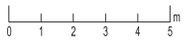
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage rooms, staircase, and the attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of the steep roof with thermal insulation layer of 20cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, pyrolytic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

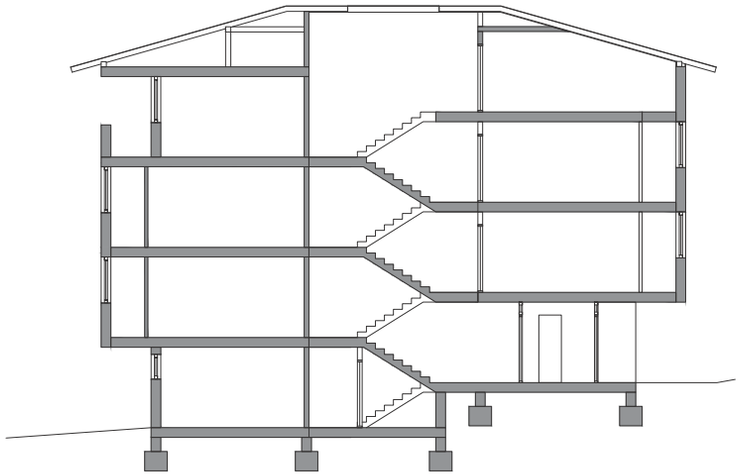
UNAPREĐENJE 2 | IMPROVEMENT 2

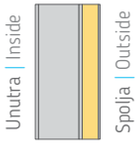
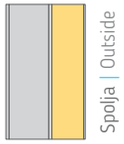
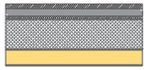
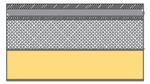
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova (stepenišni prostor) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave, stepenišni prostor i tavan) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Na dijelu stambenog potkrovnog prostora izolovati kosi krov termoizolacionim slojem debljine 30cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote visoke efikasnosti. Instalacija dopunskog sistema grijanja potrošne tople vode. Sistem grijanja hidraulički balansiran po krugovima i vertikalama sa balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage rooms, staircase, and the attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the steep roof above the residential space with thermal insulation layer of 30cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, high efficiency pyrolytic boiler with heat accumulator. Installing of additional system for domestic hot water. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves.



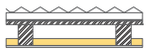
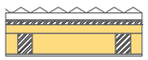
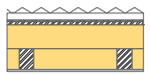




	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 25cm, malter 2cm plaster 2cm, brick wall 25cm, plaster 2cm	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,88 W/m^2/K	U = 0,33 W/m^2/K	U = 0,18 W/m^2/K
ZID KA NEGRIJANOM PROSTORU ZID KA NEGRIJANOM PROSTORU	 malter 2cm, puna opeka 12cm, malter 2cm plaster 2cm, brick wall 12cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, puna opeka 12cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, brick wall 12cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 2,34 W/m^2/K	U = 2,34 W/m^2/K	U = 0,59 W/m^2/K
PROZORI WINDOWS	 drveni s jednostrukim staklom wooden, with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 4,50 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	Unutra | Inside  Spolja | Outside parket 2cm, cementni estrih 5cm, natron papir, ploče od drvenih vlakana 1,5cm, betonska konstrukcija 20cm, malter 1cm parquet 2cm, cement screed 5cm, kraft paper, wood fibre boards 1,5cm, concrete slab 20cm, plaster 1cm	Unutra | Inside  Spolja | Outside parket 2cm, cementni estrih 5cm, natron papir, ploče od drvenih vlakana 1,5cm, betonska konstrukcija 20cm, malter 1cm, termoizolacija 10cm, malter 1cm parquet 2cm, cement screed 5cm, kraft paper, wood fibre boards 1,5cm, concrete slab 20cm, plaster 1cm, thermal insulation 10cm, plaster 1cm	Unutra | Inside  Spolja | Outside parket 2cm, cementni estrih 5cm, natron papir, ploče od drvenih vlakana 1,5cm, betonska konstrukcija 20cm, malter 1cm, termoizolacija 20cm, malter 1cm parquet 2cm, cement screed 5cm, kraft paper, wood fibre boards 1,5cm, concrete slab 20cm, plaster 1cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 1,30 W/m^2/K	U = 0,31 W/m^2/K	U = 0,18 W/m^2/K

ELEMENTI UNAPREĐENJA OMOTAČA | BUILDING ENVELOPE IMPROVEMENTS ELEMENTS

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside AB ploča 20cm, malter 1cm reinforced concrete slab 20cm, plaster 1cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, parna brana, AB ploča 20cm, malter 1cm thermal insulation 10cm, vapor barrier, reinforced concrete slab 20cm, plaster 1cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, parna brana, AB ploča 20cm, malter 1cm thermal insulation 20cm, vapor barrier, reinforced concrete slab 20cm, plaster 1cm
U ($W/m^2/K$)	U = 2,33 $W/m^2/K$	U = 0,35 $W/m^2/K$	U = 0,19 $W/m^2/K$
KOSI KROV PITCHED ROOF	Spolja | Outside  Unutra | Inside salonit ploče 1cm, drvene letve/vazduh 5cm, hidroizolacija 1cm, daske 2,5cm, rog 10x14cm, termoizolacija 5cm, PE folija, daske 2,5cm, malter 1cm asbestos cement slabs 1cm, wooden battens/ air 5cm, waterproofing 1cm, planks 2.5cm, rafter 10x14cm, thermal insulation 5cm, PE foil, planks 2.5cm, plaster 1cm	Spolja | Outside  Unutra | Inside novi krovni pokrivač, drvene letve/vazduh 5cm, hidroizolacija 1cm, daske 2,5cm, termoizolacija 20cm (između i iznad rogova sa sekundarnom podkonstrukcijom 10x14cm), PE folija, daske 2,5cm, malter 1cm new roof covering, wooden battens/air 5cm, waterproofing 1cm, planks 2.5cm, thermal insulation 20cm (between and above rafters with secondary substructure 10x14cm), PE foil, planks 2.5cm, plaster 1cm	Spolja | Outside  Unutra | Inside novi krovni pokrivač, drvene letve/vazduh 5cm, hidroizolacija 1cm, daske 2,5cm, termoizolacija 30cm (između i iznad rogova sa sekundarnom podkonstrukcijom 10x14cm), PE folija, daske 2,5cm, malter 1cm new roof covering, wooden battens/air 5cm, waterproofing 1cm, planks 2.5cm, thermal insulation 30cm (between and above rafters with secondary substructure 10x14cm), PE foil, planks 2.5cm, plaster 1cm
U ($W/m^2/K$)	U = 0,68 $W/m^2/K$	U = 0,20 $W/m^2/K$	U = 0,13 $W/m^2/K$

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood + coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote, hidrauličkim balansiranjem mreže i termostatstkim ventilima Central heating system - wood or wood pellet, with heat accumulator, hydraulic system balance and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	 	 	
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

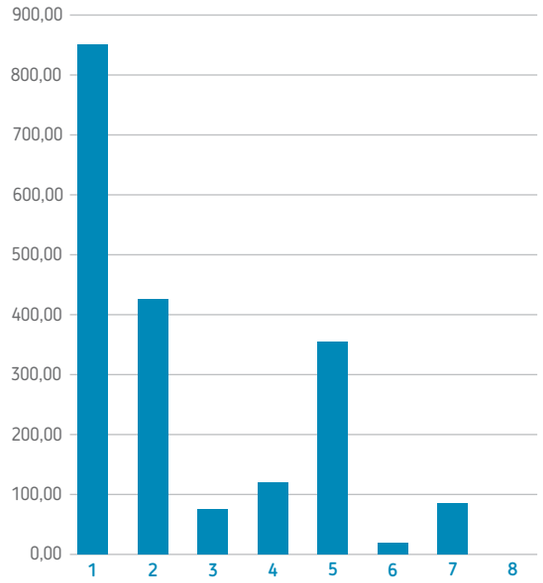
UNAPREĐENJE 2 | IMPROVEMENT 2

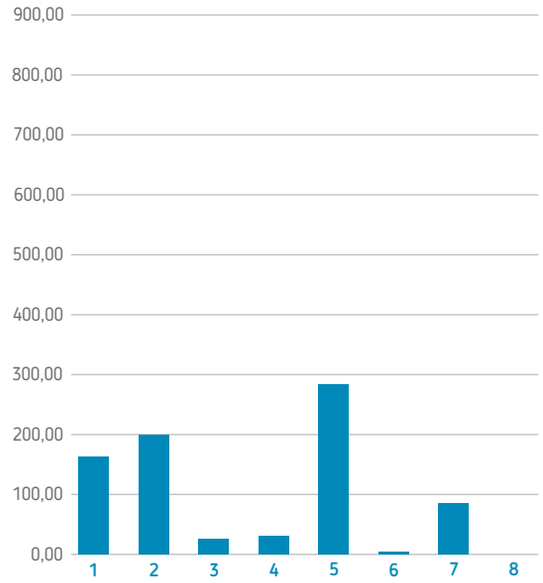
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

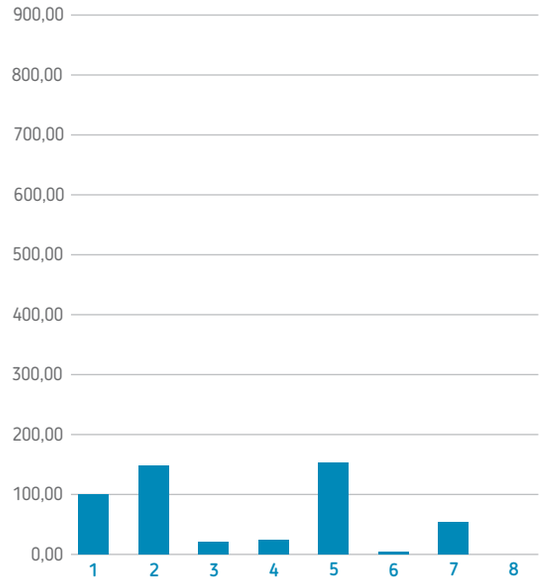
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Kosi krov
5 - Gubici prema negrijanom stepeništu
6 - Strop prema okolini
7 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance doors
4 - Shed roof
5 - To the unheated staircase
6 - Ceiling to the surroundings
7 - Floor on the ground

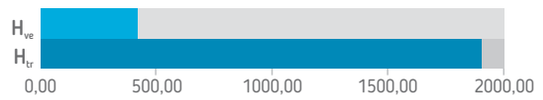


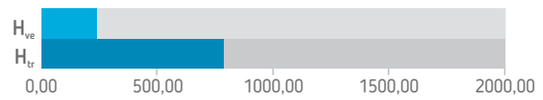


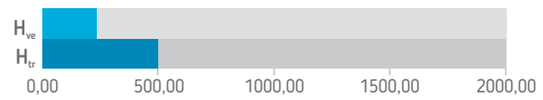


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



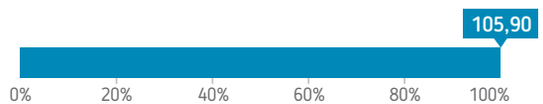


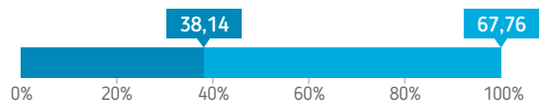


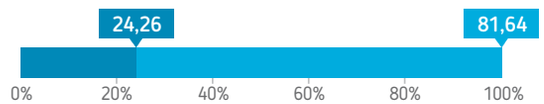
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

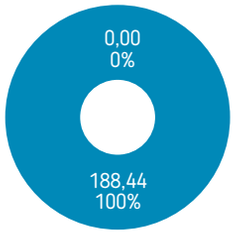
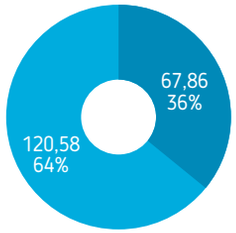
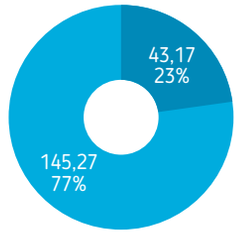
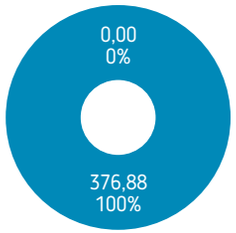
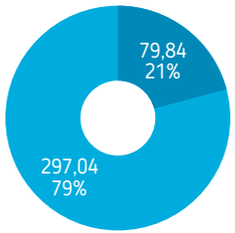
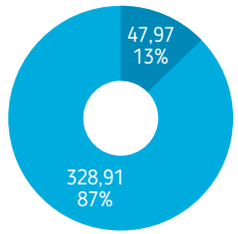
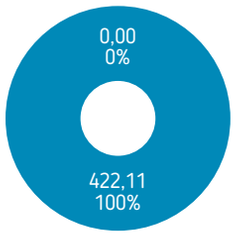
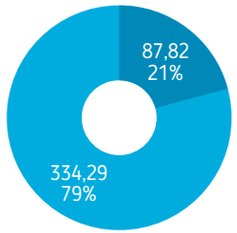
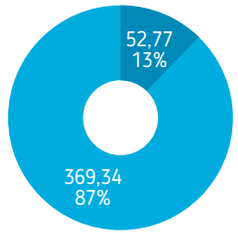
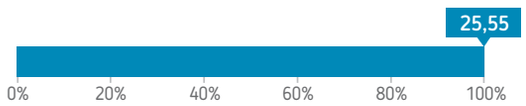
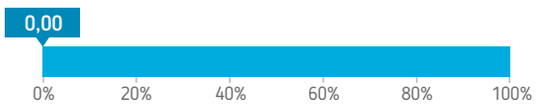
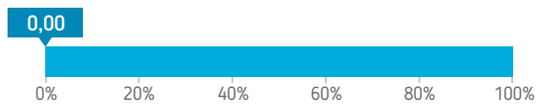
(MWh/god) | (MWh/year)

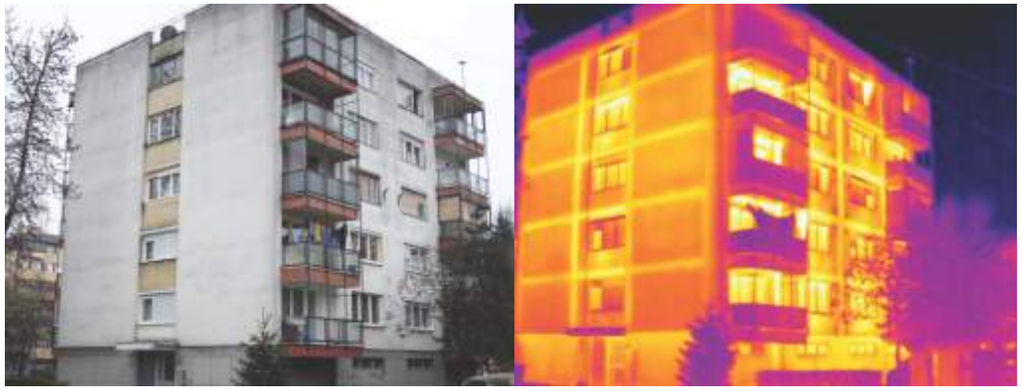
Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELETI WOOD OR PELLET	DRVO ILI PELETI WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			



OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

D3

Kategorija objekta Building category	**MANJA STAMBENA ZGRADA** **MULTI-FAMILY HOUSE**
Godina izgradnje Built in	**1971.**
Broj etaža Number of floors	**6**
Broj stanova Number of apartments	**20**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**239,65**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**862**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**2241**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,53**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**146,79**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**191,50**

Stambena slobodnostojeća zgrada je kompaktne kvadratne osnove s ravnim prohodnim krovom. Najčešća spratnost je P+4 ili P+5 (5-6 etaža). Karakteriše je masivni konstruktivni sistem. Konstruktivni zidovi od 25cm su u oba pravca od ošupljene opeke s vertikalnim armirano-betonskim serklažima, dok su spoljašnji zidovi masivniji od 38cm i obostrano su omalterisani. Međuspratne konstrukcije su pune armirano-betonske ploče, a javljaju se i kao polumontaže, s ispunom od šupljih blokova. U ovom periodu termoizolacija se pojavljuje samo u krovu, u debljinama od 3 do 5cm. Prozori i balkonska vrata su dvostruka drvena spojena krila koja imaju dva obična jednostruka stakla i posjeduju unutrašnju platnenu roletnu. Zgrade imaju negrijane prostore stepeništa i podrumske prostore, u okviru kojih se nekad pojavljuju i garaže. Podrumski prostori su poluukopani ili su u nivou terena.

Termovizijski snimak ukazuje da stambena zgrada ima najveće površinske toplotne gubitke na poziciji armirano-betonskih vertikalnih i horizontalnih serklaža. Veći linijski toplotni gubici su kod postojećih prozora u gornjoj zoni okvira gdje prvobitno nije postojala vanjska roletna, nego samo unutrašnja platnena roletna, te kod postojećih balkona, javljaju se u poziciji prodora ploče balkona i kod ispusta spoljašnjeg zida kod bočne strane balkona.

Free-standing multi-family house of compact square base with flat accessible roof. Buildings in this category usually have ground floor + 4 or + 5 floors (5-6 floors). Typical massive construction. Construction walls are 25cm thick on both sides made of hollow brick with RC ring beams, while external walls are more massive, 38 cm thick, with plaster finish on both sides. Construction between the floors includes solid reinforced concrete slabs, or prefabricated slabs, with hollow blocks filling. During this period, thermal insulation was installed only in the roof, ranging between 3 and 5cm. Windows and balcony doors are double conjoined wooden frames, with regular single glazing, and built-in fabric shades. Buildings have unheated staircases and basement rooms, sometimes used as garages. Basement is partially underground or at ground level.

Thermovision image shows the highest level of heat loss in the area of vertical and horizontal RC ring beams. Major linear heat loss is detected at the upper edge of existing windows, which were originally without external roller blinds, featuring only indoor fabric blinds, as well as at the existing balconies, in the zone where the deck protrudes, and where the external wall recedes at the balcony side.

UNAPREĐENJE 1 | IMPROVEMENT 1

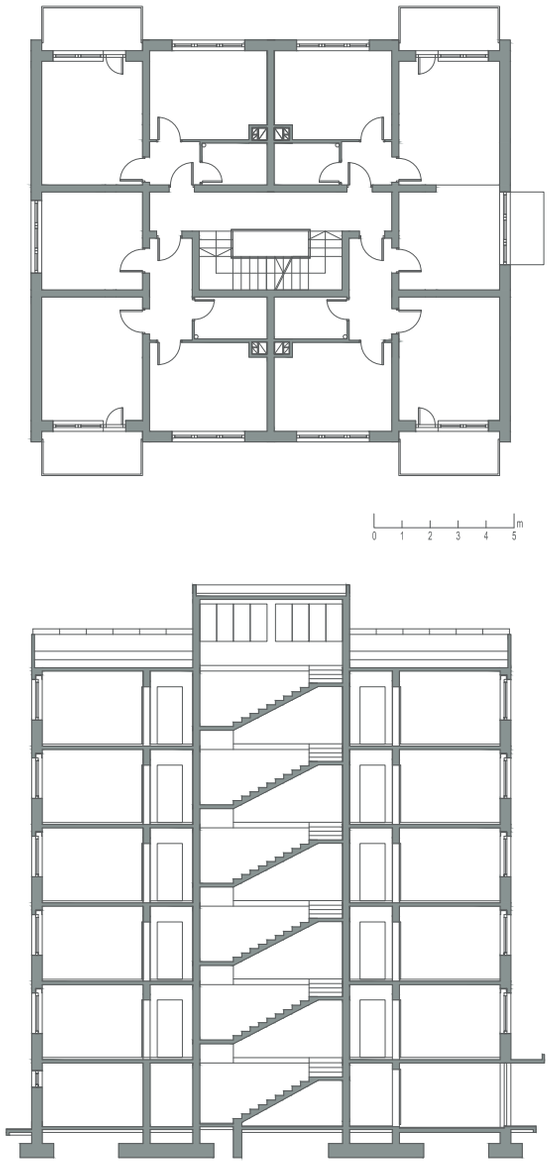
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 10 cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefiksne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima.

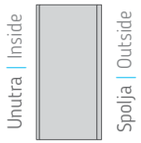
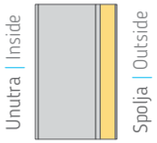
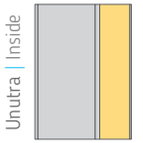
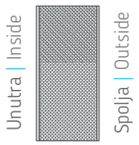
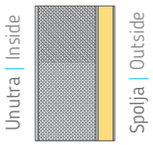
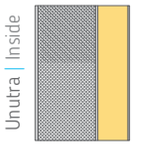
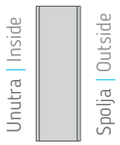
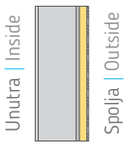
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system is linked to the heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

UNAPREĐENJE 2 | IMPROVEMENT 2

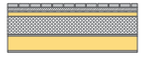
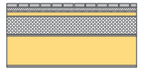
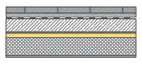
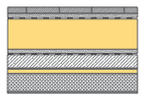
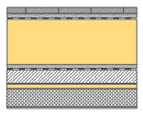
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog podrumskog prostora termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (stepenište) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated basement with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Insulation of internal walls to unheated areas (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system is linked to the heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 38cm, malter 3cm plaster 2cm, brick wall 38cm, plaster 3cm	 malter 2cm, puna opeka 38cm, malter 3cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 38cm, plaster 3cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 38cm, malter 3cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 38cm, plaster 3cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,04 W/m^2/K	U = 0,29 W/m^2/K	U = 0,17 W/m^2/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, AB zid 38cm, malter 1,5cm plaster 2cm, reinforced concrete wall 38cm, plaster 1.5cm	 malter 2cm, AB zid 38cm, malter 1,5cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 38cm, plaster 1.5cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, AB zid 38cm, malter 1,5cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 38cm, plaster 1.5cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 2,54 W/m^2/K	U = 0,35 W/m^2/K	U = 0,19 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, puna opeka 25cm, malter 2cm plaster 2cm, brick wall 25cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 1,27 W/m^2/K	U = 1,27 W/m^2/K	U = 0,49 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki sa spojenim krilima i jednostrukim staklom wooden, single frame, connected double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 2,92 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IIZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA U (W/m²/K)	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 2,5cm, natron papir, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm parket 2cm, cement screed 2.5cm, natron paper, thermal insulation 3cm, reinforced concrete slab 12cm, plaster 1cm U = 0,75 W/m²/K	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 2,5cm, natron papir, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm, termoizolacija 10cm, malter 1cm parket 2cm, cement screed 2.5cm, natron paper, thermal insulation 3cm, reinforced concrete slab 12cm, plaster 1cm, thermal insulation 10cm, plaster 1cm U = 0,26 W/m²/K	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 2,5cm, natron papir, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm, termoizolacija 20cm, malter 1cm parket 2cm, cement screed 2.5cm, natron paper, thermal insulation 3cm, reinforced concrete slab 12cm, plaster 1cm, thermal insulation 20cm, plaster 1cm U = 0,16 W/m²/K
RAVAN KROV FLAT ROOF U (W/m²/K)	 Spolja | Outside Unutra | Inside kulir ploče 4cm, pijesak 3cm, hidroizolacija, beton 9cm, krovna ljepenka, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm kulir slabs 4cm, sand 3cm, waterproofing, concrete 9cm, roofing felt, thermal insulation 3cm, reinforced concrete slab 12cm, plaster 1cm U = 0,91 W/m²/K	 Spolja | Outside Unutra | Inside kulir ploče 4cm, pijesak 3cm, PE folija, termoizolacija 20cm, hidroizolacija, beton 9cm, krovna ljepenka, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm kulir slabs 4cm, sand 3cm, PE foil, thermal insulation 20cm, waterproofing, concrete 9cm, roofing felt, thermal insulation 3cm, reinforced concrete slab12 cm, plaster 1cm U = 0,15 W/m²/K	 Spolja | Outside Unutra | Inside kulir ploče 4cm, pijesak 3cm, PE folija, termoizolacija 30cm, hidroizolacija, beton 9cm, krovna ljepenka, termoizolacija 3cm, AB konstrukcija 12cm, malter 1cm kulir slabs 4cm, sand 3cm, PE foil, thermal insulation 30cm, waterproofing, concrete 9cm, roofing felt, thermal insulation 3cm, reinforced concrete slab12 cm, plaster 1cm U = 0,10 W/m²/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	 0,85	 0,90	 0,95
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

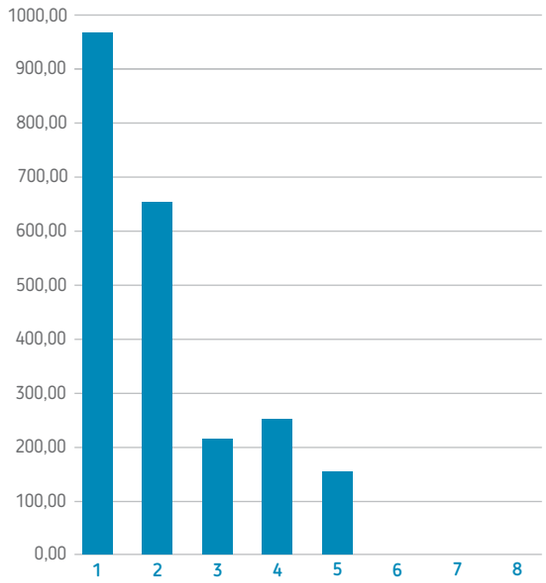
UNAPREĐENJE 2 | IMPROVEMENT 2

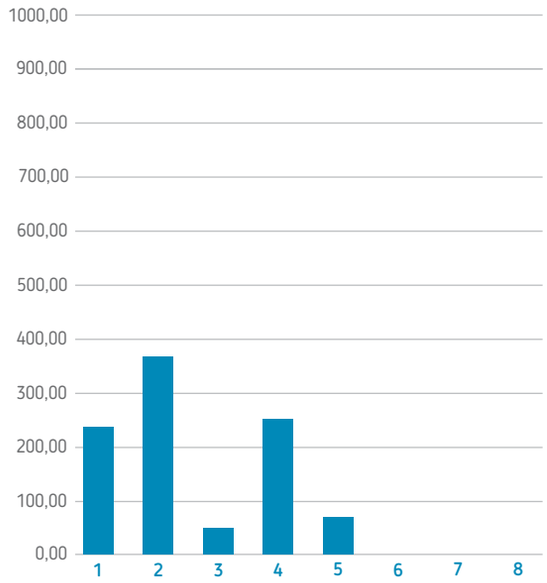
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

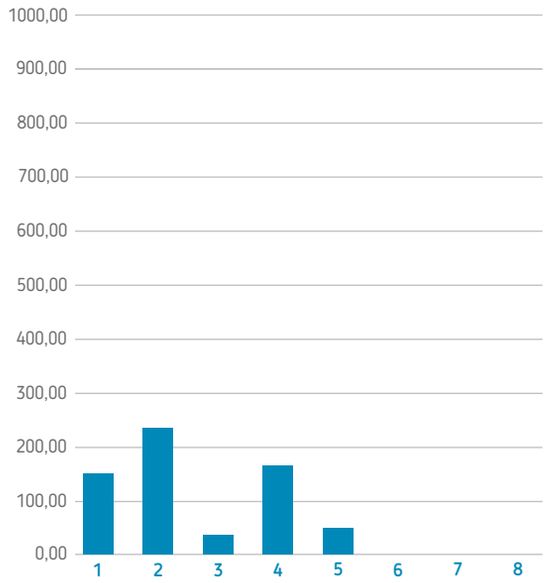
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ravni krov
4 - Gubici prema negrijanom stepeništu
5 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Flat roof
4 - To the unheated staircase
5 - Through the unheated basement

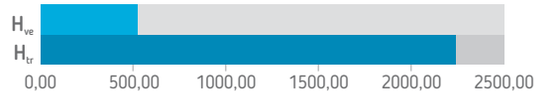


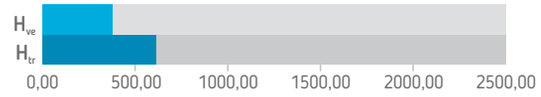




ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)

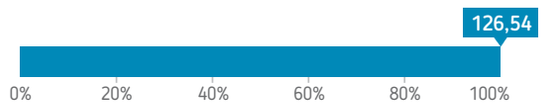


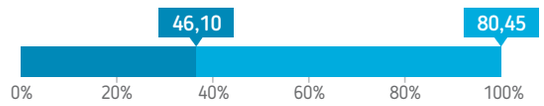


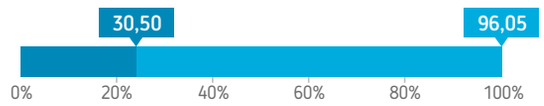
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

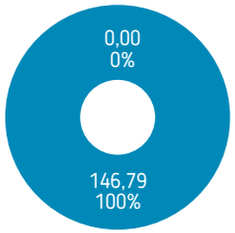
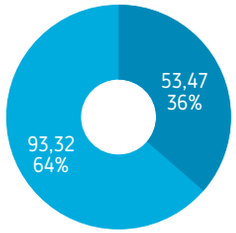
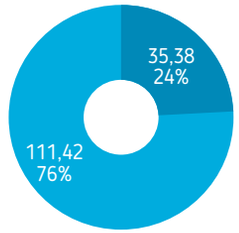
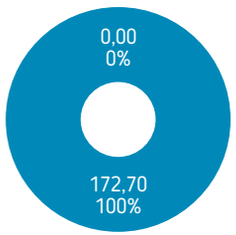
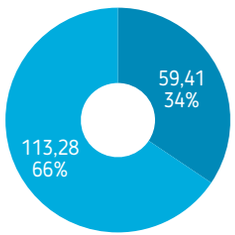
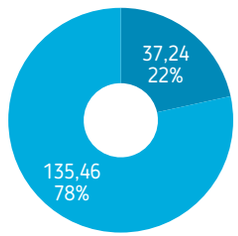
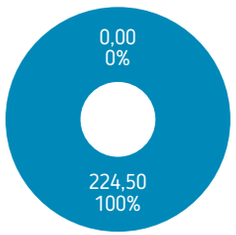
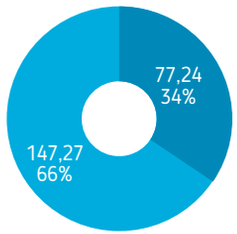
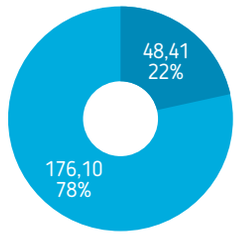
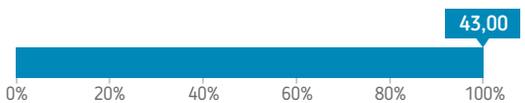
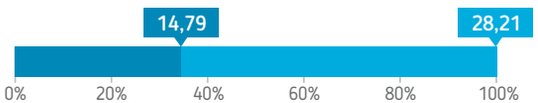
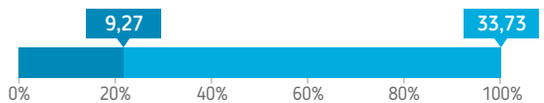
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

E3

Kategorija objekta Building category	**MANJA STAMBENA ZGRADA** **MULTI-FAMILY HOUSE**
Godina izgradnje Built in	**1981.**
Broj etaža Number of floors	**5**
Broj stanova Number of apartments	**12**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**201,00**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**613,72**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**1552,71**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,63**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ (kWh/m^2/god) Specific energy need for intermitted heating $Q_{H,nd,interm}$ (kWh/m^2/year)	**189,20**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ (kWh/m^2/god) Specific energy need for continuous heating $Q_{H,nd,cont}$ (kWh/m^2/year)	**259,18**

Stambena slobodnostojeća zgrada je blago razuđene osnove s ravnim neprohodnim krovom. Najčešća spratnost je Su+P+3 ili Po+P+4 (5-6 etaža). Karakteriše je klasična gradnja, masivni konstruktivni sistem. Konstruktivni zidovi od 25cm su u oba pravca od opekarskog bloka, obostrano omalterisani, s vertikalnim i horizontalnim armirano-betonskim serklažima. Međuspratne konstrukcije su pune armiranobetonske ploče, a javljaju se i kao polumontaže, s ispunom od šupljih blokova. U ovom periodu termoizolacija se pojavljuje u međuspratnoj konstrukciji iznad negrijanog prostora (suterena) od 3 do 5cm, ali u poziciji zvučne izolacije iznad armirano-betonske ploče. Termoizolacija se javlja i u krovu u debljinama od 3 do 5cm. Prozori i balkonska vrata su dvostruka drvena spojena krila koja imaju dva obična jednostruka stakla. Zgrade imaju negrijane prostore stepeništa i podrumske prostore u okviru kojih se pojavljuju i garaže. Podrumski prostori su poluukopani ili su u nivou terena.

Termovizijski snimak ukazuje da stambena zgrada ima najveće površinske toplotne gubitke na poziciji armiranobetonskih vertikalnih i horizontalnih serklaža. Veći linijski toplotni gubici su kod postojećih prozora u gornjoj zoni okvira gdje prvobitno nije postojala vanjska roletna, a najveći gubici su kod postojećih lođa i javljaju se u poziciji spoljašnjeg zida ispod ploče lođa i kod bočnog spoljašnjeg zida s bočne strane lođa.

Free-standing residential multi-family house of somewhat discontinuous footprint with flat inaccessible roof. Buildings in this category usually have basement + ground floor + 4 floors (5-6 floors). Typical massive construction. Construction walls are 25cm thick on both sides made of clay blocks, with plaster finish on both sides, with vertical and horizontal RC ring beams. Construction between the floors includes full reinforced concrete slabs, or pre-made, with hollow blocks filling. During this period, thermal insulation was installed between the floor and the unheated basement, thickness ranging between 3 and 5cm, in the position of the sound insulation above the RC layer. During this period, thermal insulation was installed in the roof as well, ranging between 3 and 5cm. Windows and balcony doors are double conjoined wooden frames, with regular single glazing. Buildings have unheated staircases and basement rooms, sometimes used as garages. Basement is partially underground or at ground level.

Thermovision image shows the highest level of heat loss in the area of vertical and horizontal RC ring beams. Major linear heat loss is detected at the upper edge of existing windows, which were originally without external roller blinds, as well as at the existing deep-set balconies, in the place of external wall below the protruding deck, and at the external side wall on the balcony side.

UNAPREĐENJE 1 | IMPROVEMENT 1

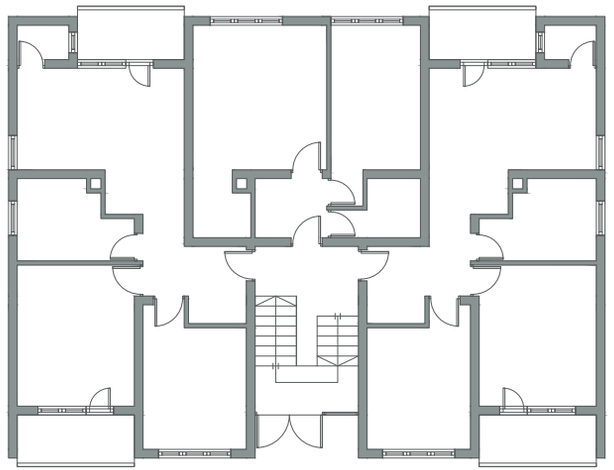
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 10 cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma/garaže) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima.

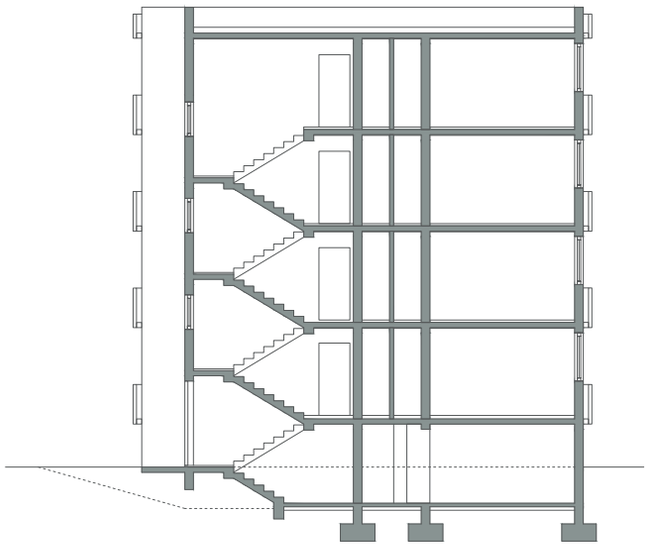
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement/garage) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

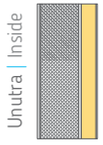
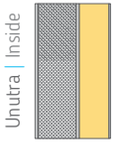
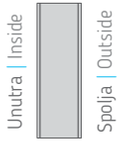
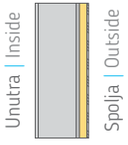
UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog podrumskog prostora s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (stepenište) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

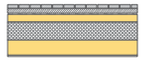
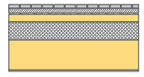
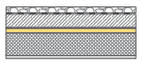
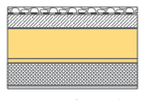
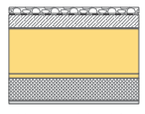
Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated basement with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Insulation of internal walls to unheated areas (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.





	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 25cm, malter 2cm plaster 2cm, clay block wall 25cm, plaster 2cm	 malter 2cm, šuplji opekarski blok 25cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, clay block wall 25cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 25cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, clay block wall 25cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,45 W/m²/K	U = 0,32 W/m²/K	U = 0,18 W/m²/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, AB zid 25cm, malter 2cm plaster 2cm, reinforced concrete wall 25cm, plaster 2cm	 malter 2cm, AB zid 25cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 25cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, AB zid 25cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 25cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 3,17 W/m²/K	U = 0,36 W/m²/K	U = 0,19 W/m²/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, šuplji opekarski blok 25cm, malter 2cm plaster 2cm, clay block wall 25cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, šuplji opekarski blok 25cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m²/K)	U = 1,27 W/m²/K	U = 1,27 W/m²/K	U = 0,49 W/m²/K
PROZORI WINDOWS	 drveni, dvostruki sa spojenim krilima i jednostrukim staklom wooden, single frame, connected double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m²/K)	U = 2,94 W/m²/K	U = 1,60 W/m²/K	U = 1,00 W/m²/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IIZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	Unutra | Inside  Spolja | Outside **parket 2cm, cementna košuljica 3cm, PVC folija, termoizolacija 5cm, AB konstrukcija 15cm** parquet 2cm, cement screed 3cm, PVC foil, thermal insulation 5cm, reinforced concrete slab 15cm	Unutra | Inside  Spolja | Outside **parket 2cm, cementna košuljica 3cm, PVC folija, termoizolacija 5cm, AB konstrukcija 15cm, termoizolacija 10cm, malter 1cm** parquet 2cm, cement screed 3cm, PVC foil, thermal insulation 5cm, reinforced concrete slab 15cm, thermal insulation 10cm, plaster 1cm	Unutra | Inside  Spolja | Outside **parket 2cm, cementna košuljica 3cm, PVC folija, termoizolacija 5cm, AB konstrukcija 15cm, termoizolacija 20cm, malter 1cm** parquet 2cm, cement screed 3cm, PVC foil, thermal insulation 5cm, reinforced concrete slab 15cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 0,55 W/m^2/K	U = 0,24 W/m^2/K	U = 0,15 W/m^2/K
RAVAN KROV FLAT ROOF	Spolja | Outside  Unutra | Inside **šljunak 4cm, hidroizolacija, beton 9cm, krovna ljepenka, termoizolacija 3cm, AB konstrukcija 15cm, malter 2cm** gravel 4cm, waterproofing, concrete 9cm, roofing felt, thermal insulation 3cm, reinforced concrete slab 15cm, plaster 2cm	Spolja | Outside  Unutra | Inside **šljunak 4cm, hidroizolacija, beton 9cm, PE folija, termoizolacija 20cm, termoizolacija 3cm, AB konstrukcija 15cm, malter 2cm** gravel 4cm, waterproofing, concrete 9cm, PE foil, thermal insulation 20cm, thermal insulation 3cm, reinforced concrete slab 15cm, plaster 2cm	Spolja | Outside  Unutra | Inside **šljunak 4cm, hidroizolacija, beton 9cm, PE folija, termoizolacija 30cm, termoizolacija 3cm, AB konstrukcija 15cm, malter 2cm** gravel 4cm, waterproofing, concrete 9cm, PE foil, thermal insulation 30cm, thermal insulation 3cm, reinforced concrete slab 15cm, plaster 2cm
U (W/m^2/K)	U = 0,87 W/m^2/K	U = 0,25 W/m^2/K	U = 0,10 W/m^2/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

(W/K)

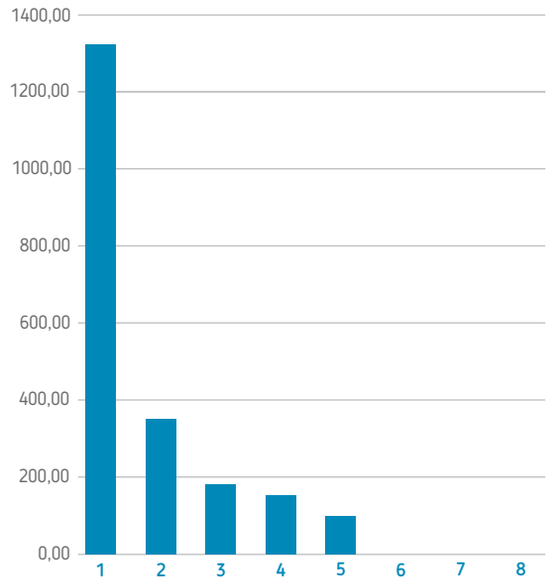
1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ravni krov
4 - Gubici prema negrijanom stepeništu
5 - Gubici kroz negrijani podrum

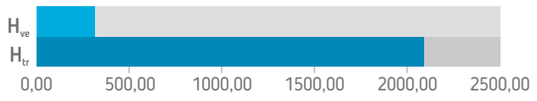
1 - External wall
2 - Windows and balcony doors
3 - Flat roof
4 - To the unheated staircase
5 - Through the unheated basement

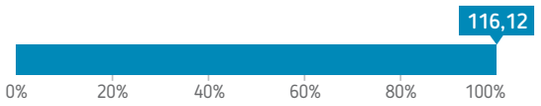
ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)

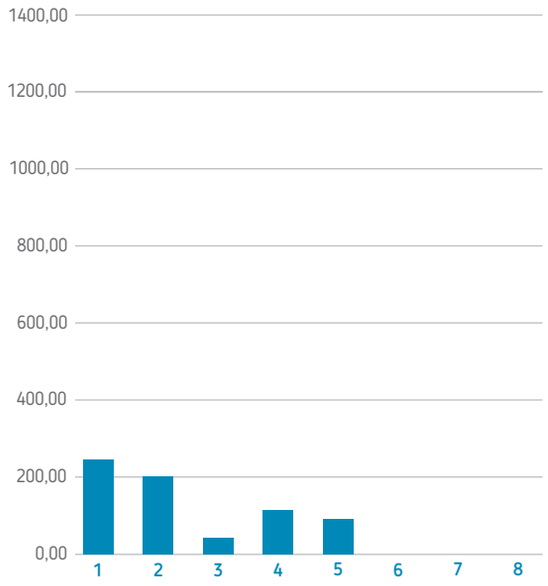
POSTOJEĆE STANJE | CURRENT CONDITION

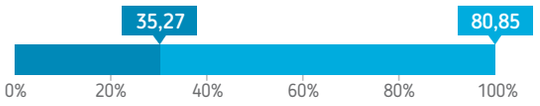




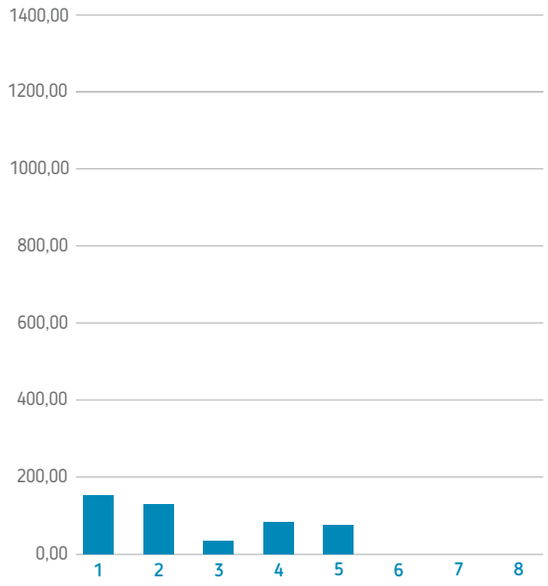


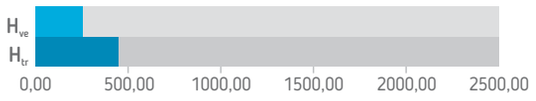
UNAPREĐENJE 1 | IMPROVEMENT 1

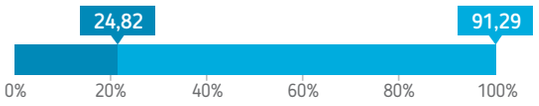


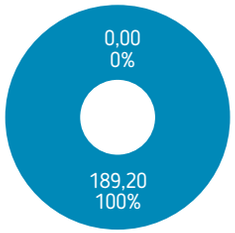
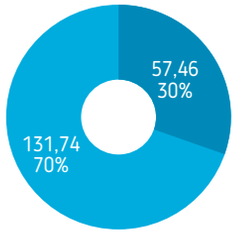
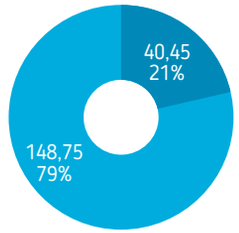
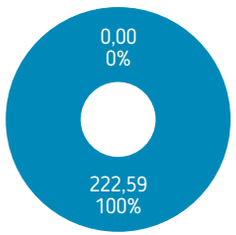
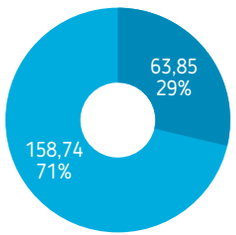
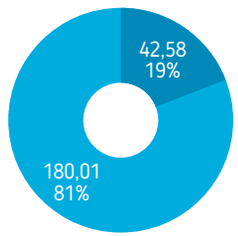
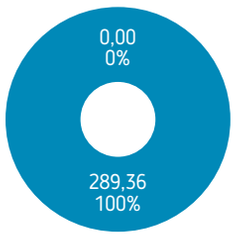
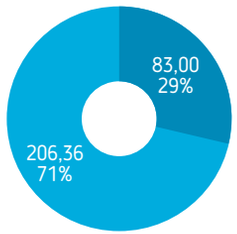
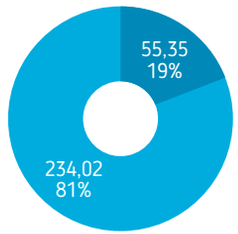
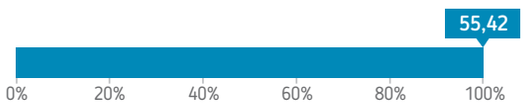
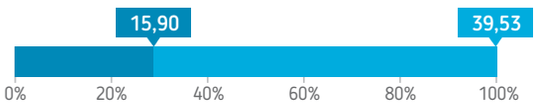
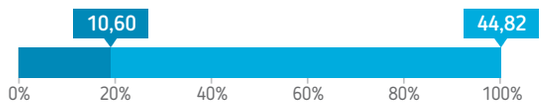


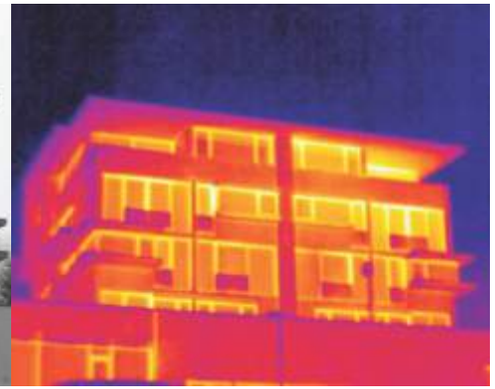
UNAPREĐENJE 2 | IMPROVEMENT 2







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			



OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

F3

Kategorija objekta Building category	**MANJA STAMBENA ZGRADA** **MULTI-FAMILY HOUSE**
Godina izgradnje Built in	**1992-2014.**
Broj etaža Number of floors	**6**
Broj stanova Number of apartments	**15**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**336,34**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**1294,8**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**3574,47**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,55**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**65,22**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**87,14**

Stambena slobodnostojeća zgrada je kompaktne kvadratne osnove s neprohodnim ravnim krovom. Najčešća spratnost objekata iz ove kategorije je od P+3 do P+6. Karakteriše je klasična gradnja, masivni konstruktivni sistem. Konstruktivni zidovi su od armiranog betona debljine 20cm isto kao i vanjski zidovi koji su termički izolovani s fasadnom oblogom od tvrdo presovanih laminata (HPL) i maltera. Međuspratna konstrukcija je armiranobetonska ploča, dok je na krovnoj konstrukciji izvedena termička izolacija sa završnim slojem od šljunka. Vanjski otvori na objektu su od aluminijskih profila s dvostrukim termostaklom. Negrijani prostori u zgradi su stepenišni i djelomično ukopani garažni prostor.

Termovizijski snimak na slobodnostojećoj stambenoj zgradi ukazuje na ujednačenu i ravnomjernu raspoređenost reflektovanih temperatura na vanjskim zidovima bez pojave termičkih mostova, što je pokazatelj malih toplotnih gubitaka. Vanjski otvori imaju dobre termičke karakteristike i mala temperaturna očitanja na ostakljenjima. Tamniji dijelovi su transparentne staklene ograde na mjestima francuskih vrata. Manji linijski gubici mogu se uočiti na promjeni geometrije objekta.

The multi-family house is of compact square base with flat inaccessible roof. Buildings in this category usually have ground floor + 3 to + 6 floors. Typical massive construction. Construction walls are 20cm reinforced concrete, same as the external walls in thermal envelope, and facade in form of Hard-Pressed Laminate (HPL) and plaster. The floors are separated by a reinforced concrete deck, and the roof features thermal insulation with gravel finish. External openings are double glazed thermal windows in aluminium framing. Unheated space includes the staircase and partially underground garage.

The thermovision image of the free-standing residential building shows evenly distributed reflected temperatures on external walls with no thermal bridges, which is indicative of minor heat loss. External openings have good thermal characteristics with low temperature readings on glass surfaces. Darker areas represent transparent glass fences at French doors. Minor linear losses detected in areas where building geometry changes.

***Napomena:** pri proračunu energetskih karakteristika reprezentativnog/tipskog objekta, da bi se adekvatno odgovorilo na prosječne statističke vrijednosti, koje su karakteristične za ovu kategoriju i period objekata, na konkretnom primjeru povećane su vrijednosti U-koeficijenta elemenata omotača.
***Note:** for the purpose of calculating energy performance of the typical building, in order to properly address average statistics typical of the category and age of the buildings, values of the U-coefficient of the envelope elements.

UNAPREĐENJE 1 | IMPROVEMENT 1

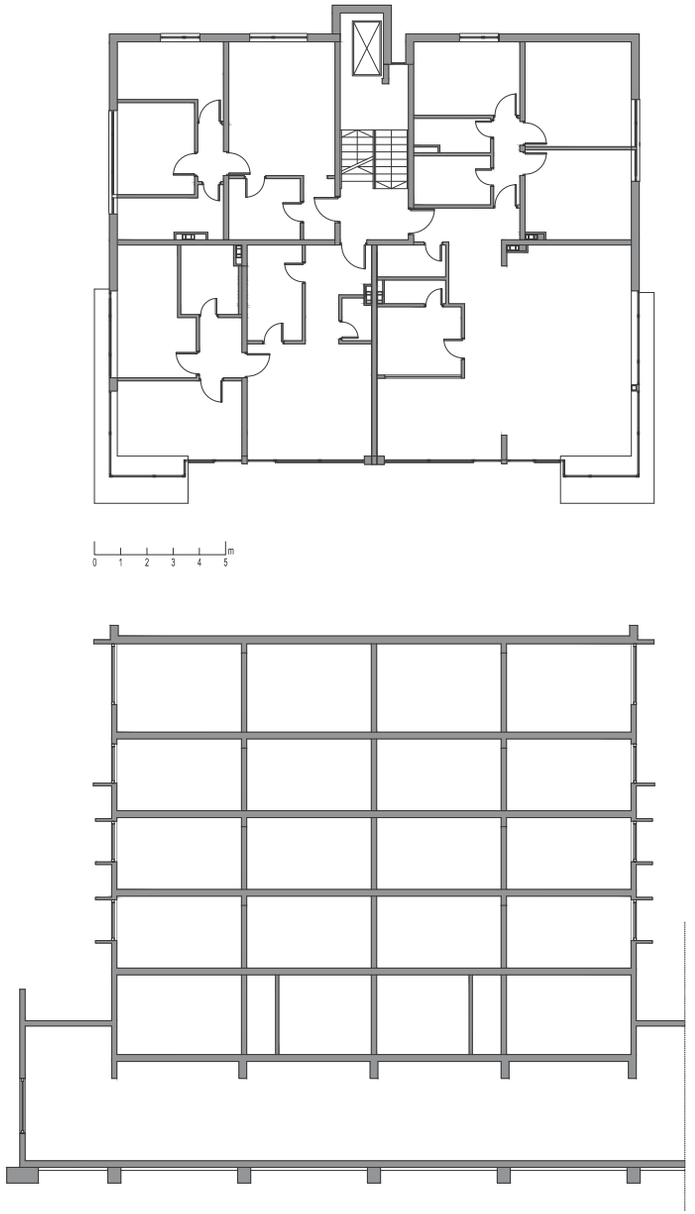
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (garaže) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima.

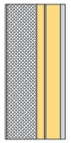
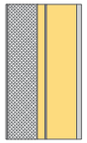
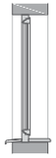
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (garage) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

UNAPREĐENJE 2 | IMPROVEMENT 2

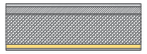
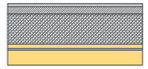
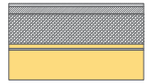
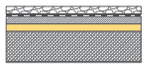
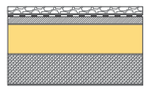
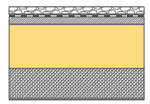
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (garaže) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (stepenište) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (garage) with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Insulation of internal walls to unheated areas (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 1cm, AB zid 20cm, termoizolacija 5cm EPS, fasadni malter 1cm plaster 1cm, reinforced concrete wall 20cm, thermal insulation 5cm EPS, facade plaster 1cm	 malter 1cm, AB zid 20cm, termoizolacija 5cm EPS, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 1cm, reinforced concrete wall 20cm, thermal insulation 5cm EPS, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 1cm, AB zid 20cm, termoizolacija 5cm EPS, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 1cm, reinforced concrete wall 20cm, thermal insulation 5cm EPS, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 0,66 W/m^2/K	U = 0,37 W/m^2/K	U = 0,19 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 1cm, AB zid 20cm, termoizolacija EPS 3cm, malter 1cm plaster 1cm, reinforced concrete wall 20cm, thermal insulation EPS 3cm, plaster 1cm	 NEMA IZMJENA NO CHANGES	 malter 1cm, AB zid 20cm, termoizolacija EPS 3cm, malter 1cm, termoizolacija 5cm, malter 1cm plaster 1cm, reinforced concrete wall 20cm, thermal insulation 3cm EPS, plaster 1cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 0,90 W/m^2/K	U = 0,90 W/m^2/K	U = 0,63 W/m^2/K
PROZORI WINDOWS	 aluminijski s dvostrukim staklom aluminium with double glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 2,20 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IIZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	Unutra | Inside  Spolja | Outside **parket 2cm, estrih 5cm, AB konstrukcija 20cm, termoizolacija 3cm, malter 1cm** parquet flooring 2cm, screed 5cm, reinforced concrete construction 20cm, thermal insulation 3cm, plaster 1cm	Unutra | Inside  Spolja | Outside **parket 2cm, estrih 5cm, AB konstrukcija 20cm, termoizolacija 3cm, malter 1cm, termoizolacija 10cm, malter 1cm** parquet flooring 2cm, screed 5cm, reinforced concrete construction 20cm, thermal insulation 3cm, plaster 1cm, thermal insulation 10cm, plaster 1cm	Unutra | Inside  Spolja | Outside **parket 2cm, estrih 5cm, AB konstrukcija 20cm, termoizolacija 3cm, malter 1cm, termoizolacija 20cm, malter 1cm** parquet flooring 2cm, screed 5cm, reinforced concrete construction 20cm, thermal insulation 3cm, plaster 1cm, thermal insulation 20cm, plaster 1cm
U (W/m²/K)	U = 0,59 W/m²/K	U = 0,24 W/m²/K	U = 0,15 W/m²/K
RAVAN KROV FLAT ROOF	Spolja | Outside  Unutra | Inside **šljunak 5cm, geotekstilna folija, hidroizolacija, estrih 5cm, PE folija, termoizolacija 5cm, parna brana, AB konstrukcija 20cm, malter 1cm** gravel 5cm, geotextile foil, hydro insulation, screed 5cm, PE foil, thermal insulation 5cm, vapour barrier, reinforced concrete construction 20cm, plaster 1cm	Spolja | Outside  Unutra | Inside **šljunak 5cm, geotekstilna folija, hidroizolacija, estrih 5cm, PE folija, termoizolacija 20cm, termoizolacija 5cm, parna brana, AB konstrukcija 20cm, malter 1cm** gravel 5cm, geotextile foil, hydro insulation, screed 5cm, PE foil, thermal insulation 20cm, thermal insulation 5cm, vapour barrier, reinforced concrete construction 20cm, plaster 1cm	Spolja | Outside  Unutra | Inside **šljunak 5cm, geotekstilna folija, hidroizolacija, estrih 5cm, PE folija, termoizolacija 30cm, termoizolacija 5cm, parna brana, AB konstrukcija 20cm, malter 1cm** gravel 5cm, geotextile foil, hydro insulation, screed 5cm, PE foil, thermal insulation 30cm, thermal insulation 5cm, vapour barrier, reinforced concrete construction 20cm, plaster 1cm
U (W/m²/K)	U = 0,51 W/m²/K	U = 0,17 W/m²/K	U = 0,11 W/m²/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

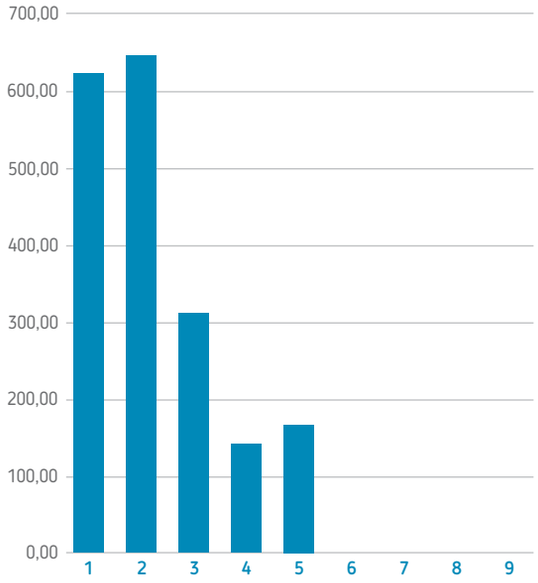
UNAPREĐENJE 2 | IMPROVEMENT 2

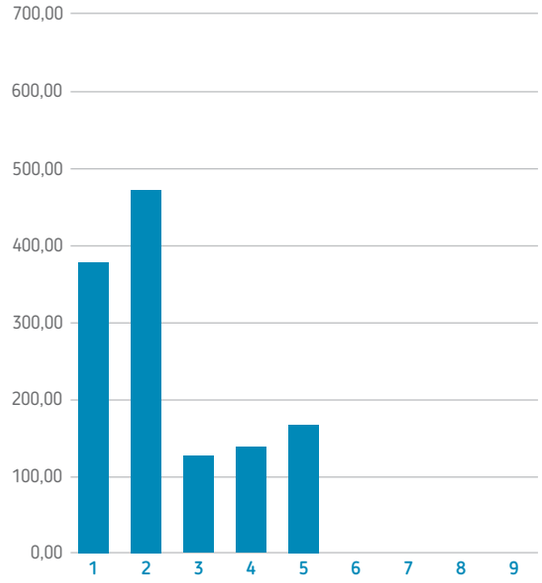
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

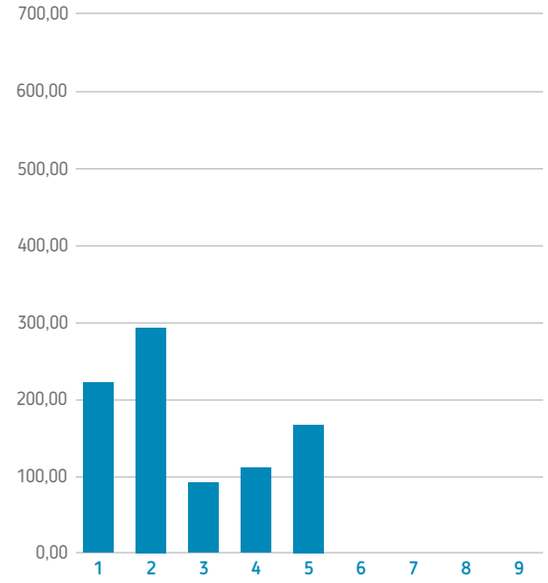
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ravni krov
4 - Gubici prema negrijanom stepeništu
5 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Flat roof
4 - To the unheated staircase
5 - Through the unheated basement

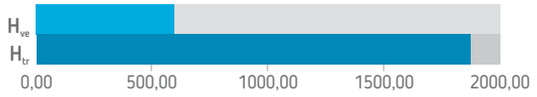


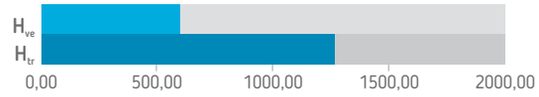


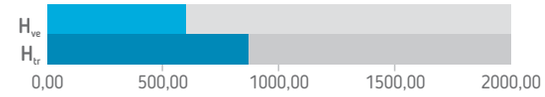


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



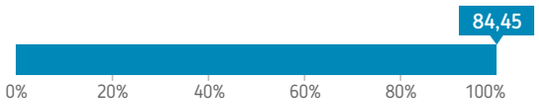


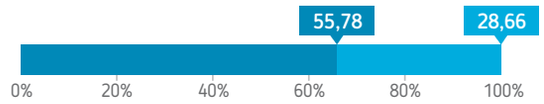


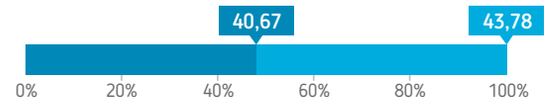
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

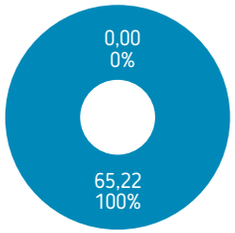
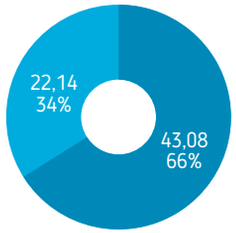
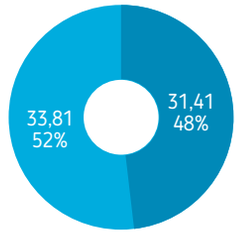
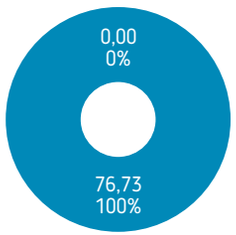
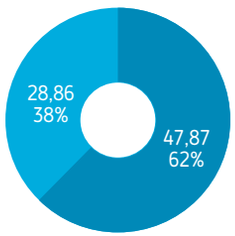
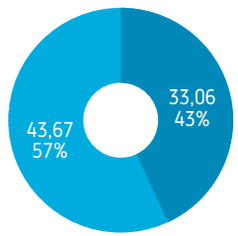
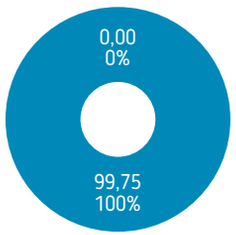
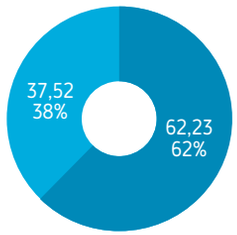
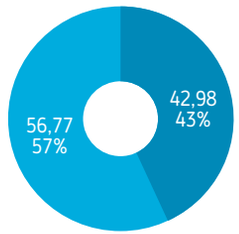
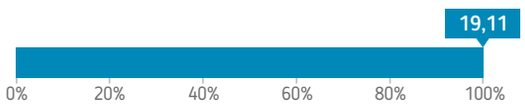
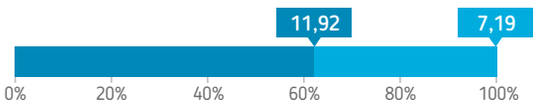
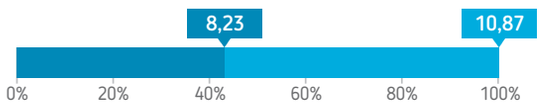
(MWh/god) | (MWh/year)

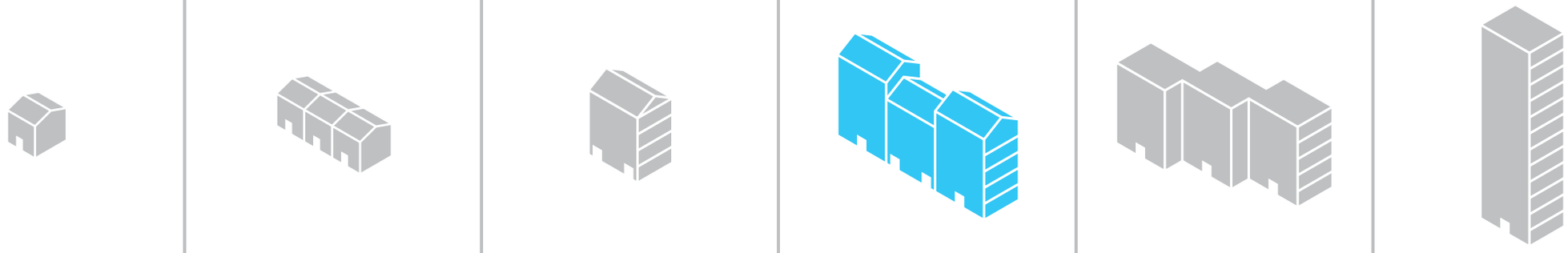
Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			



individualno stanovanje
single-family housing

kolektivno stanovanje
collective housing

STAMBENE ZGRADE U NIZU / GRADSKOM BLOKU
APARTMENT BUILDINGS IN URBAN BLOCKS

<1945 | 1946-1960 | 1961-1970 | 1971-1980 | 1981-1991 | 1992-2014

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

A4

Kategorija objekta Building category	**STAMBENA ZGRADA U NIZU / GRADSKOM BLOKU** **APARTMENT BUILDING IN URBAN BLOCKS**
Godina izgradnje Built in	**Do 1945. | Up to 1945**
Broj etaža Number of floors	**5**
Broj stanova Number of apartments	**10**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**362,3**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**1322,8**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**4249,6**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,52**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**176,08**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**247,83**

Stambena zgrada u nizu je karakteristična za užu gradsku jezgru, s urbanističkom postavkom baziranom na gradskim blokovima. Zgrada je pravougaone osnove s dvovodnim krovom. Za objekte iz ovog perioda karakterističan je masivni konstruktivni sistem, sa zidovima od pune opeke, armiranobetonskim serklažima i bez termoizolacionog omotača. Konstrukcija objekta je klasična, s masivnim zidovima od pune opeke, debljina koje variraju od 30 do 65cm sa završnom obradom od maltera. Međuspratne konstrukcije su sitnorebraste armiranobetonske ploče ukupne visine 40cm, dok je konstrukcija krova drvena s pokrovom od lima. Vanjski otvori na objektu su drveni, dvostruki, s razmaknutim krilima i jednostrukim staklom. Podrumski i stepenišni prostori su negrijani, dok je prizemlje javnog a tavanski prostor stambenog karaktera.

Na termovizijskom snimku stambene zgrade s masivnim zidovima od opeke primjećuje se nepostojanje termoizolacionog sloja, što za posljedicu ima velike toplotne gubitke kroz fasadne zidove, s naglašenim zonama u dijelu horizontalnih i vertikalnih armiranobetonskih serklaža. Evidentan je različiti nivo zagrijavanja prostora unutar objekta. Vanjska stolarija je izrazito loših karakteristika, posebno na ostakljenjima stambenog i stepenišnog prostora gdje su prisutna velika temperaturna očitanja.

Apartment building urban blocks, typical of the city centre, planned on a city block layout. The building is rectangular with a gable roof. Buildings from that period usually feature massive construction system with solid bricks, RC ring beams and without thermal envelope. Walls are traditional, solid brick 30 to 65cm, covered with plaster. Floors are separated by finely-ridged reinforced-concrete plates, 40cm high, and the roof is consisted of a wooden framework and tin sheets. External openings on the building are double single-glazed wood windows, with space between wings. Storage rooms in the basement and staircase are left unheated, and the ground floor is public, while the attic space is residential.

Thermal vision image of the residential building with massive brick walls indicate the lack of insulation, which causes significant heat losses through facade walls, particularly in the area of horizontal and vertical RC ring beams. Different levels of heating of rooms in the building are evident. Window framing is of poor characteristics, especially windows of the residential area and the staircase, which is evident from high temperature readings.

UNAPREĐENJE 1 | IMPROVEMENT 1

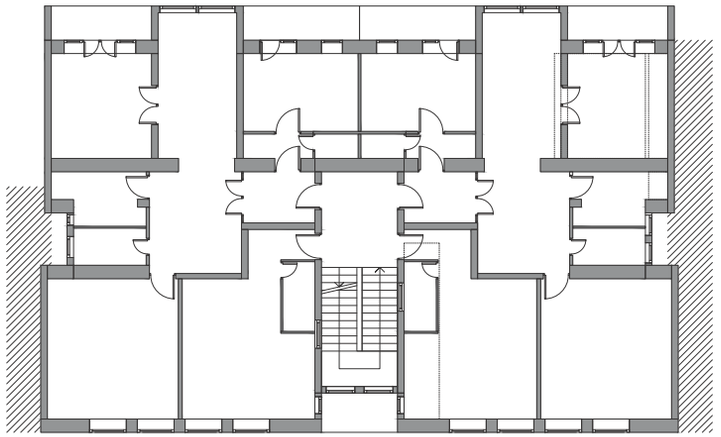
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u podrumu i tavan) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Na dijelu stambenog potkrovnog prostora izolovati kosi krov termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote visoke efikasnosti. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

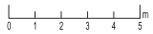
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the basement and in the attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of the steep roof with thermal insulation layer of 20cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, high efficiency pyrolytic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

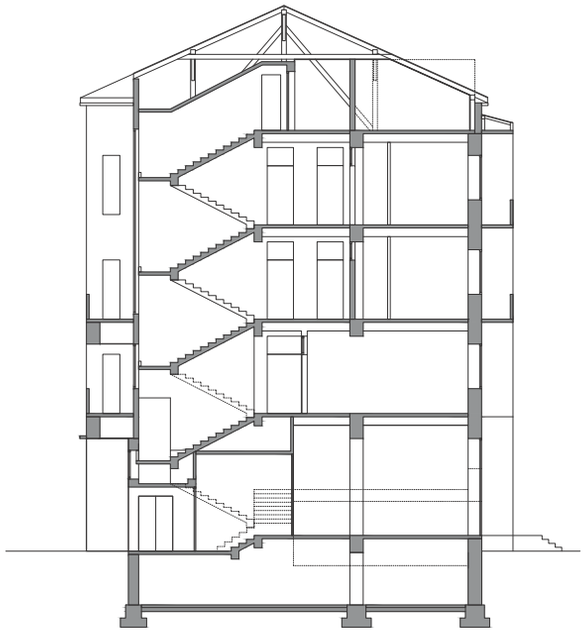
UNAPREĐENJE 2 | IMPROVEMENT 2

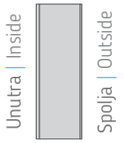
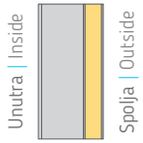
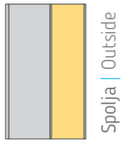
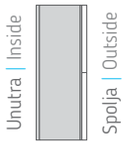
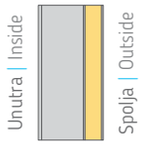
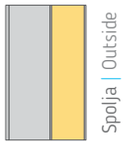
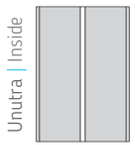
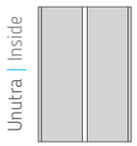
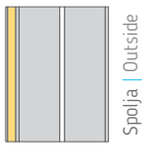
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova (stepenišni prostor i zid prema susjednom objektu) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u podrumu i tavan) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Na dijelu stambenog potkrovnog prostora izolovati kosi krov termoizolacionim slojem debljine 30cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote visoke efikasnosti. Instalacija dopunskog sistema grijanja potrošne tople vode putem sunčevih kolektora. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls (staircase and wall to the adjacent building) with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the basement and in the attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the steep roof above the residential space with thermal insulation layer of 30cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Installing of central heating system for heating and household water on wood or wood pellet, high efficiency pyrolytic boiler with heat accumulator. Installing of additional system for domestic hot water powered by solar energy. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves.

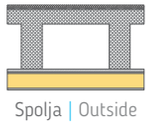
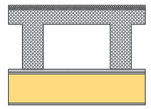






	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,30 W/m²/K	U = 0,31 W/m²/K	U = 0,18 W/m²/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, kamene ploče 3cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, stone slabs 3cm	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 25cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, hollow clay block 25cm, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,28 W/m²/K	U = 0,31 W/m²/K	U = 0,18 W/m²/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 2cm, šuplji opekarski blok 25cm, vazduh (dilatacija) 3cm, šuplji opekarski blok 25cm, malter 2cm plaster 2cm, hollow clay block 25cm, air (dilatation) 3cm, hollow clay block 25cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 gips-kartonske ploče 1,25cm, termoizolacija 5cm, malter 2cm, šuplji opekarski blok 25cm, vazduh (dilatacija) 3cm, šuplji opekarski blok 25cm, malter 2cm gypsum plasterboard 1.25cm, thermal insulation 5cm, plaster 2cm, hollow clay block 25cm, air (dilatation) 3cm, hollow clay block 25cm, plaster 2cm
U (W/m²/K)	U = 1,68 W/m²/K	U = 1,68 W/m²/K	U = 0,54 W/m²/K
PROZORI WINDOWS	 drveni, jednostruki s dvostrukim staklom wooden, single frame with double glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m²/K)	U = 3,00 W/m²/K	U = 1,60 W/m²/K	U = 1,00 W/m²/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 Unutra | Inside Spolja | Outside keramičke pločice 2cm, bitumenski premaz, AB sitnorebrasta konstrukcija 40cm, drvene daske 2cm, malter 1cm ceramic tiles 2cm, bitumen felt, ribbed concrete slab 40cm, wooden floorboards 2cm, plaster 1cm	 Unutra | Inside Spolja | Outside keramičke pločice 2cm, bitumenski premaz, AB sitnorebrasta konstrukcija 40cm, drvene daske 2cm, malter 1cm, termoizolacija 10cm, malter 1cm ceramic tiles 2cm, bitumen felt, ribbed concrete slab 40cm, wooden floorboards 2cm, plaster 1cm, thermal insulation 10cm, plaster 1cm	 Unutra | Inside Spolja | Outside keramičke pločice 2cm, bitumenski premaz, AB sitnorebrasta konstrukcija 40cm, drvene daske 2cm, malter 1cm, termoizolacija 20cm, malter 1cm ceramic tiles 2cm, bitumen felt, ribbed concrete slab 40cm, wooden floorboards 2cm, plaster 1cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 0,97 W/m^2/K	U = 0,29 W/m^2/K	U = 0,17 W/m^2/K
KOSI KROV PITCHED ROOF	 Spolja | Outside Unutra | Inside ravan lim 1cm, hidroizolacija, drvene daske 2cm, rog 10x14cm, termoizolacija 6cm, PVC folija, drvena lamperija 2cm sheet metal 1cm, waterproofing, wooden floorboards 2cm, wooden roof beams 10x14cm, thermal insulation 6cm, PVC foil, wood paneling 2cm	 Spolja | Outside Unutra | Inside ravan lim 1cm, hidroizolacija, drvene daske 2cm, rog 10x14cm, termoizolacija 6cm, termoizolacija 20 cm sa podkonstrukcijom, PE folija, gips-kartonske ploče 1,2cm sheet metal 1cm, waterproofing, wooden floorboards 2cm, wooden roof beams 10x14cm, thermal insulation 6cm, thermal insulation 20cm with substructure, PE foil, gypsum boards 1.2cm	 Spolja | Outside Unutra | Inside ravan lim 1cm, hidroizolacija, drvene daske 2cm, rog 10x14cm, termoizolacija 6cm, termoizolacija 30 cm sa podkonstrukcijom, PE folija, gips-kartonske ploče 1,2cm sheet metal 1cm, waterproofing, wooden floorboards 2cm, wooden roof beams 10x14cm, thermal insulation 6cm, thermal insulation 30cm with substructure, PE foil, gypsum boards 1.2cm
U (W/m^2/K)	U = 0,49 W/m^2/K	U = 0,15 W/m^2/K	U = 0,11 W/m^2/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote, hidrauličkim balansiranjem mreže i termostatstkim ventilima Central heating system - wood or wood pellet, with heat accumulator, hydraulic system balance and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	 0,50	 0,85	 0,90
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

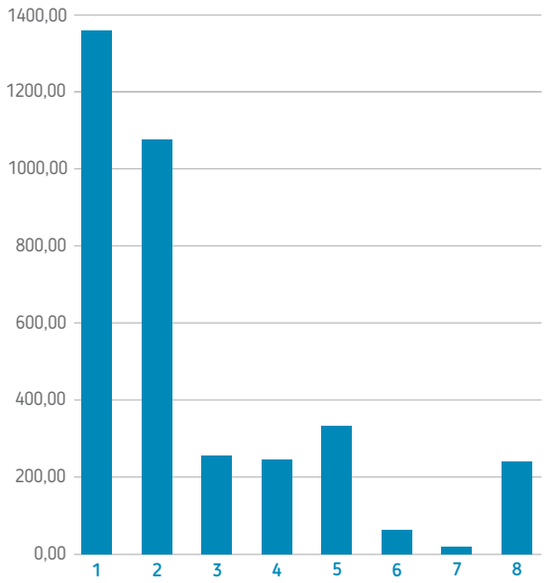
UNAPREĐENJE 2 | IMPROVEMENT 2

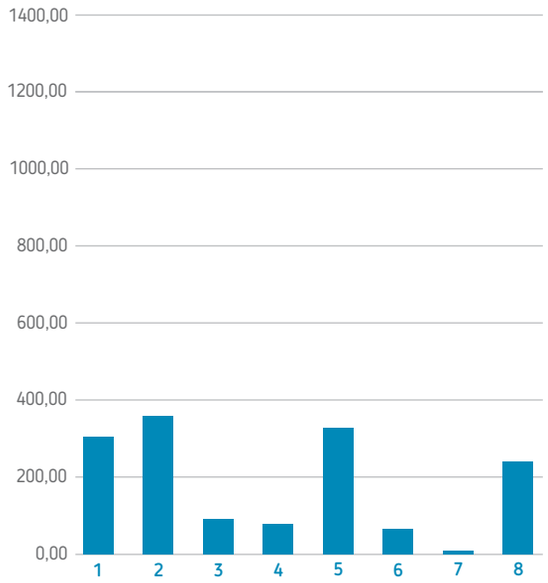
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

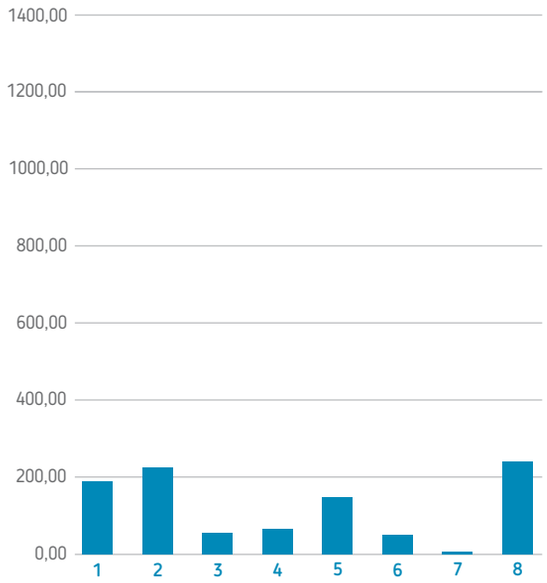
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Kosi krov
5 - Gubici prema negrijanom stepeništu
6 - Zid ka susjednom objektu
7 - Strop prema okolini
8 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance door
4 - Shed roof
5 - To the unheated staircase
6 - Wall to the adjacent building
7 - Ceiling to the surroundings
8 - Through the unheated basement

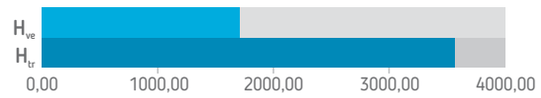






ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

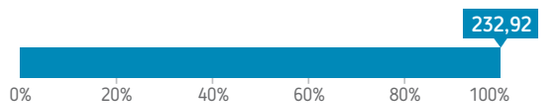
(W/K)

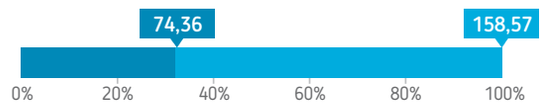


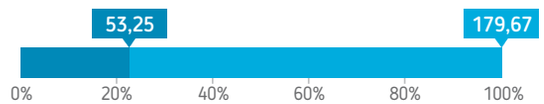
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

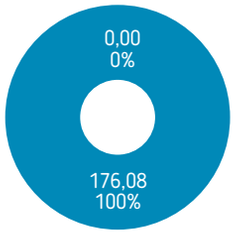
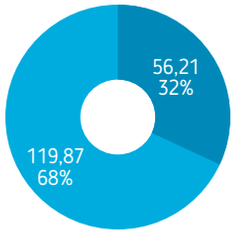
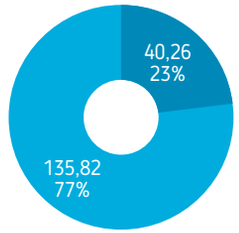
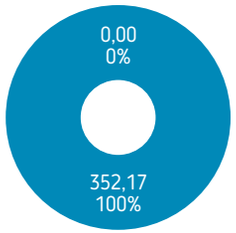
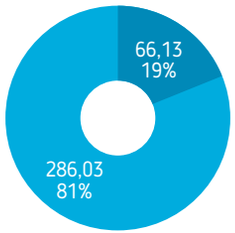
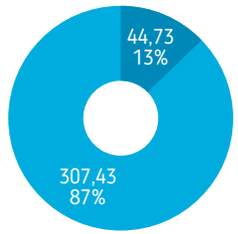
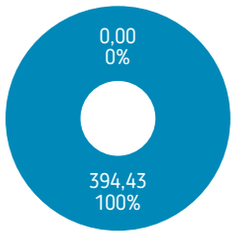
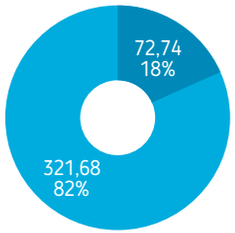
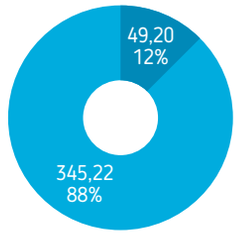
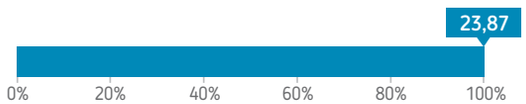
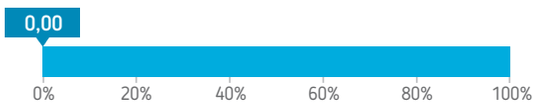
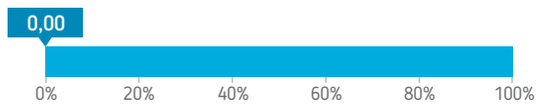
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELETI WOOD OR PELLET	DRVO ILI PELETI WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

B4

Kategorija objekta Building category	**STAMBENA ZGRADA U NIZU / GRADSKOM BLOKU** **APARTMENT BUILDING IN URBAN BLOCKS**
Godina izgradnje Built in	**1946-1960.**
Broj etaža Number of floors	**7**
Broj stanova Number of apartments	**23**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**351,26**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**1556,28**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**4314,95**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,45**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**158,75**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**224,06**

Stambena zgrada u gradskom bloku je pravougaone osnove s djelimično ravnim, neprohodnim i dvovodnim kosim krovom. Za objekte iz ovog perioda karakterističan je masivni konstruktivni sistem s armiranobetonskim serklažima i bez termoizolacionog omotača. Konstrukcija objekta je klasična, sa zidovima od pune opeke čija debljina varira od 25 do 40cm, i sa završnom obradom od maltera. Međuspratne konstrukcije su sitnorebraste armiranobetonske ploče, konstruktivne visine 40cm. Završni sloj neprohodnog ravnog krova je šljunak, dok je konstrukcija dvovodnog krova od drveta s pokrovom od crijepa. Vanjski otvori na objektu su drveni, dvostruki, s razmaknutim krilima i jednostrukim staklom, osim na stepenišnom prostoru gdje je konstrukcija prozora metalna, s jednostrukim ostakljenjem. Ostave u podrumu i stepenišni prostor su negrijani, dok je grijano prizemlje stambeno-poslovnog karaktera.

Termovizijski snimak stambene zgrade u nizu pokazuje izražene gubitke toplote kroz vanjske zidove zbog nepostojanja termičke izolacije, što je vidljivo iz visokih temperaturnih očitanja na površinama vanjskih zidova. Primjetni su nehomogenost vanjskih zidova i različite termičke karakteristike dijelova zidne konstrukcije. Termički mostovi su vidljivi na horizontalnim armiranobetonskim serklažima i natprozornicima, kao i na promjenama u geometriji objekta. Vanjska stolarija na snimku ima loše karakteristike i uočljive su velike razlike prema tipu prozora, a na većem broju njih se može registrovati velika reflektovana temperatura.

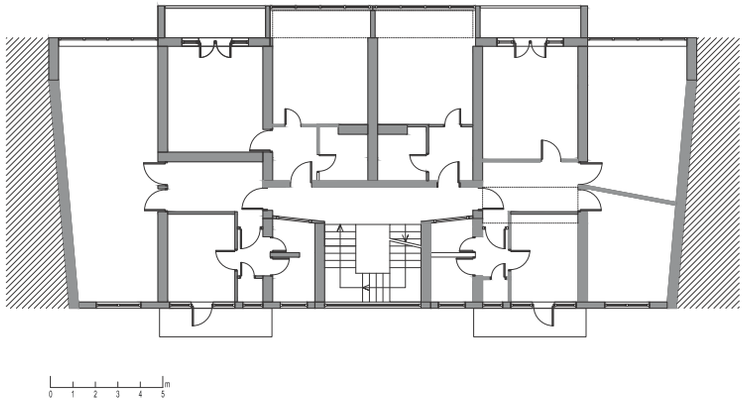
The apartment building in urban blocks is of rectangular footprint, with partially flat, inaccessible gable roof. Buildings from that period usually feature massive construction system with ring beams of reinforced concrete, and without thermal envelope. Walls are traditional, solid brick 25 to 40cm, covered with plaster. Floors are separated by finely-ridged reinforced-concrete plates, 40cm high. Finish on non-accessible roof is gravel, while the gable roof is made of wooden construction covered with roofing tiles. External openings on the building are double single-glazed wood windows, with space between wings, except in stairways, where windows are single, with metal frames. Storage rooms in the basement and stairway are left unheated, while the ground floor used as residential/office space is heated.

The thermovision image shows high readings on external walls indicating significant loss of heat due to the lack of thermal insulation. There are evident lack of homogeneity of external walls, and different thermal characteristics of wall construction sections. Thermal bridges are visible on horizontal RC ring beams and window arches, as well as on changes in the building geometry. External frames show poor performance as well as major differences depending on the window type; high reflected temperature can be registered on majority of them.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u podrumu i tavan) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno Izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote visoke efikasnosti, te niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

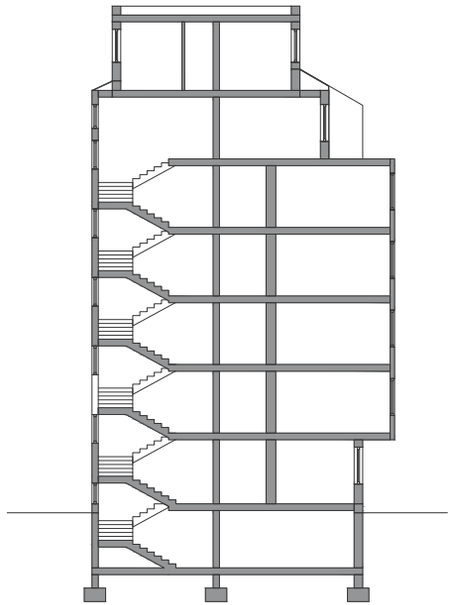
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the basement and on the attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, high efficiency pyrolytic boiler with heat accumulator, and low-temperature heating system with pipes insulated in unheated rooms, operated by a programmable timer according to the outside temperature.

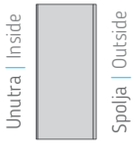
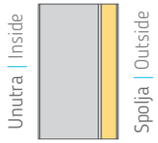
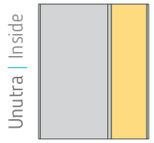
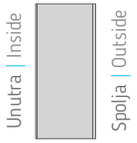
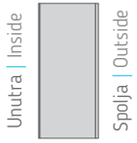
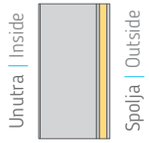
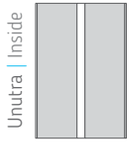
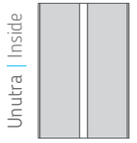
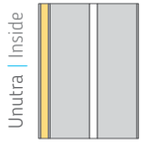
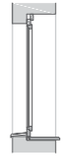
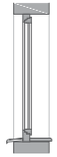


UNAPREĐENJE 2 | IMPROVEMENT 2

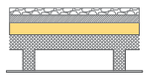
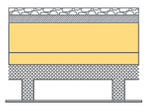
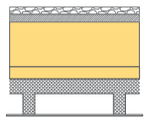
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova (stepenišni prostor i zida prema susjednom objektu) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u podrumu i tavan) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote visoke efikasnosti, te dopunskog sistema grijanja potrošne tople vode putem sunčevih kolektora. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls (stairway and wall to the adjacent building) with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the basement and on the attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, high efficiency pyrolytic boiler with heat accumulator, and additional heating system for domestic hot water powered by solar energy. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 1cm, puna opeka 38cm, malter 2cm plaster 1cm, brick wall 38cm, plaster 2cm	 malter 1cm, puna opeka 38cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 1cm, brick wall 38cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 1cm, puna opeka 38cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 1cm, brick wall 38cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,50 W/m^2/K	U = 0,32 W/m^2/K	U = 0,18 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 1cm, puna opeka 38cm, malter 2cm plaster 1cm, brick wall 38cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 1cm, puna opeka 38cm, malter 2cm, termoizolacija 5cm, malter 2cm plaster 1cm, brick wall 38cm, plaster 2cm, thermal insulation 5cm, plaster 2cm
U (W/m^2/K)	U = 1,28 W/m^2/K	U = 1,28 W/m^2/K	U = 0,50 W/m^2/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 1cm, puna opeka 25cm, vazduh (dilatacija) 5cm, puna opeka 25cm, malter 1cm plaster 1cm, brick wall 25cm, air (dilatation) 5cm, brick wall 25cm, plaster 1cm	 NEMA IZMJENA NO CHANGES	 gips-kartonske ploče 1,25cm, termoizolacija 5cm, malter 1cm, puna opeka 25cm, vazduh (dilatacija) 5cm, puna opeka 25cm, malter 1cm gypsum plasterboard 1.25cm, thermal insulation 5cm, plaster 1cm, brick wall 25cm, air (dilatation) 5cm, brick wall 25cm, plaster 1cm
U (W/m^2/K)	U = 1,72 W/m^2/K	U = 1,72 W/m^2/K	U = 0,54 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki sa jednostrukim staklom wooden, with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,50 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 Unutra | Inside Spolja | Outside keramičke pločice 2cm, bitumenska ljepenka, AB sitnorebrasta konstrukcija 24cm ceramic tiles 2cm, bitumen cardboard, finely ribbed reinforced concrete construction 24cm	 Unutra | Inside Spolja | Outside keramičke pločice 2cm, bitumenska ljepenka, AB sitnorebrasta konstrukcija 24cm, termoizolacija 10cm, malter 1cm ceramic tiles 2cm, bitumen cardboard, finely ribbed reinforced concrete construction 24cm, thermal insulation 10cm, plaster 1cm	 Unutra | Inside Spolja | Outside keramičke pločice 2cm, bitumenska ljepenka, AB sitnorebrasta konstrukcija 24cm, termoizolacija 20cm, malter 1cm ceramic tiles 2cm, bitumen cardboard, finely ribbed reinforced concrete construction 24cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 1,78 W/m^2/K	U = 0,33 W/m^2/K	U = 0,18 W/m^2/K
RAVAN KROV FLAT ROOF	 Spolja | Outside Unutra | Inside šljunak 5cm, hidroizolacija, estrih 5cm, termoizolacija 8cm, parna brana, beton za nagib 10cm, AB sitnorebrasta konstrukcija 24cm, ploče od drvenih vlakana 1,0cm, malter 2cm gravel 5cm, waterproofing, screed 5cm, thermal insulation 8cm, vapour barrier, concrete for inclination 10cm, fine rib reinforced concrete construction 24cm, wood fibre boards 1.0cm, plaster 2cm	 Spolja | Outside Unutra | Inside šljunak 5cm, hidroizolacija, estrih 5cm, termoizolacija 20cm, termoizolacija 8cm, parna brana, beton za nagib 10cm, AB sitnorebrasta konstrukcija 24cm, ploče od drvenih vlakana 1cm, malter 2cm gravel 5cm, waterproofing, screed 5cm, thermal insulation 20cm, thermal insulation 8cm, vapour barrier, concrete for inclination 10cm, fine rib reinforced concrete construction 24cm, wood fibre boards 1.0cm, plaster 2cm	 Spolja | Outside Unutra | Inside šljunak 5cm, hidroizolacija, estrih 5 cm, termoizolacija 30cm, termoizolacija 8cm, parna brana, beton za nagib 10cm, AB sitnorebrasta konstrukcija 24cm, ploče od drvenih vlakana 1cm, malter 2cm gravel 5cm, waterproofing, screed 5cm, thermal insulation 30cm, thermal insulation 8cm, vapour barrier, concrete for inclination 10cm, fine rib reinforced concrete construction 24cm, wood fibre boards 1.0cm, plaster 2cm
U (W/m^2/K)	U = 0,41 W/m^2/K	U = 0,16 W/m^2/K	U = 0,11 W/m^2/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood + coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote, hidrauličkim balansiranjem mreže i termostatstkim ventilima Central heating system - wood or wood pellet, with heat accumulator, hydraulic system balance and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	 0,50	 0,85	 0,90
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

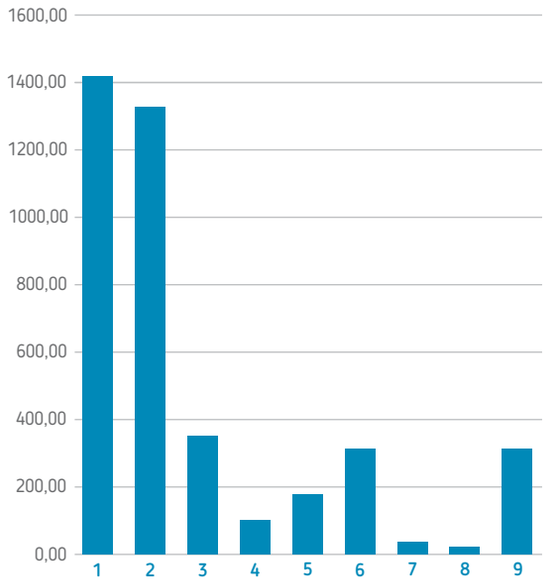
UNAPREĐENJE 2 | IMPROVEMENT 2

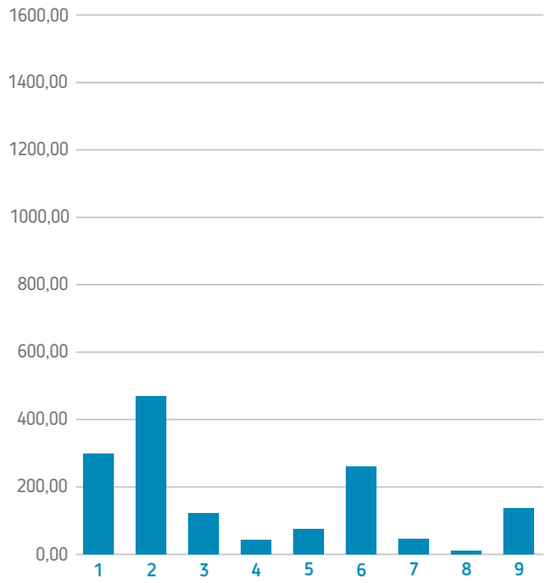
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

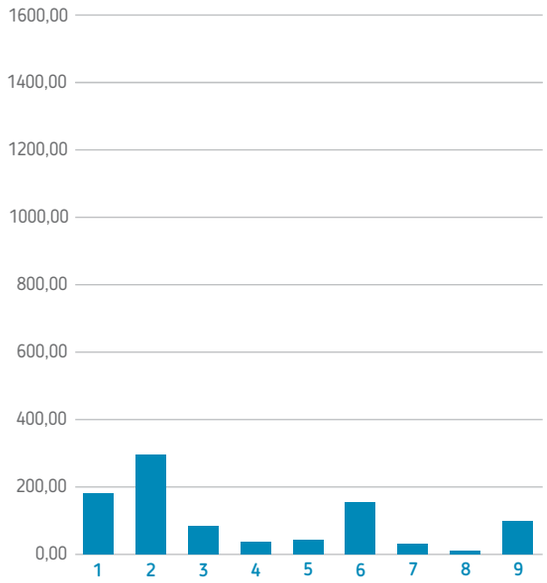
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Ravni krov
5 - Gubici prema negrijanom tavanu
6 - Gubici prema negrijanom stepeništu
7 - Zid ka susjednom objektu
8 - Strop prema okolini
9 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance door
4 - Flat roof
5 - To the unheated attic
6 - To the unheated staircase
7 - Wall to the adjacent building
8 - Ceiling to the surroundings
9 - Through the unheated basement

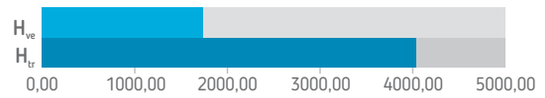


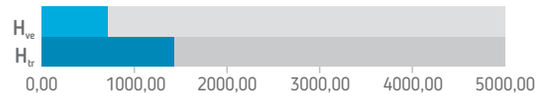


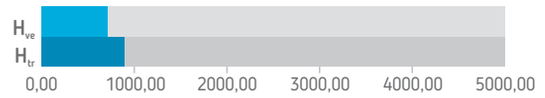


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



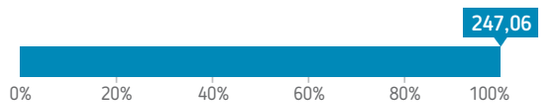


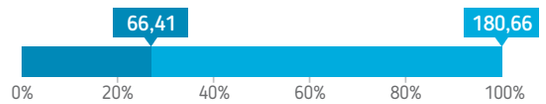


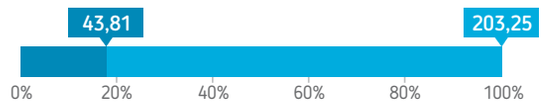
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

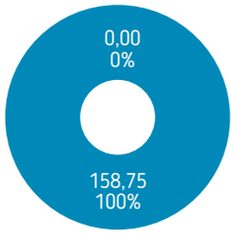
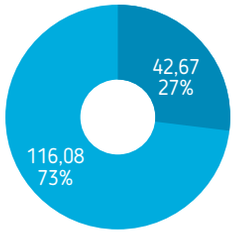
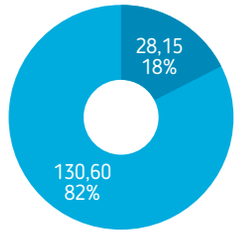
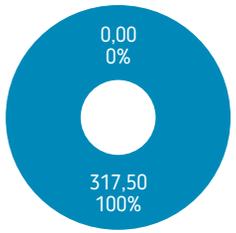
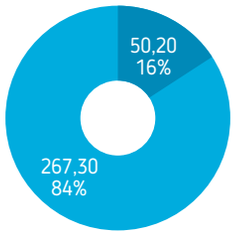
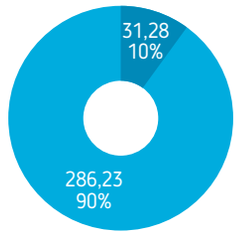
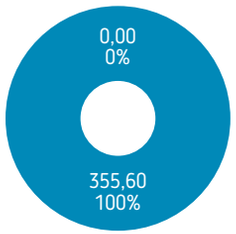
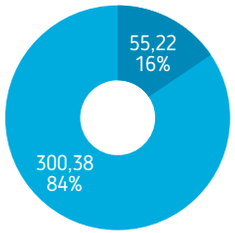
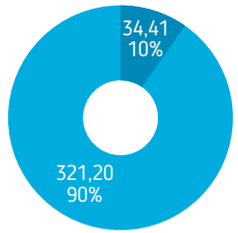
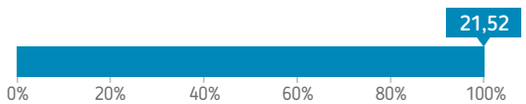
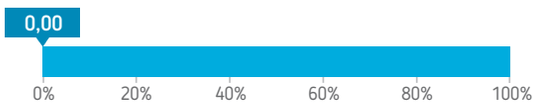
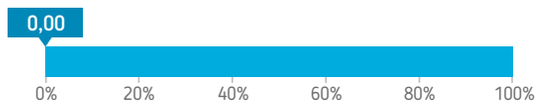
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELETI WOOD OR PELLET	DRVO ILI PELETI WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

STAMBENE ZGRADE U NIZU / GRADSKOM BLOKU
APARTMENT BUILDINGS IN URBAN BLOCKS

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

C4

Kategorija objekta Building category	**STAMBENA ZGRADA U NIZU / GRADSKOM BLOKU** **APARTMENT BUILDING IN URBAN BLOCKS**
Godina izgradnje Built in	**1961-1970.**
Broj etaža Number of floors	**5**
Broj stanova Number of apartments	**25**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**307,55**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**1020,65**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**2652,95**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,50**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**153,05**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**213,58**

Stambena zgrada u gradskom bloku je pravougaone osnove sa kosim viševodnim krovom. Za objekte iz ovog perioda karakterističan je masivni konstruktivni sistem sa horizontalnim armiranobetonskim serklažima i bez termoizolacionog omotača. Konstrukcija objekta je klasična sa zidovima od pune opeke debljine 25cm i sa završnom obradom od maltera a vanjski zidovi u kontaktnoj zoni sa tlom su obrađeni kulirom. Međuspratne konstrukcije su rebraste armiranobetonske ploče sa ispunom od porobetonskih blokova ukupne visine 25cm. Konstrukcija viševodnog krova je drvena sa pokrovom od crijepa. Prozori su drveni, dvostruki sa spojenim krilima, jednostrukim staklom i ugradbenim roletnama. Ostave u podrumu, dio potkrovlja i stepenišni prostor su negrijani.

Termovizijski snimak stambene zgrade u nizu pokazuje visoka temperaturna očitanja što ukazuje na velike gubitke kroz vanjske zidove. Zidovi suterena u kontaktnoj zoni sa tlom, imaju lošije karakteristike i izraženo su svjetlije boje. Uočavaju se termički mostovi na mjestima horizontalnih serklaža, kao i na mjestu spoja fasadnog zida sa krovnom konstrukcijom. Vanjska stolarija, prozori i francuska vrata, pokazuje različite karakteristike, jer je najvećim dijelom zamijenjena u odnosu na izvorno stanje.

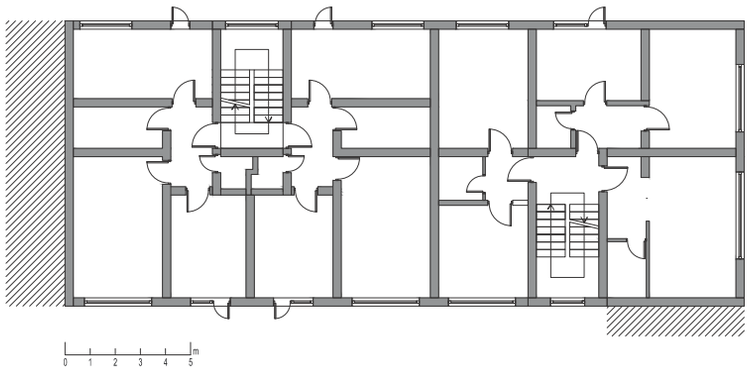
This attached apartment building in urban blocks is of rectangular footprint with steep multi-faceted roof. Buildings from that period usually feature massive construction system with horizontal ring beams of reinforced concrete, and without thermal insulation. Construction is traditional, full 25cm brick covered with plaster, with slapdash on the low line of external walls. Constructions between floors are ridged RC plates filled with porous concrete with total height of 25cm. Multi-faceted roof is placed on a wooden construction and covered with roof tiles. Windows are made of wood, double winged, with wings joined together, single-glazed, and with built-in shades. Storage rooms in the basement, as well as attic and staircase are not heated.

Thermovision image of the apartment building in row shows high readings on external walls indicating significant loss of heat. Basement walls in contact with the ground show poorer characteristics and are prominently lighter in colour. There are evident thermal bridges in horizontal beams and on joints where facade meets the roof construction. External window and door frames show different characteristics, and majority of original framing is replaced.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida kontaktnom fasadom sa termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u podrumu i tavan) sa termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Na dijelu stambenog potkrovnog prostora izolovati kosi krov termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Ugradnja novih prozora sa dostizanjem U-koeficijenta od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice sa regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe sa promjenjivim protokom ili visokoefikasne. Daljinski upravljana podstanica sa mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja sa izolovanim cijevnim vodovima u negrijanim prostorima.

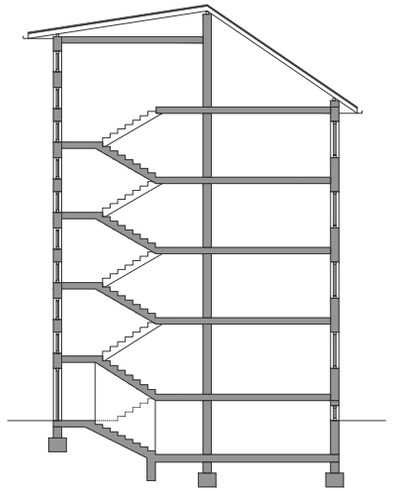
Insulation of external wall with contact facade with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the basement and on the attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of steep roof above the attic apartments using 20cm thermal insulation layer (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a reservoir at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

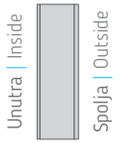
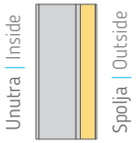
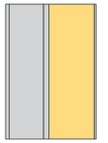
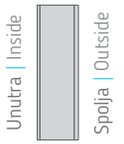
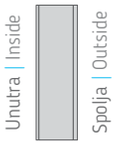
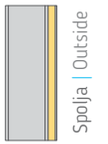
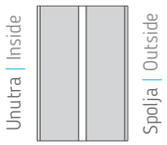
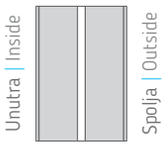
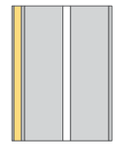


UNAPREĐENJE 2 | IMPROVEMENT 2

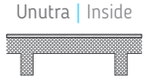
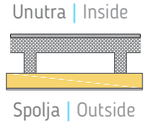
Izolovanje spoljašnjeg zida kontaktnom fasadom sa termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova (stepenišni prostor i zid prema susjednom objektu) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u podrumu i tavan) sa termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Na dijelu stambenog potkrovnog prostora izolovati kosi krov termoizolacionim slojem debljine 30cm (λ=0,041 W/mK). Ugradnja novih prozora sa dostizanjem U-koeficijenta od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice sa regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe sa promjenjivim protokom ili visokoefikasne. Daljinski upravljana podstanica sa mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama sa balans ventilima. Ugradnja ventila sa termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, sa dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls (staircase and wall to the adjacent building) with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the basement and on the attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of steep roof above the attic apartments using 30cm thermal insulation layer (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 25cm, malter 3cm plaster 2cm, brick wall 25cm, plaster 3cm	 malter 2cm, puna opeka 25cm, malter 3cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 3cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 25cm, malter 3cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 25cm, plaster 3cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,79 W/m²/K	U = 0,33 W/m²/K	U = 0,18 W/m²/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, puna opeka 25cm, malter 3cm plaster 2cm, brick wall 25cm, plaster 3cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, puna opeka 25cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, brick wall 25cm, plaster 2cm, thermal insulation 5cm, facade plaster 1cm
U (W/m²/K)	U = 1,62 W/m²/K	U = 1,62 W/m²/K	U = 0,54 W/m²/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 2cm, puna opeka 25cm, vazduh (dilatacija) 5cm, puna opeka 25cm, malter 2cm plaster 2cm, brick wall 25cm, air (dilatation) 5cm, brick wall 25cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 gips-kartonske ploče 1,25cm, termoizolacija 5cm, malter 2cm, puna opeka 25cm, vazduh (dilatacija) 5cm, puna opeka 25cm, malter 2cm gypsum plasterboard 1.25cm, thermal insulation 5cm, plaster 2cm, brick wall 25cm, air (dilatation) 5cm, brick wall 25cm, plaster 2cm
U (W/m²/K)	U = 1,68 W/m²/K	U = 1,68 W/m²/K	U = 0,54 W/m²/K
PROZORI WINDOWS	 drveni, dvostruki sa spojenim krilima i jednostrukim staklom wooden single frame, connected double sash with glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom Windows with triple glazing
U (W/m²/K)	U = 3,50 W/m²/K	U = 1,60 W/m²/K	U = 1,00 W/m²/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 parket 2cm, AB rebrasta konstrukcija 24cm parquet flooring 2cm, fine rib reinforced concrete construction 24cm	 parket 2cm, AB rebrasta konstrukcija 24cm, termoizolacija 10cm, malter 1cm parquet flooring 2cm, fine rib reinforced concrete construction 24cm, thermal insulation 10cm, plaster 1cm	 parket 2cm, AB rebrasta konstrukcija 24cm, termoizolacija 20cm, malter 1cm parquet flooring 2cm, fine rib reinforced concrete construction 24cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 1,64 W/m^2/K	U = 0,33 W/m^2/K	U = 0,18 W/m^2/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana, i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	0,85	0,90	0,95
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

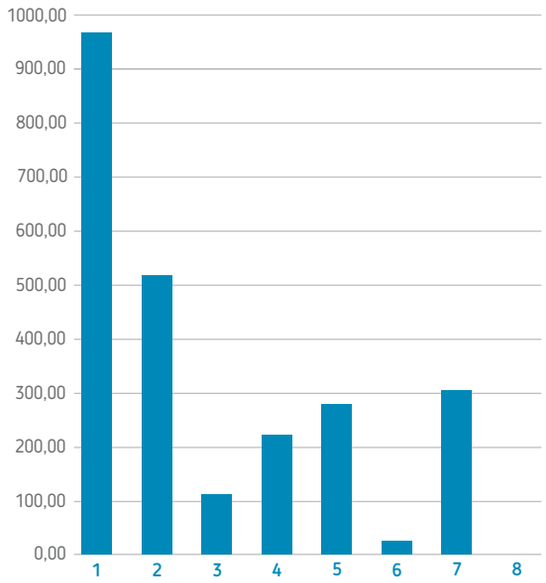
UNAPREĐENJE 2 | IMPROVEMENT 2

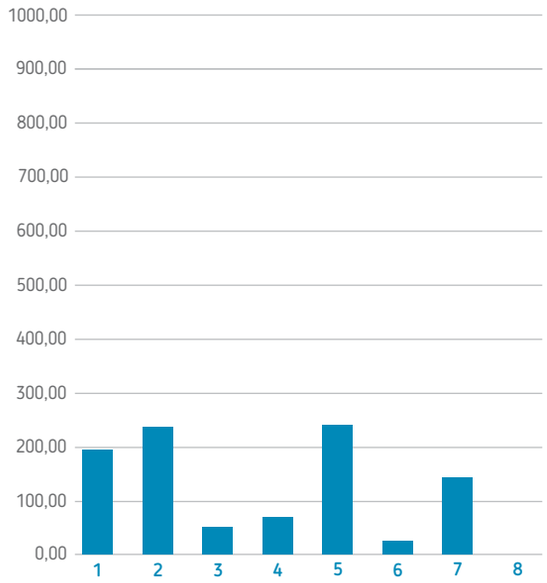
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

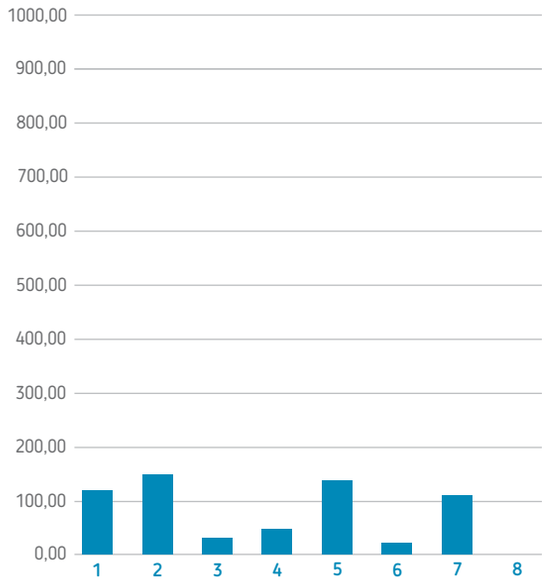
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Gubici prema negrijanom tavanu
5 - Gubici prema egrijanom stepeništu
6 - Zid ka susjednom objektu
7 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance door
4 - To the unheated attic
5 - To the unheated staircase
6 - Wall to the adjacent building
7 - Through the unheated basement

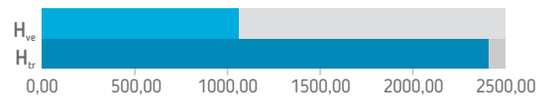


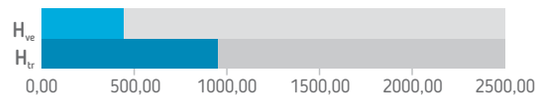


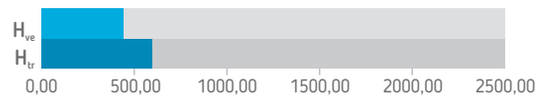


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



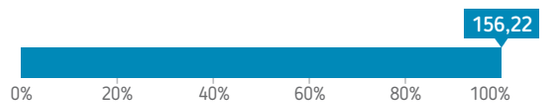


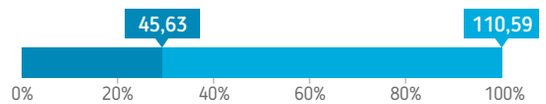


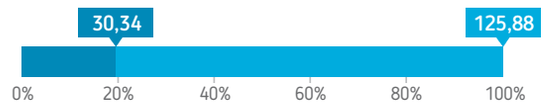
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

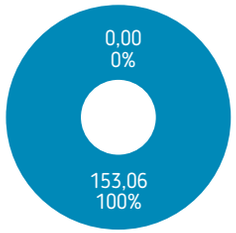
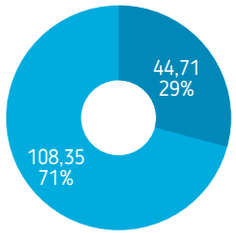
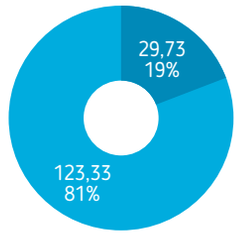
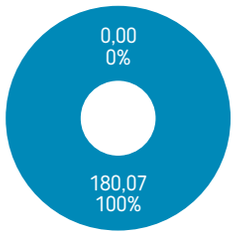
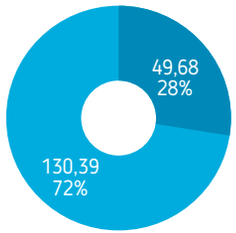
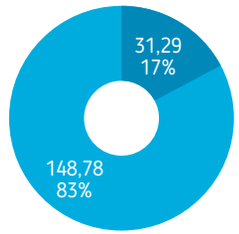
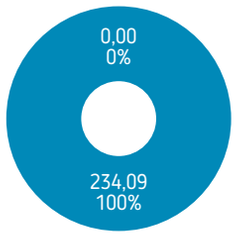
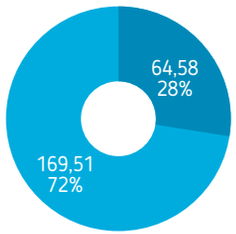
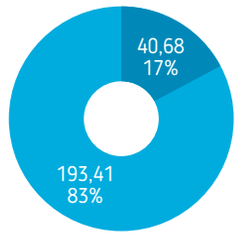
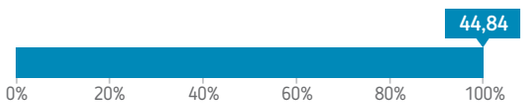
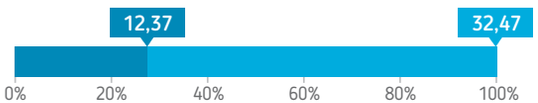
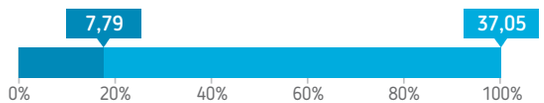
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

E4

Kategorija objekta Building category	**STAMBENA ZGRADA U NIZU / GRADSKOM BLOKU** **APARTMENT BUILDING IN URBAN BLOCKS**
Godina izgradnje Built in	**1981-1991.**
Broj etaža Number of floors	**5**
Broj stanova Number of apartments	**8**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**311,38**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**1046,35**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**2714,59**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,47**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ (kWh/m^2/god) Specific energy need for intermitted heating $Q_{H,nd,interm}$ (kWh/m^2/year)	**93,62**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ (kWh/m^2/god) Specific energy need for continuous heating $Q_{H,nd,cont}$ (kWh/m^2/year)	**132,17**

Stambena zgrada u gradskom bloku je nepravilne osnove s kosim viševodnim krovom. Najčešća spratnost objekata iz ove kategorije je P+3 i P+4. Za objekte iz ovog perioda karakterističan je masivni konstruktivni sistem s horizontalnim i vertikalnim armiranobetonskim serklažima. Vanjski zidovi su izvedeni kao sendvič od blokova opeke debljine 20cm, termoizolacionog sloja debljine 5cm, vazdušnog prostora i finalnog sloja od fasadne opeke debljine 12cm. Međuspratne konstrukcije su monolitne armiranobetonske ploče debljine 15cm, dok je krovna konstrukcija drvena, s pokrovom od profiliranog lima. Vanjski otvori na objektu su drveni, s dvostrukim termostaklom s ugradbenim roletnama. U prizemlju objekta se nalaze grijani poslovni prostori, dok su ostave i stepenišni prostori negrijani.

Termovizijski snimak stambene zgrade u nizu, s vanjskim sendvič zidom i termoizolacionim slojem u sredini, pokazuje ravnomjerne temperature na zidnim plohama s niskim temperaturnim očitanjem, što govori o pravilnoj postavci izolacije. Toplotni gubici su vidljivi na mjestima horizontalnih serklaža koji nisu dovoljno izolovani. Uočljivi su i na svim mjestima gdje je promijenjena geometrija objekta. Zbog različitog stepena zagrijanosti stanova, mogu se uočiti različita temperaturna očitanja na vanjskoj stolariji koja generalno ima loše karakteristike.

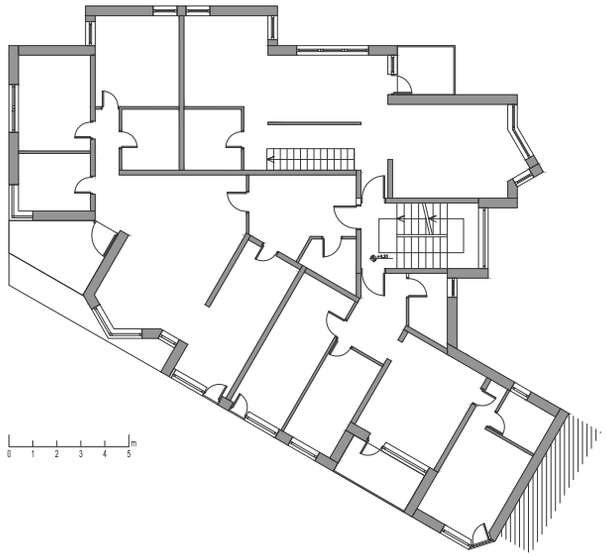
Apartment building in urban blocks of irregular shape with steep, multi-faceted roof. Buildings in this category usually have ground floor + 3 or 4 floors. Buildings from that period usually feature massive construction system with horizontal and vertical ring beams made of reinforced concrete. External walls are built as a sandwich of 20cm bricks, 5cm thermal insulation, air pocket, and final layer of 12cm facade brick. Constructions between floors are monolith 15cm layers of reinforced concrete, and the roof is consisted of a wooden framework and moulded tin sheets. External openings on the building are wooden, with double thermal glass and pre-installed shades. The ground floor includes heated office space, and unheated storage rooms and staircase.

The thermovision image of the apartment building in row, with external sandwich wall with thermal insulation in the middle, shows evenly distributed low temperatures on the walls, which indicates properly installed insulation. Heat loss is visible only along horizontal ring beams with insufficient insulation. Heat loss is also evident on the areas where the shape of the building changed. Due to varying temperature between heated spaces, external temperature readings at window framing of generally poor characteristics also vary.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida s unutrašnje strane termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u prizemlju i tavan) s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima.

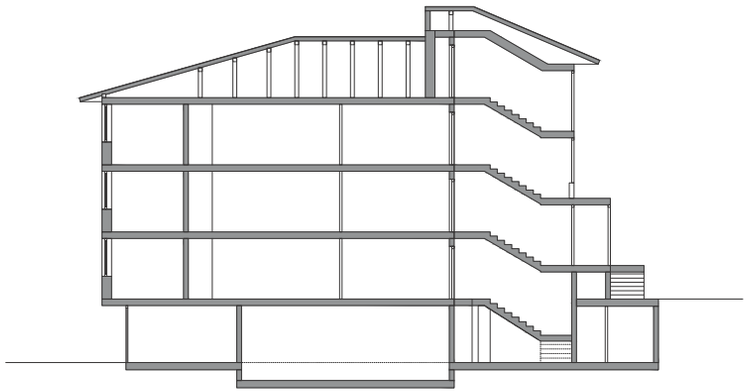
Insulation of external wall on the inside with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage on the ground floor and on the attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

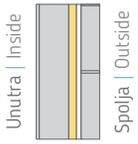
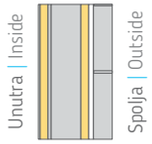
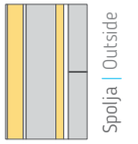
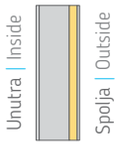
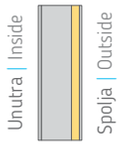
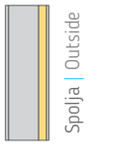
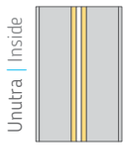
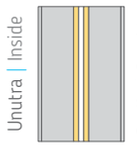
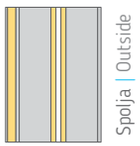


UNAPREĐENJE 2 | IMPROVEMENT 2

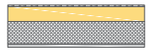
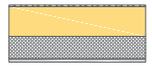
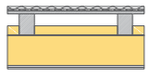
Izolovanje spoljašnjeg zida s unutrašnje strane termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje unutrašnjeg zida prema susjednom objektu termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u podrumu i tavan) s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

Insulation of external wall on the inside with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of internal walls in contact with the next building with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the basement and on the attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circles and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 19cm, termoizolacija 5cm, vazdušni prostor 3cm, puna fasadna opeka 12cm, plaster 2cm, hollow clay block 19cm, thermal insulation 5cm, air space 3cm, full facade clay 12cm	 gips-kartonske ploče 1,2cm, termoizolacija 5cm, malter 2cm, šuplji opekarski blok 19cm, termoizolacija 5cm, vazdušni prostor 3cm, puna fasadna opeka 12cm gypsum plasterboard 1.2cm, thermal insulation 5cm, plaster 2cm, hollow clay block 19cm, thermal insulation 5cm, air space 3cm, full facade clay 12cm	 gips-kartonske ploče 1,2cm, termoizolacija 10cm, malter 2cm, šuplji opekarski blok 19cm, termoizolacija 5cm, vazdušni prostor 3cm, puna fasadna opeka 12cm gypsum plasterboard 1.2cm, thermal insulation 10cm, plaster 2cm, hollow clay block 19cm, thermal insulation 5cm, air space 3cm, full facade clay 12cm
U (W/m²/K)	U = 0,32 W/m²/K	U = 0,23 W/m²/K	U = 0,18 W/m²/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, šuplji opekarski blok 19cm, termoizolacija 5cm, malter 1,5cm plaster 2cm, hollow clay block 19cm, thermal insulation 5cm, plaster 1.5cm	 NEMA IZMJENA NO CHANGES	 NEMA IZMJENA NO CHANGES
U (W/m²/K)	U = 0,53 W/m²/K	U = 0,53 W/m²/K	U = 0,53 W/m²/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 2cm, šuplji opekarski blok 19cm, termoizolacija 3cm, vazduh (dilatacija) 3cm, termoizolacija 3cm, šuplji opekarski blok 19cm, malter 2cm plaster 2cm, hollow clay block 19cm, thermal insulation 3cm, air (dilatation) 3cm, thermal insulation 3cm, hollow clay block 19cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 gips-kartonske ploče 1,2cm, termoizolacija 5cm, malter 2cm, šuplji opekarski blok 19cm, termoizolacija 3cm, vazduh (dilatacija) 3cm, termoizolacija 3cm, šuplji opekarski blok 19cm, malter 2cm gypsum plasterboard 1.2cm, thermal insulation 5cm, plaster 2cm, hollow clay block 19cm, thermal insulation 3cm, air (dilatation) 3cm, thermal insulation 3cm, hollow clay block 19cm, plaster 2cm
U (W/m²/K)	U = 0,74 W/m²/K	U = 0,74 W/m²/K	U = 0,38 W/m²/K
PROZORI WINDOWS	 drveni, jednostruki s dvostrukim staklom wooden frame, with double glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m²/K)	U = 3,50 W/m²/K	U = 1,60 W/m²/K	U = 1,00 W/m²/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA ISPOD NEGRIJANOG TAVANA FLOOR CONSTRUCTION TO UNHEATED ATTIC	Spolja | Outside  Unutra | Inside AB konstrukcija 15cm, malter 2cm reinforced concrete floor 15cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 10cm, parna brana, AB konstrukcija 15cm, malter 2cm thermal insulation 10cm, vapor barrier, reinforced concrete floor 15cm, plaster 2cm	Spolja | Outside  Unutra | Inside termoizolacija 20cm, parna brana, AB konstrukcija 15cm, malter 2cm thermal insulation 20cm, vapor barrier, reinforced concrete floor 15cm, plaster 2cm
U (W/m²/K)	U = 2,39 W/m²/K	U = 0,35 W/m²/K	U = 0,19 W/m²/K
KOSI KROV PITCHED ROOF	Spolja | Outside  Unutra | Inside profisilan lim 2cm, hidroizolacija, drvene daske 2cm, rog 10x14cm, termoizolacija 6cm, PVC folija, gips-kartonske ploče 1,2cm aluform sheets 2cm, waterproofing, wooden floorboards 2cm, wooden roof beams 10x14cm, thermal insulation 6cm, PVC foil, gypsum boards 1.2cm	Spolja | Outside  Unutra | Inside profilisani lim 2cm, hidroizolacija, drvene daske 2cm, rog 10x14cm, termoizolacija 6cm, PE folija, termoizolacija 20 cm sa podkonstrukcijom, PE folija, gips-kartonske ploče 1,2cm aluform sheets 2cm, waterproofing, wooden floorboards 2cm, wooden roof beams 10x14cm, thermal insulation 6cm, PE foil, thermal insulation 20 cm with substructure, PE foil, gypsum boards 1.2cm	Spolja | Outside  Unutra | Inside profisilan lim 2cm, hidroizolacija, drvene daske 2cm, rog 10x14cm, termoizolacija 6cm, PE folija, termoizolacija 30 cm sa podkonstrukcijom, PE folija, gips-kartonske ploče 1,2cm aluform sheets 2cm, waterproofing, wooden floorboards 2cm, wooden roof beams 10x14cm, thermal insulation 6cm, PE foil, thermal insulation 30 cm with substructure, PE foil, gypsum boards 1.2cm
U (W/m²/K)	U = 6,67 W/m²/K	U = 0,20 W/m²/K	U = 0,13 W/m²/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

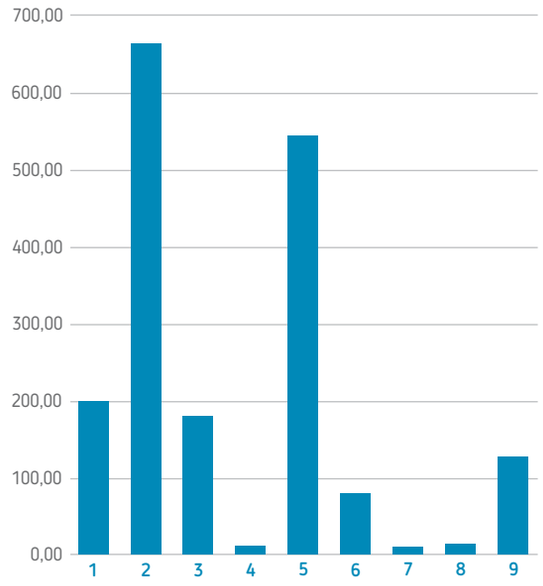
UNAPREĐENJE 2 | IMPROVEMENT 2

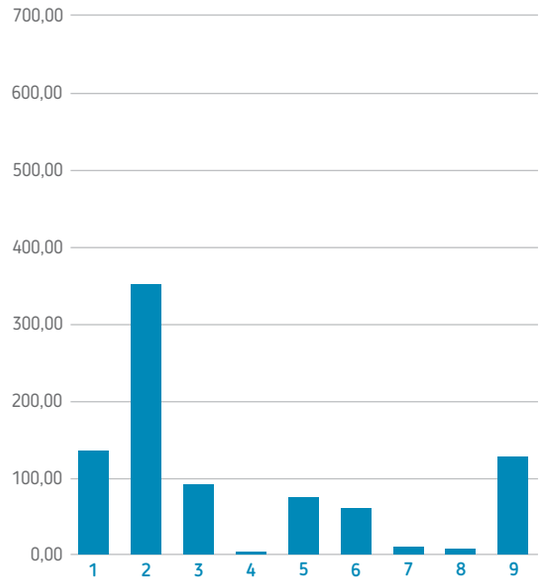
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

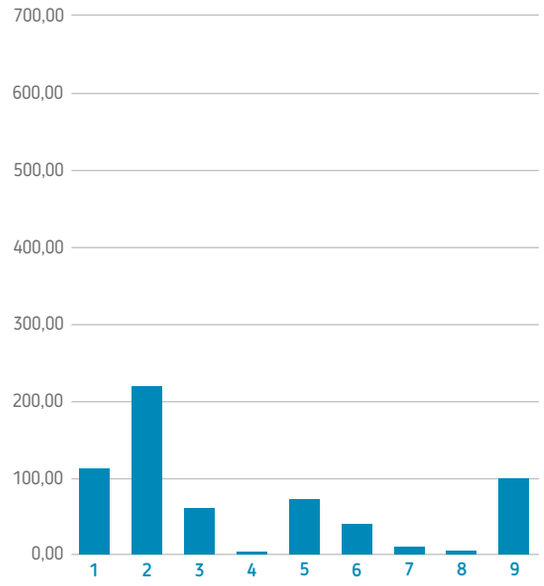
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Kosi krov
5 - Gubici prema negrijanom tavanu
6 - Gubici prema negrijanom stepeništu
7 - Zid ka susjednom objektu
8 - Strop prema okolini
9 - Pod na tlu

1 - External wall
2 - Windows and balcony doors
3 - Entrance door
4 - Sloping roof
5 - To the unheated attic
6 - To the unheated staircase
7 - Wall to the adjacent building
8 - Ceiling to the surroundings
9 - Floor on the ground

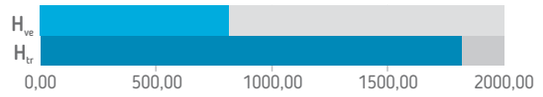


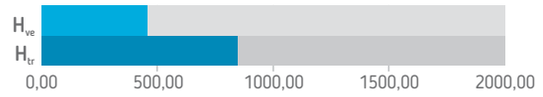


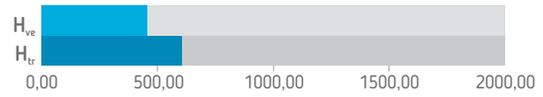


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



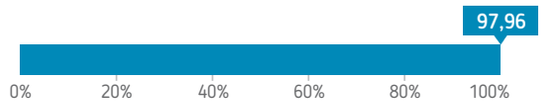


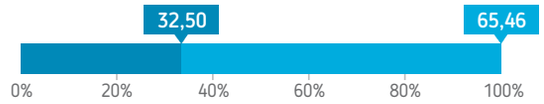


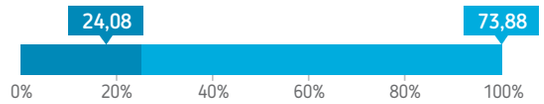
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

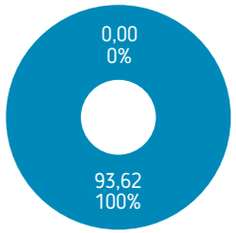
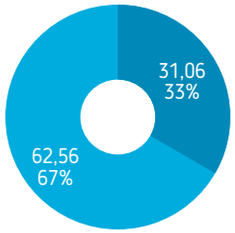
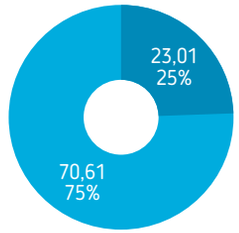
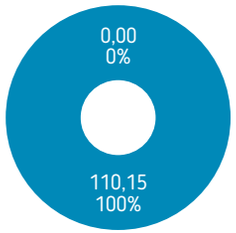
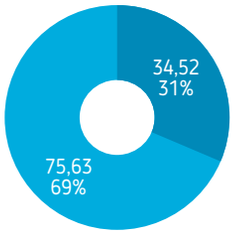
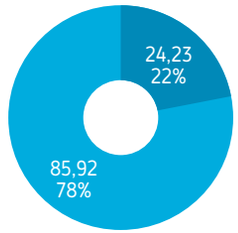
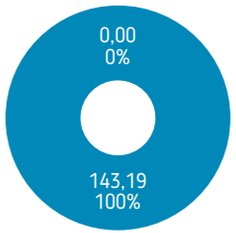
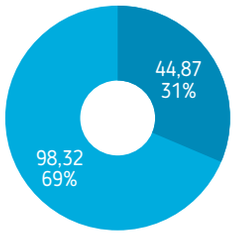
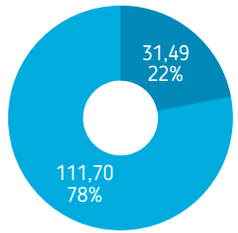
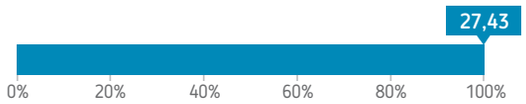
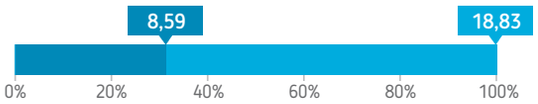
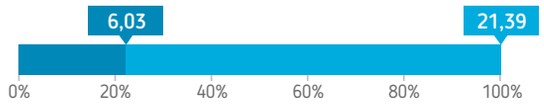
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

F4

Kategorija objekta Building category	**STAMBENA ZGRADA U NIZU / GRADSKOM BLOKU** **APARTMENT BUILDING IN URBAN BLOCKS**
Godina izgradnje Built in	**1992-2014.**
Broj etaža Number of floors	**6**
Broj stanova Number of apartments	**11**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**226,6**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**867,12**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**2232,47**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,59**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**68,06**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**86,30**

Stambena zgrada u gradskom bloku je nepravilne osnove s mansardnim i djelimično ravnim krovom. Vanjski zidovi su masivni, od armiranog betona, debljine 25cm ili zidani porobetonskim blokovima, obloženi različitim kontaktnim termoizolacionim fasadnim sistemima sa završnom obradom u malteru. Međuspratne konstrukcije su izvedene kao monolitne armiranobetonske ploče debljine 12cm, dok je krovna konstrukcija drvena, s pokrovom od lima, s termoizolacionim slojem između konstrukcije. Vanjski otvori na objektu su od PVC profila na spratovima, dok su u prizemlju, u poslovnom dijelu, aluminijski okviri s dvostrukim termostaklom. U suterenu objekta se nalazi garaža koja je, kao i stepenišni prostor, negrijana.

Termovizijski snimak stambene zgrade s izvedenom termoizolacijom pokazuje ravnomjeran raspored reflektovanih temperatura na zidovima bez izrazitih zona toplotnih gubitaka. Vidljiva je manja temperatura na zidovima u poređenju sa susjednim objektima koji nemaju termofasadu. Linijski termički mostovi su primjetni na promjenama geometrije objekta dok vanjska stolarija pokazuje određene toplotne gubitke s manjim temperaturnim očitanjima. Na vanjskim otvorima prizemlja okvir ima veće temperaturno očitanje zbog različitosti u koeficijentu emisivnosti.

Apartment building in urban blocks is of irregular shape with attic roof and partially flat roof. External walls are massive 25cm reinforced concrete walls, or walls made of porous concrete blocks, wrapped in different thermal insulation facade systems, and finished with plaster. Constructions between floors are monolith 12cm layers of reinforced concrete, and the roof is consisted of a wooden framework and moulded tin sheets, with thermal insulation in between. External openings on the building are PVC frames on the upper floors, while the ground floor features aluminium frames with double thermal glass. The basement includes a garage and a staircase, both unheated.

Thermal vision image of the residential building with installed thermal insulation shows equally distributed reflected temperatures on the walls, without significant heat losses. Walls show lower temperatures compared to adjacent buildings without thermal facade. Line thermal bridges can be found where the shape of the building is changed, while window and door frames show some heat loss with lower temperature readings. Frames on the ground floor show higher temperature readings due to the difference in emission coefficient.

***Napomena:** pri proračunu energetskih karakteristika reprezentativnog/tipskog objekta, da bi se adekvatno odgovorilo na prosječne statističke vrijednosti koje su karakteristične za ovu kategoriju i period objekata, na konkretnom primjeru povećane su vrijednosti U-koeficijenta elemenata omotača.
***Note:** for the purpose of calculating energy performance of the typical building, in order to properly address average statistics typical of the category and age of the buildings, values of the U-coefficient of the envelope elements.

UNAPREĐENJE 1 | IMPROVEMENT 1

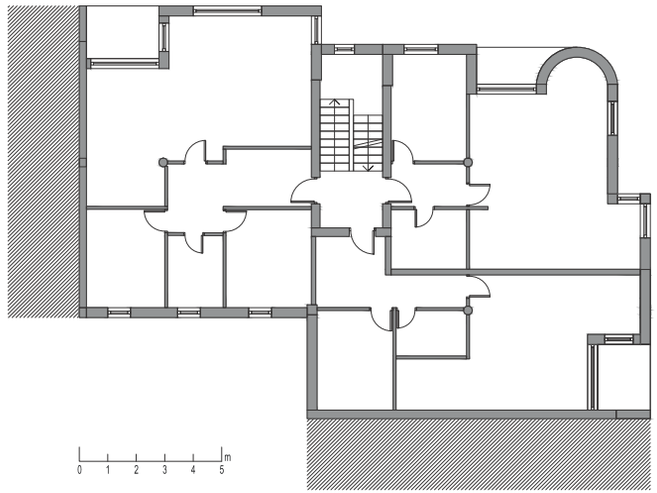
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (garaža u suterenu) s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima.

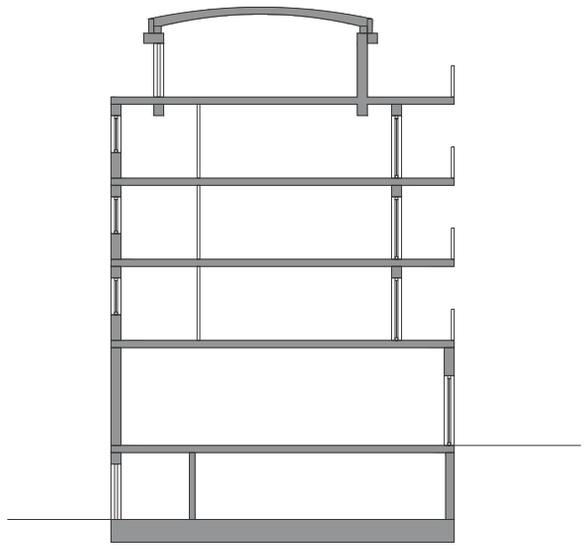
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (garage in the basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

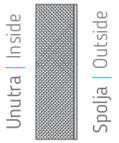
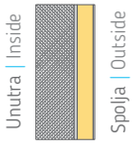
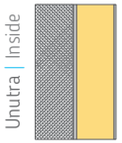
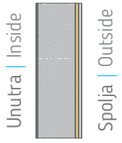
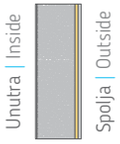
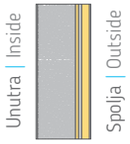
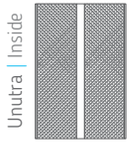
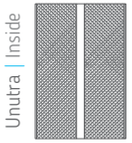
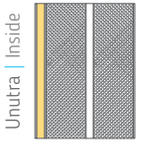
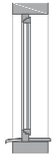
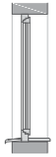
UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova (stepenišni prostor i zid prema susjednom objektu) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (garaža u suterenu) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova s termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

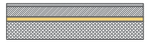
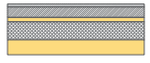
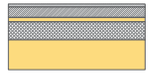
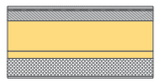
Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls (staircase and wall to the adjacent building) with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (garage in the basement) with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.





	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 AB zid 25cm, malter 2cm reinforced concrete wall 25cm, plaster 2cm	 AB zid 25cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm reinforced concrete wall 25cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 AB zid 25cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm reinforced concrete wall 25cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 3,47 W/m^2/K	U = 0,36 W/m^2/K	U = 0,19 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 1cm, gas-beton 25cm, termoizolacija 2cm, malter 2cm plaster 1cm, aerated concrete 25cm, thermal insulation 2cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 1cm, gas-beton 25cm, termoizolacija 2cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 1cm, aerated concrete 25cm, thermal insulation 2cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 0,36 W/m^2/K	U = 0,36 W/m^2/K	U = 0,25 W/m^2/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 1cm, AB zid 25cm, vazduh (dilatacija) 5cm, AB zid 25cm, malter 1cm plaster 1cm, reinforced concrete wall 25cm, air (dilatation) 5cm, reinforced concrete wall 25cm, plaster 1cm	 NEMA IZMJENA NO CHANGES	 gips-kartonske ploče 1,2cm, termoizolacija 5cm, malter 1cm, AB zid 25cm, vazduh (dilatacija) 5cm, AB zid 25cm, malter 1cm gypsum plasterboard 1.2cm, thermal insulation 5cm, plaster 1cm, reinforced concrete wall 25cm, air (dilatation) 5cm, reinforced concrete wall 25cm, plaster 1cm
U (W/m^2/K)	U = 0,35 W/m^2/K	U = 0,35 W/m^2/K	U = 0,24 W/m^2/K
PROZORI WINDOWS	 PVC s dvostrukim staklom PVC with double glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 2,20 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 Unutra | Inside Spolja | Outside keramičke pločice 1cm, estrih 7cm, termoizolacija 3cm, AB konstrukcija 12cm ceramic tiles 1cm, screed 7cm, thermal insulation 3cm, reinforced concrete construction 12cm	 Unutra | Inside Spolja | Outside keramičke pločice 1cm, estrih 7cm, termoizolacija 3cm, AB konstrukcija 12cm, termoizolacija 10cm, malter 1cm ceramic tiles 1cm, screed 7cm, thermal insulation 3cm, reinforced concrete construction 12cm, thermal insulation 10cm, plaster 1cm	 Unutra | Inside Spolja | Outside keramičke pločice 1cm, estrih 7cm, termoizolacija 3cm, AB konstrukcija 12cm, termoizolacija 20cm, malter 1cm ceramic tiles 1cm, screed 7cm, thermal insulation 3cm, reinforced concrete construction 12cm, thermal insulation 20cm, plaster 1cm
U ($W/m^2/K$)	U = 0,89 $W/m^2/K$	U = 0,28 $W/m^2/K$	U = 0,17 $W/m^2/K$
RAVAN KROV FLAT ROOF	 Spolja | Outside Unutra | Inside keramičke pločice 2cm, hidroizolacija, estrih 7cm, termoizolacija 5cm, AB konstrukcija 12cm, malter 1cm ceramic tiles 1cm, screed 7cm, thermal insulation 3cm, reinforced concrete construction 12cm, thermal insulation 20cm, plaster 1cm	 Spolja | Outside Unutra | Inside keramičke pločice 2cm, hidroizolacija, estrih 7cm, termoizolacija 20cm, termoizolacija 5cm, parna brana, AB konstrukcija 12cm, malter 1cm ceramic tiles 2cm, waterproofing, screed 7cm, thermal insulation 20cm, thermal insulation 5cm, vapour barrier, reinforced concrete construction 12cm, plaster 1cm	 Spolja | Outside Unutra | Inside keramičke pločice 2cm, hidroizolacija, estrih 7cm, termoizolacija 30cm, termoizolacija 5cm, parna brana, AB konstrukcija 12cm, malter 1cm ceramic tiles 2cm, waterproofing, screed 7cm, thermal insulation 30cm, thermal insulation 5cm, vapour barrier, reinforced concrete construction 12cm, plaster 1cm
U ($W/m^2/K$)	U = 0,62 $W/m^2/K$	U = 0,17 $W/m^2/K$	U = 0,11 $W/m^2/K$

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	0,85	0,90	0,95
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

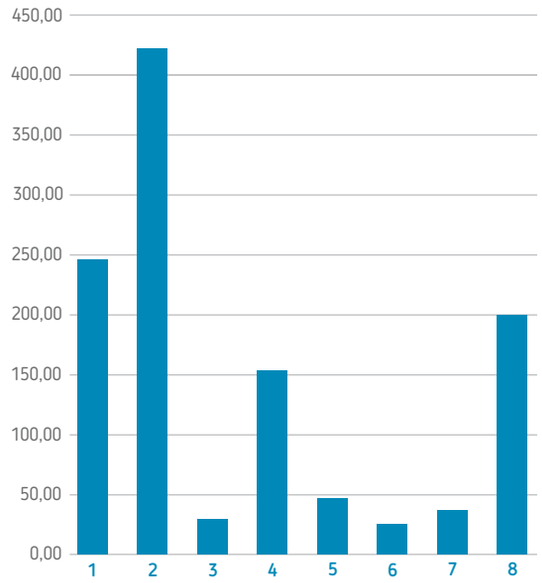
UNAPREĐENJE 2 | IMPROVEMENT 2

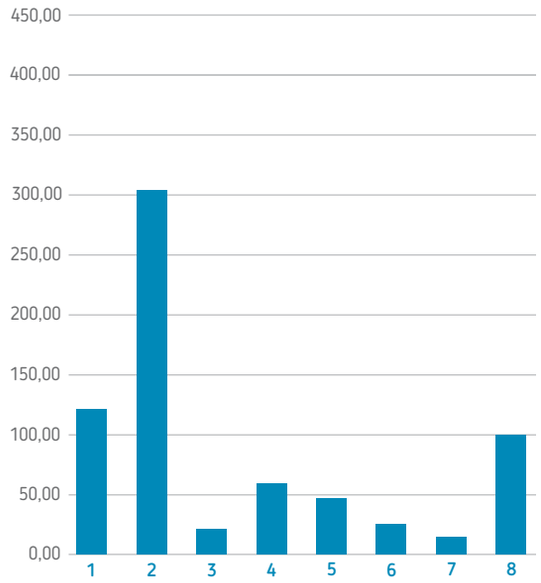
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

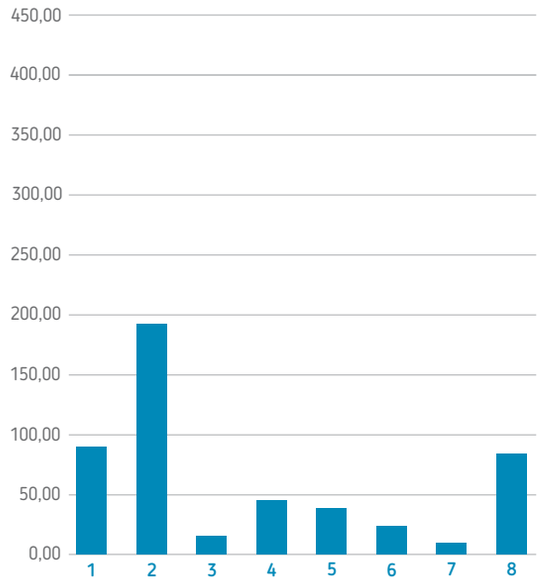
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Ravni krov
5 - Gubici prema negrijanom stepeništu
6 - Zid ka susjednom objektu
7 - Strop prema okolini
8 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance door
4 - Flat roof
5 - To the unheated staircase
6 - Wall to the adjacent building
7 - Ceiling to the surroundings
8 - Through the unheated basement

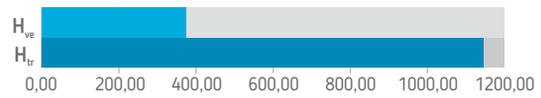


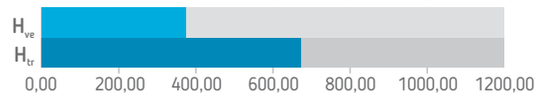


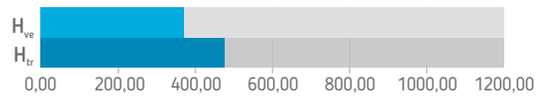


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



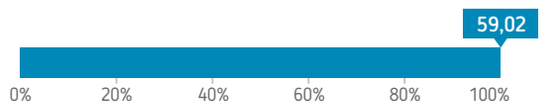


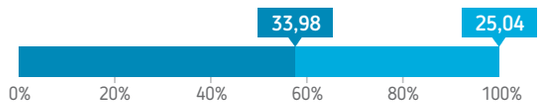


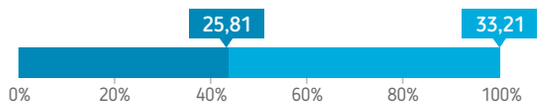
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

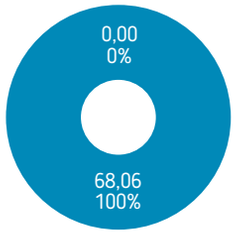
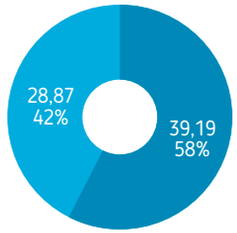
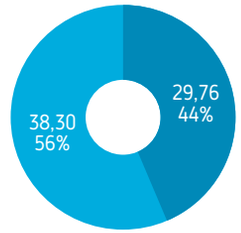
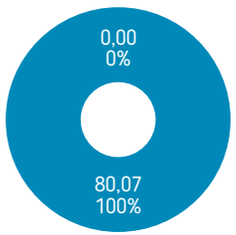
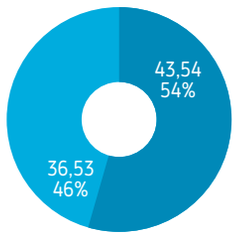
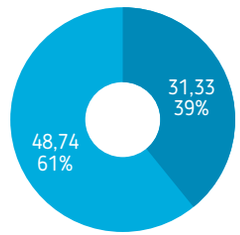
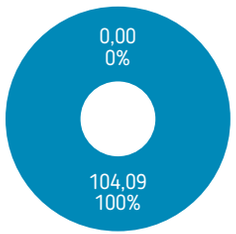
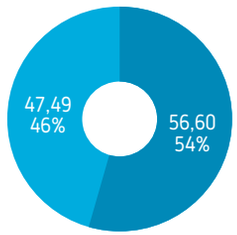
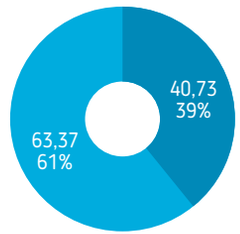
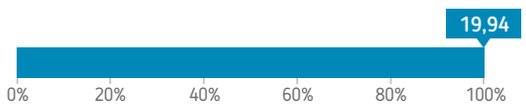
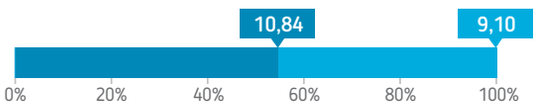
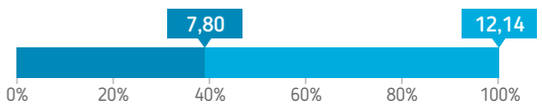
(MWh/god) | (MWh/year)

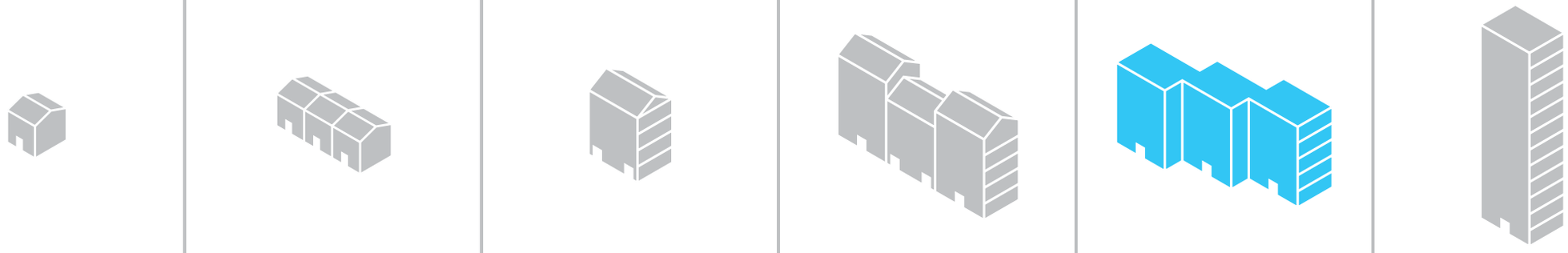
Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			



individualno stanovanje
single-family housing

kolektivno stanovanje
collective housing

VELIKI STAMBENI BLOKOVI / STAMBENE LAMELE
APARTMENT BLOCKS

<1945 | 1946-1960 | 1961-1970 | 1971-1980 | 1981-1991 | 1992-2014

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

B5

Kategorija objekta Building category	**STAMBENA LAMELA** **APARTMENT BLOCK**
Godina izgradnje Built in	**1946-1960.**
Broj etaža Number of floors	**4**
Broj stanova Number of apartments	**11**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**270,24**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**627,94**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**1649,73**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,61**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**176,71**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**249,47**

Stambena lamela je pozicionirana na kosom terenu i formira niz istovjetnih zgrada, s jednostavnim pravougaonim osnovama i prohodnim ravnim krovovima. Najčešća spratnost je od P+1 do P+5. Za objekte iz ovog perioda karakterističan je masivni konstruktivni sistem sa horizontalnim armiranobetonskim serklažima i bez termoizolacionog omotača. Konstrukcija objekta je klasična, sa zidovima od pune opeke varirajućih debljina od 25 do 40cm i sa završnom obradom od maltera. Međuspratne konstrukcije su od sitnorebrastih armiranobetonskih ploča, konstruktivne visine 36cm, a završni sloj ravnog prohodnog krova su kulir ploče. Prozori su drveni, dvostruki, sa spojenim krilima, jednostrukim staklom osim na stepenišnom prostoru gdje su jednostruka armirana stakla ugrađena na otvore od prefabrikovanih betonskih profila. U suterenu je djelimično grijani stambeni prostor, dok veći dio čine ostave koje su negrijane kao i stepenišni prostor.

Termovizijski snimak stambene lamele pokazuje visoka temperaturna očitanja na površinama vanjskih zidova uslijed nepostojanje termičke izolacije. Uočljive su nehomogene strukture vanjskih zidova i njihove različite termičke karakteristike. Termički mostovi vidljivi su na horizontalnim serklažima i natprozornicima. Na termovizijskom snimku vanjske stolarije je registrovana velika reflektovana temperatura uslijed loših karakteristika posebno uočljivih na ostakljenjima.

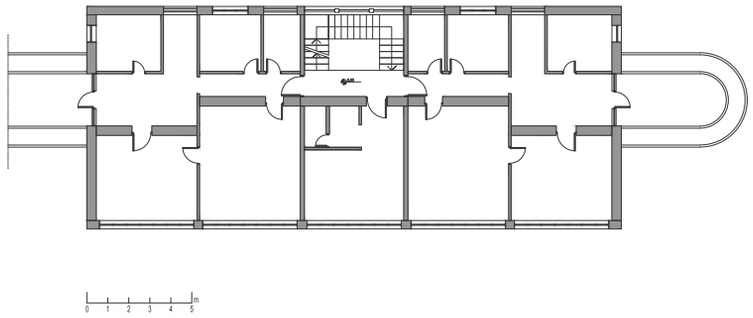
The apartment block is positioned on a slope and forms a series of identical buildings, with simple rectangular base and accessible flat roofs. Buildings in this category usually have ground floor + 1 to + 5 floors. Buildings from that period usually feature massive construction system with horizontal ring beams of reinforced concrete, and without thermal envelope. Walls are traditional, solid brick 25 to 40cm, covered with plaster. Floors are separated by finely-ridged reinforced-concrete plates, 36cm high, and the accessible flat roof is finished with aggregate concrete tiles. External openings on the building are double single-glazed wood windows, with conjoined wings; only staircases feature single reinforced glass layer in concrete framing. The basement features heated residential area, but the major part of space is unheated storage and staircase.

The thermovision image of the block shows high readings on external walls due to the lack of thermal insulation. There is evident lack of homogeneity of external walls, and different thermal characteristics of wall construction sections. Thermal bridges are visible on horizontal ring beams and window arches. The thermovision image of external framings shows high reflected temperature due to poor characteristics, especially on glass surfaces.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u suterenu) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote visoke efikasnosti. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima i upravljan prema spoljnjoj temperaturi s programskim satom.

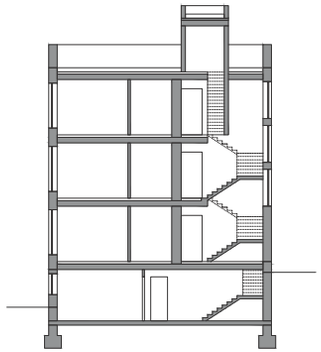
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (garage in the basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, high efficiency pyrolytic boiler with heat accumulator. Low-temperature heating system with insulated pipeline in unheated spaces and operated according to the outside temperature using a programmable timer.

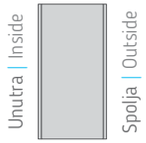
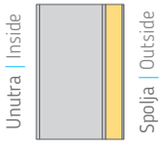
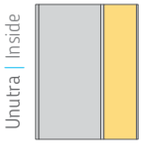
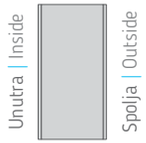
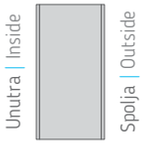
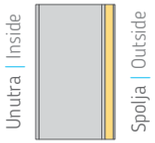


UNAPREĐENJE 2 | IMPROVEMENT 2

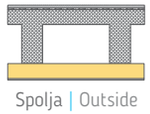
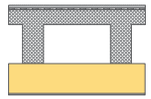
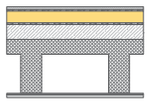
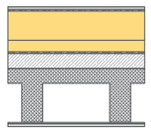
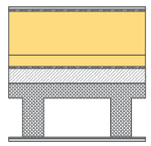
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova (stepenišni prostor) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u suterenu) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Instalacija centralnog sistema grijanja i pripreme potrošne tople vode s kotlom na pelet ili drva, pirolitički kotao s akumulatorom toplote visoke efikasnosti. Instalacija dopunskog sistema grijanja potrošne tople vode putem sunčevih kolektora. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (garage in the basement) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Installing of central heating system for heating and domestic hot water on wood or wood pellet, high efficiency pyrolytic boiler with heat accumulator. Installing of additional system for domestic hot water powered by solar energy. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, puna opeka 38cm, malter 2cm plaster 2cm, brick wall 38cm, plaster 2cm	 malter 2cm, puna opeka 38cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, brick wall 38cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, puna opeka 38cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, brick wall 38cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,37 W/m^2/K	U = 0,31 W/m^2/K	U = 0,18 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, puna opeka 38cm, malter 2cm plaster 2cm, brick wall 38cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, puna opeka 38cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, brick wall 38cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 1,24 W/m^2/K	U = 1,24 W/m^2/K	U = 0,49 W/m^2/K
PROZORI WINDOWS	 drveni, jednostruki s jednostrukim staklom wooden, with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,60 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 Unutra | Inside Spolja | Outside parket 2cm, bitumenski premaz, AB rebrasta konstrukcija 36cm parquet flooring 2cm, bitumen finish, ribbed reinforced concrete construction 36cm	 Unutra | Inside Spolja | Outside parket 2cm, bitumenski premaz, AB rebrasta konstrukcija 36cm, termoizolacija 10cm, malter 1cm parquet flooring 2cm, bitumen finish, ribbed reinforced concrete construction 36cm, thermal insulation 10cm, plaster 1cm	 Unutra | Inside Spolja | Outside parket 2cm, bitumenski premaz, AB rebrasta konstrukcija 36cm, termoizolacija 20cm, malter 1cm parquet flooring 2cm, bitumen finish, ribbed reinforced concrete construction 36cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 1,63 W/m^2/K	U = 0,32 W/m^2/K	U = 0,18 W/m^2/K
RAVAN KROV FLAT ROOF	 Spolja | Outside Unutra | Inside kulir ploče 2cm, hidroizolacija, termoizolacija 8cm, parna brana, nagibni beton 10cm, AB rebrasta konstrukcija 36cm, ploče od drvenih vlakana 1cm, malter 2cm exposed aggregate concrete slabs 2cm, waterproofing, thermal insulation 8cm, vapour barrier, inclined concrete 10cm, ribbed reinforced concrete construction 36cm, wood fibre boards 1.0cm, plaster 2cm	 Spolja | Outside Unutra | Inside kulir ploče 2cm, hidroizolacija, termoizolacija 20cm, termoizolacija 8cm, parna brana, nagibni beton 10cm, AB rebrasta konstrukcija 36cm, ploče od drvenih vlakana 1cm, malter 2cm exposed aggregate concrete slabs 2cm, waterproofing, thermal insulation 20cm, vapour barrier, inclined concrete 10cm, ribbed reinforced concrete construction 36cm, wood fibre boards 1.0cm, plaster 2cm	 Spolja | Outside Unutra | Inside kulir ploče 2cm, hidroizolacija, termoizolacija 30cm, termoizolacija 8cm, parna brana, nagibni beton 10cm, AB rebrasta konstrukcija 36cm, ploče od drvenih vlakana 1cm, malter 2cm exposed aggregate concrete slabs 2cm, waterproofing, thermal insulation 30cm, thermal insulation 8cm, vapour barrier, inclined concrete 10cm, ribbed reinforced concrete construction 36cm, wood fibre boards 1.0cm, plaster 2cm
U (W/m^2/K)	U = 0,39 W/m^2/K	U = 0,16 W/m^2/K	U = 0,11 W/m^2/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Pojedinačne peći na čvrsto gorivo (drvo+ugalj) Individual solid fuel-burning furnaces (wood+coal)	 Centralni sistem grijanja na drva ili pelet Central heating system - wood or wood pellet	 Centralni sistem grijanja na drva ili pelet, s akumulatorom toplote, hidrauličkim balansiranjem mreže i termostatstkim ventilima Central heating system - wood or wood pellet, with heat accumulator, hydraulic system balance and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	 0,50	 0,85	 0,90
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora Central domestic hot water system in conjunction with a heating system and solar collector system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

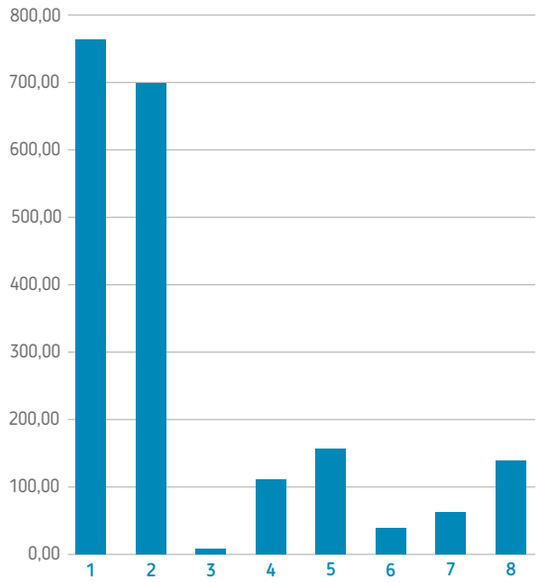
UNAPREĐENJE 2 | IMPROVEMENT 2

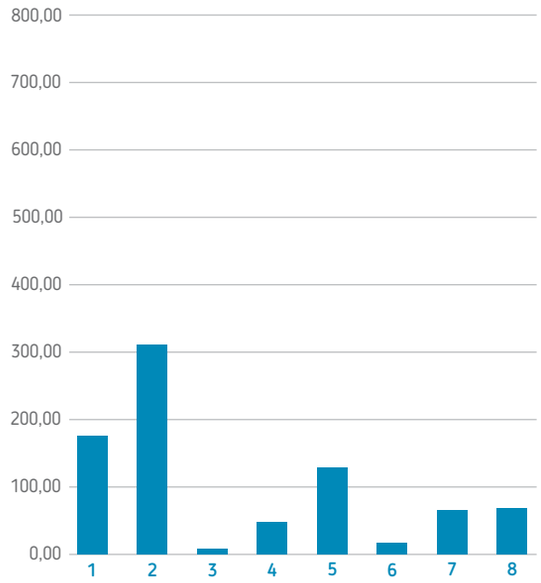
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

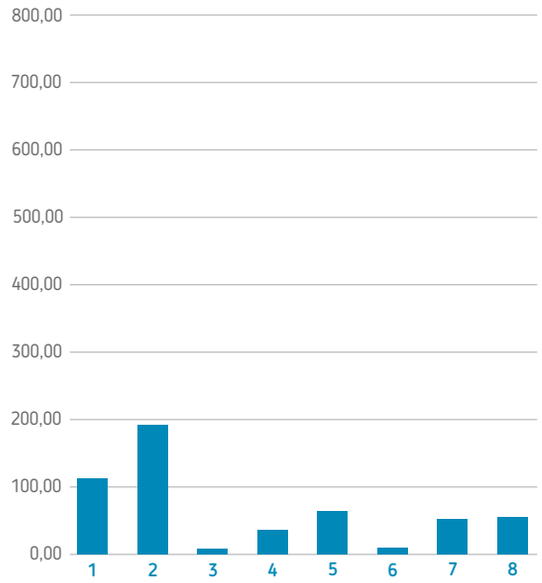
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Ravni krov
5 - Gubici prema negrijanom stepeništu
6 - Strop prema okolini
7 - Gubici kroz grijani podrum
8 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance door
4 - Flat roof
5 - To the unheated staircase
6 - Ceiling to the surroundings
7- Through the heated basement
8 - Through the unheated basement

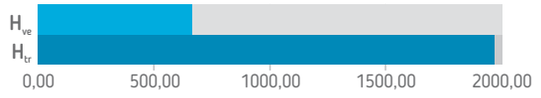


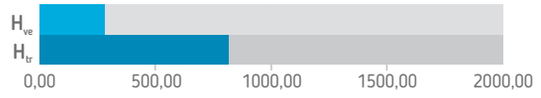


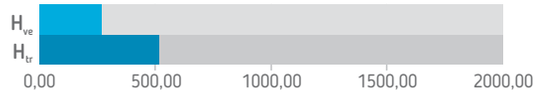


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



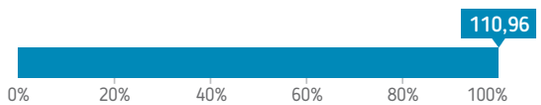


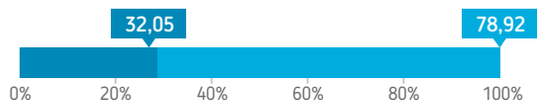


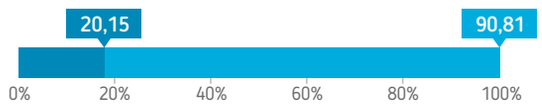
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

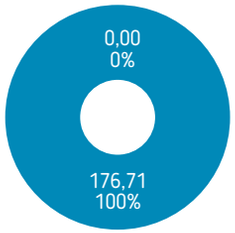
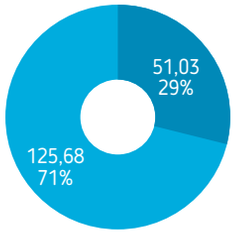
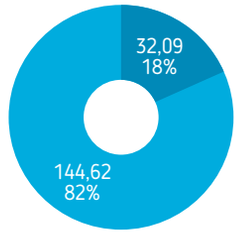
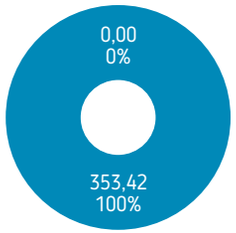
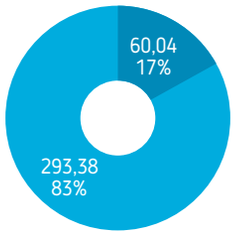
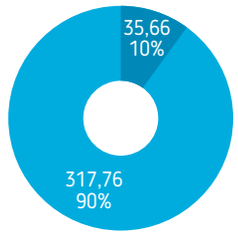
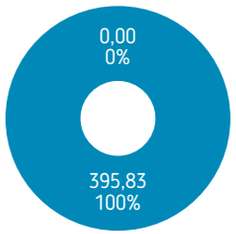
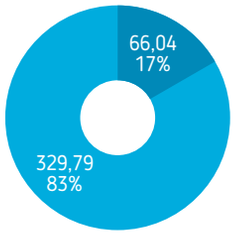
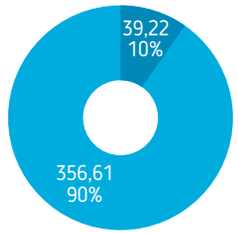
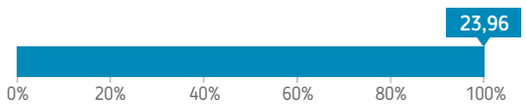
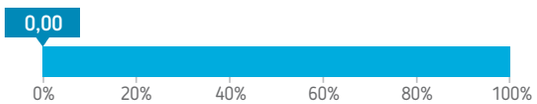
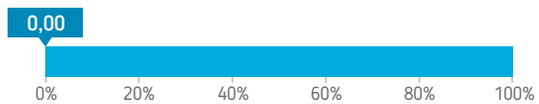
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	DRVO I UGALJ WOOD AND COAL	DRVO ILI PELET WOOD OR PELLET	DRVO ILI PELET WOOD OR PELLET
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

C5

Kategorija objekta Building category	**STAMBENA LAMELA** **APARTMENT BLOCK**
Godina izgradnje Built in	**1961-1970.**
Broj etaža Number of floors	**7**
Broj stanova Number of apartments	**56**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**515,19**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**2833,96**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**7084,9**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,48**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**170,10**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**228,66**

Stambena lamela je jednostavna, s izduženom pravougaonom osnovom i neprohodnim ravnim krovom. Za objekte iz ovog perioda karakterističan je masivni konstruktivni sistem s horizontalnim armiranobetonskim serklažima i bez termoizolacionog omotača. Konstrukcija objekta je klasična, s vanjskim zidovima od šljako-betonskih blokova debljine 20cm sa završnom obradom od maltera, dok su u suterenskoj etaži od betona debljine 20cm. Međuspratne konstrukcije su od sitnorebrastih armiranobetonskih ploča, konstruktivne visine 22cm s horizontalnim armiranobetonskim serklažima. Ravni neprohodni krov je riješen s termoizolacionim slojem debljine 5cm, a a završni sloj je šljunak.Prozori su drveni, dvostruki, sa spojenim krilima i jednostrukim staklom osim na stepenišnom prostoru gdje su jednostruka armirana stakla ugrađena na otvore od prefabrikovanih betonskih profila. Ulazna vrata od metalnih profila su također ostakljena jednostrukim armiranim staklom.

Termovizijski snimak stambene lamele pokazuje visoka temperaturna očitanja na površinama vanjskih zidova uslijed nepostojanja termičke izolacije. Uočljive su nehomogene strukture vanjskih zidova i različite termičke karakteristike dijelova konstrukcije zida. Zidovi suterenskog prostora imaju viša temperaturna očitanja uslijed lošijih karakteristika materijala. Termički mostovi vidljivi su na horizontalnim armiranobetonskim serklažima i natprozornicima. Na termovizijskom snimku vanjske stolarije registrovana je velika reflektovana temperatura uslijed loših karakteristika posebno uočljivih na ostakljenjima.

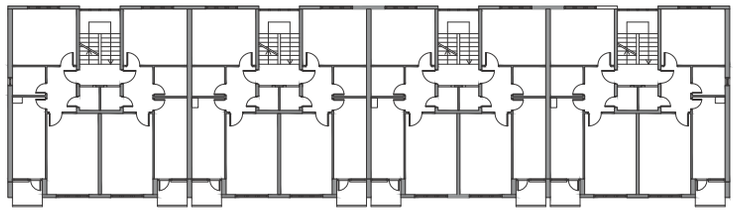
The apartment block is simple, with stretched rectangular base and inaccessible flat roof. Buildings from that period usually feature massive construction system with horizontal ring beams of reinforced concrete, and without thermal envelope. Traditionally constructed, with external walls made of 20cm slag-concrete blocks, with plaster finish, and 20cm concrete walls in the basement. Floors are separated by finely-ridged reinforced-concrete plates, 22cm high, with horizontal RC ring beams. Flat, inaccessible roof is insulated with a 5cm thick layer, and covered in gravel. External openings on the building are double single-glazed wood windows, with conjoined wings; only staircases feature single reinforced glass layer in concrete framing. Entrance door is reinforced glass in metal framing.

The thermovision image of the block shows high readings on external walls due to the lack of thermal insulation. There is evident lack of homogeneity of external walls, and different thermal characteristics of wall construction sections. Basement walls show higher temperature readings due to poor material characteristics. Thermal bridges are evident on RC ring beams and window arches. The thermovision image of external framings shows high reflected temperature due to poor characteristics, especially on glass surfaces.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u suterenu) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima.

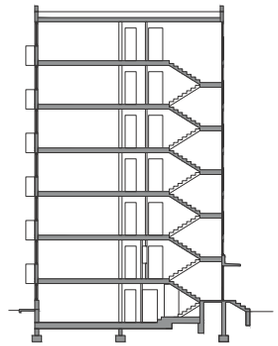
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (garage in the basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

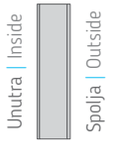
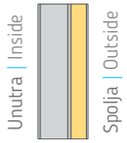
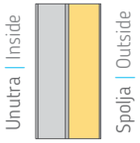
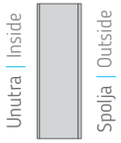
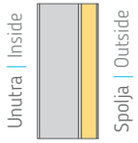
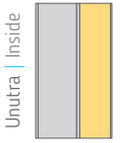
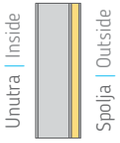
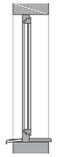


UNAPREĐENJE 2 | IMPROVEMENT 2

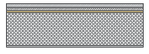
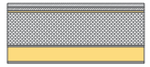
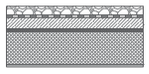
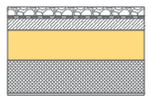
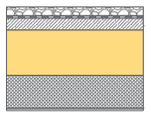
Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova (stepenišni prostor) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave u suterenu) termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of internal walls (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (garage in the basement) with thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 1,5cm, beton s lakim agregatom 18cm, malter 2cm plaster 1.5cm, light aggregate concrete 18cm, plaster 2cm	 malter 1,5cm, beton s lakim agregatom 18cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 1.5cm, light aggregate concrete 18cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 1,5cm, beton s lakim agregatom 18cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 1.5cm, light aggregate concrete 18cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 2,31 W/m²/K	U = 0,34 W/m²/K	U = 0,19 W/m²/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 1,5cm, šuplji blokovi od lakog betona 25cm, malter 2cm plaster 1.5cm, hollow light concrete blocks 25cm, plaster 2cm	 malter 1,5cm, šuplji blokovi od lakog betona 25cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 1.5cm, hollow light concrete blocks 25cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 1,5cm, šuplji blokovi od lakog betona 25cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 1.5cm, hollow light concrete blocks 25cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,81 W/m²/K	U = 0,33 W/m²/K	U = 0,18 W/m²/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 1,5cm, šuplji blokovi od lakog betona 20cm, malter 1,5cm plaster 1.5cm, hollow light concrete blocks 20cm, plaster 1.5cm	 NEMA IZMJENA NO CHANGES	 malter 1,5cm, šuplji blokovi od lakog betona 20cm, malter 1,5cm, termoizolacija 5cm, fasadni malter 1cm plaster 1.5cm, hollow light concrete blocks 20cm, plaster 1.5cm, thermal insulation 5cm, facade plaster 1cm
U (W/m²/K)	U = 1,76 W/m²/K	U = 1,76 W/m²/K	U = 0,56 W/m²/K
PROZORI WINDOWS	 drveni, jednostruki s jednostrukim staklom wooden, with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m²/K)	U = 4,50 W/m²/K	U = 1,60 W/m²/K	U = 1,00 W/m²/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 3cm, termoizolacija 1cm, AB konstrukcija 22cm, malter 1,5cm parquet flooring 2cm, concrete screed 3cm, thermal insulation 1cm, reinforced concrete construction 22cm, plaster 1.5cm	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 3cm, termoizolacija 1cm, AB konstrukcija 22cm, malter 1,5cm, termoizolacija 10cm, malter 1cm parquet flooring 2cm, concrete screed 3cm, thermal insulation 1cm, reinforced concrete construction 22cm, plaster 1.5cm, thermal insulation 10cm, plaster 1cm	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 3cm, termoizolacija 1cm, AB konstrukcija 22cm, malter 1,5cm, termoizolacija 20cm, malter 1cm parquet flooring 2cm, concrete screed 3cm, thermal insulation 1cm, reinforced concrete construction 22cm, plaster 1.5cm, thermal insulation 20cm, plaster 1cm
U ($W/m^2/K$)	U = 1,11 $W/m^2/K$	U = 0,30 $W/m^2/K$	U = 0,17 $W/m^2/K$
RAVAN KROV FLAT ROOF	 Spolja | Outside Unutra | Inside šljunak 6cm, hidroizolacija, beton u padu 8cm, hidroizolacija, heraklit 1cm, bitumenska hidroizolacija, AB konstrukcija 22cm, malter 1,5cm gravel 6cm, waterproofing, inclined concrete 8cm, waterproofing, chipboard 1cm, bitumen waterproofing, reinforced concrete construction 22cm, plaster 1.5cm	 Spolja | Outside Unutra | Inside šljunak 6cm, geotekstilna folija, hidroizolacija, beton u padu 8cm, termoizolacija 20cm, parna brana, AB konstrukcija 22cm, malter 1,5cm gravel 6cm, geotextile foil, waterproofing, inclined concrete 8cm, waterproofing 20cm, vapour barrier, reinforced concrete construction 22cm, plaster 1.5cm	 Spolja | Outside Unutra | Inside šljunak 6cm, geotekstilna folija, hidroizolacija, beton u padu 8cm, termoizolacija 30cm, parna brana, AB konstrukcija 22cm, malter 1,5cm gravel 6cm, geotextile foil, waterproofing, inclined concrete 8cm, waterproofing 30cm, vapour barrier, reinforced concrete construction 22cm, plaster 1.5cm
U ($W/m^2/K$)	U = 1,06 $W/m^2/K$	U = 0,16 $W/m^2/K$	U = 0,11 $W/m^2/K$

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	 0,85	 0,90	 0,95
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

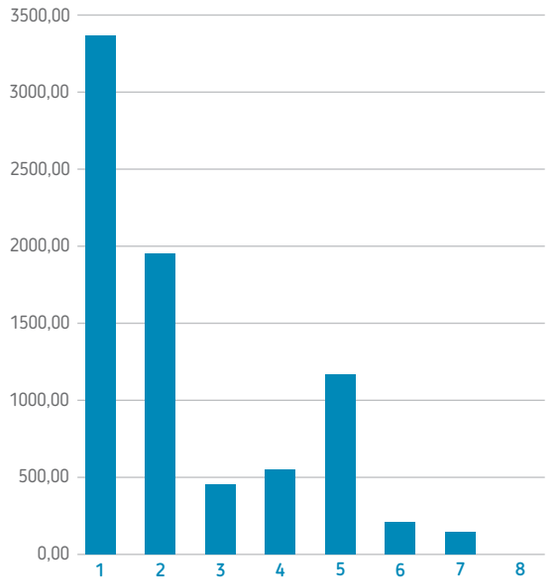
UNAPREĐENJE 2 | IMPROVEMENT 2

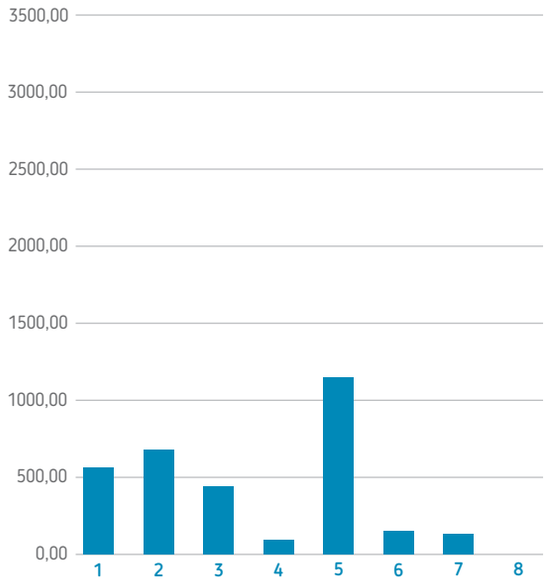
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

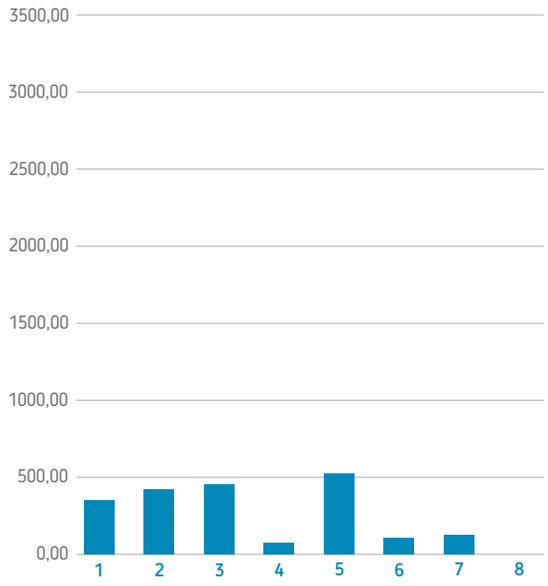
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Ravni krov
5 - Gubici prema negrijanom stepeništu
6 - Gubici kroz grijani podrum
7 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance door
4 - Flat roof
5 - To the unheated staircase
6 - To the heated basement
7 - Through the unheated basement

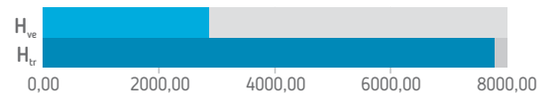


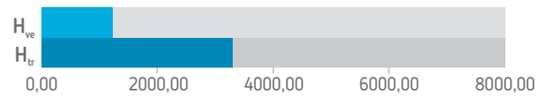


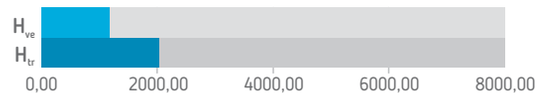


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



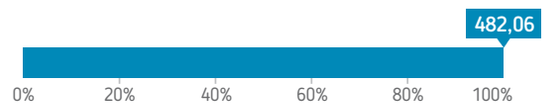


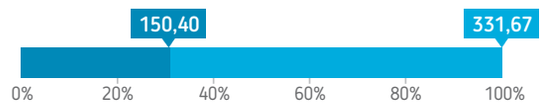


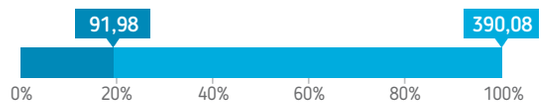
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

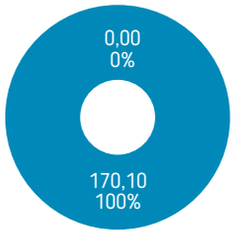
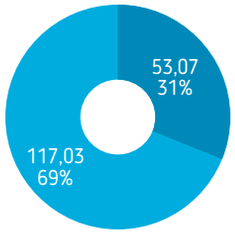
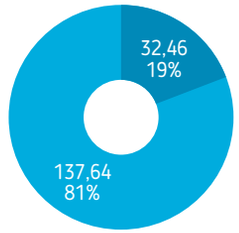
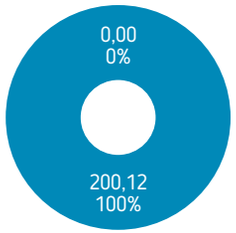
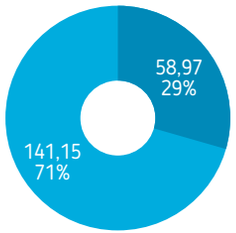
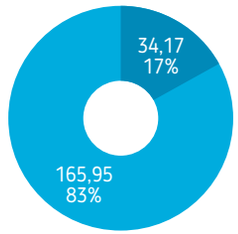
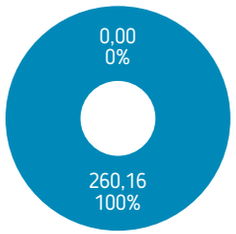
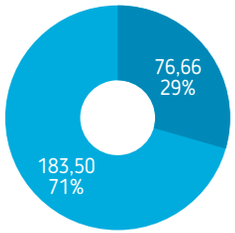
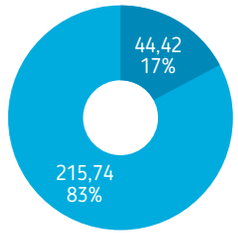
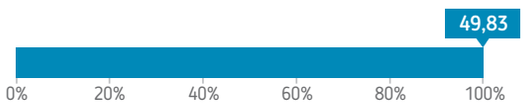
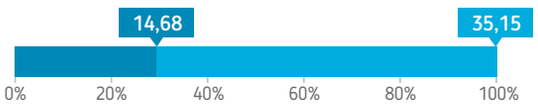
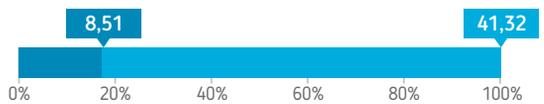
(MWh/god) | (MWh/year)

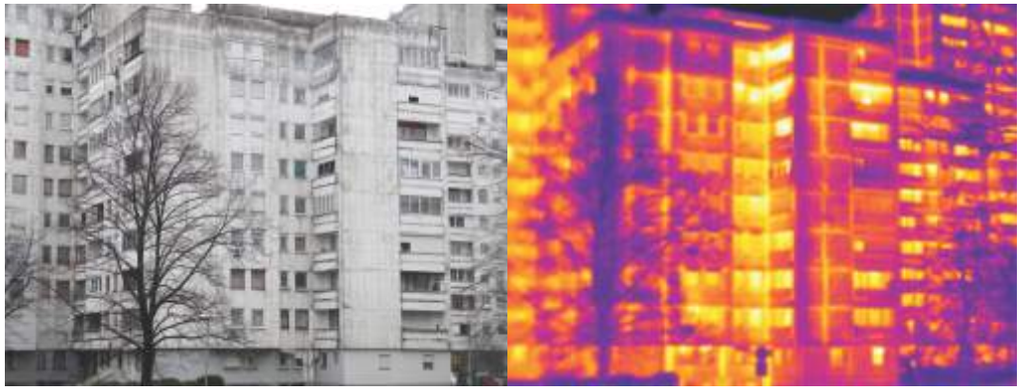
Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			



OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

D5

Kategorija objekta Building category	**STAMBENA LAMELA** **APARTMENT BLOCK**
Godina izgradnje Built in	**1977.**
Broj etaža Number of floors	**10**
Broj stanova Number of apartments	**44**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**336,98**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**2212,75**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**5487,62**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,45**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**129,85**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**161,55**

Stambena lamela je u nizu istovjetnih zgrada u okviru velikih stambenih blokova i imaju veoma razuđenu osnovu ako su u nizu s kaskadnim smicanjem i horizontalnog i vertikalnog gabarita. Karakteristično je da su lamele na pola smicane, te imaju dilataciju na polovini spoljašnjeg zida. Imaju ravan prohodan krov. Najčešće su kaskadne spratnosti, s parnim brojem spratova od Po+P+4 do Po+P+16 (od 6 do 18 etaža). Karakteriše ju skeletni konstruktivni sistem. Konstrukcija je od prefabrikovanih armiranobetonskih stubova i greda sa armiranobetonskim platnima za ukrućenje. Spoljašnji zidovi su od prefabrikovanih panela od gas betona debljine 20cm, zatim od armiranobetonskih sendvič panela ukupne debljine 17cm, jednostrano omalterisani i najčešće u lođama fasadni zidovi su od termo blokova, šljako betonskih ili opekarskih, debljine 29cm, obostrano omalterisani. Međuspratne konstrukcije su predna-pregnute armiranobetonske kasetirane ploče. U ovom periodu na stambenim lamelama kod sendvič panela na spoljašnjim zidovima pojavljuje se termoizolacija od 3cm, dok se od 5cm pojavljuje u ravnom krovu. Prozori i balkonska vrata su dvostruka, drvena spojena krila koja imaju dva obična jednostruka stakla. Lamele imaju negrijane prostore stepeništa i podrumske prostore, koji su poluukopani.

Termovizijski snimak ukazuje da lamele imaju najveće površinske toplotne gubitke na poziciji postojećih prozora, zatim fasadnih zidova unutar prvobitnih lođa i kod promjene gabarita spoljašnjeg zida na poziciji prepusta. Veći površinski toplotni gubici su i kod spojeva spoljašnjih/fasadnih sendvič panela s nosivom konstrukcijom.

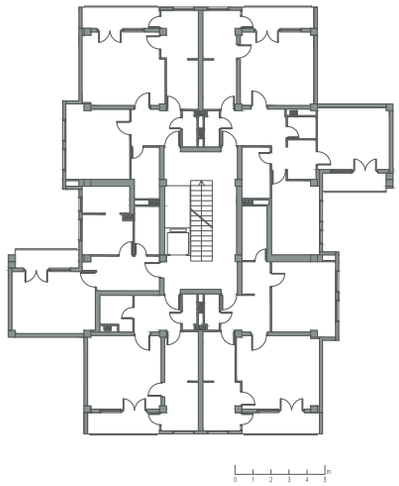
The building block is in a series of identical buildings that form large building blocks with very discontinuous footprint if the series features cascade layout of both horizontal and vertical planes. Blocks are staggered in half, with dilatation on a half of the external wall. They have a flat accessible roof. Floor are usually organised in cascades. With even number of floors - basement + ground floor + 4 to 16 (6 to 18 floors). It is typically constructed on a skeleton steel frame. It includes prefabricated reinforced concrete pillars and beams with reinforced concrete lining. External walls are made of prefabricated 20cm panels made of gas-concrete, and RC sandwich panels of overall thickness of 17cm, with plaster on one side; deep-set balconies usually feature facade walls made of thermal blocks, dross-concrete or clay brick, 29cm thick, with plaster on both sides. Floors are separated by pre-stressed rib-cassette RC slabs. Buildings from this period feature thermal insulation of 3cm at sandwich panels of the external walls, and 5cm insulation in the flat roof. Windows and balcony doors are double conjoined wooden frames, with regular single glazing. Building blocks have unheated staircases and basement rooms, which are partially underground.

The thermovision image of the building block shows the highest level of heat loss at windows, facade walls in the original deep-set balconies, and at external wall nosing. Higher levels of heat loss registered in areas where facade sandwich panels meet the load-bearing construction.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida kontaktnom fasadom s termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izolovanim cijevnim vodovima u negrijanim prostorima.

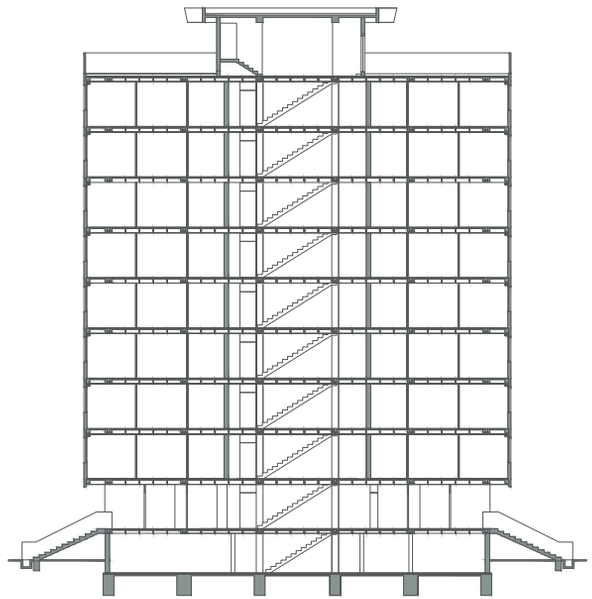
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

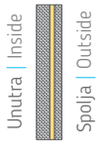
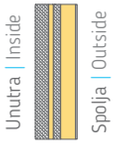
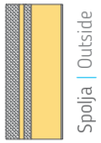
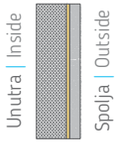
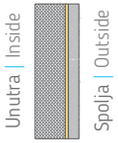
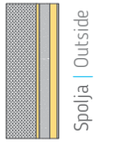
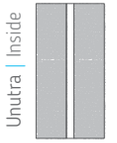
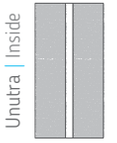
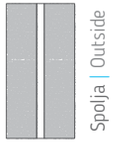


UNAPREĐENJE 2 | IMPROVEMENT 2

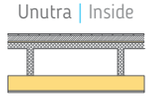
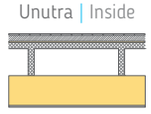
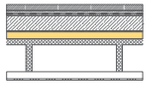
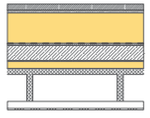
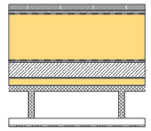
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog podrumskog prostora termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (stepenište) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated basement with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Insulation of internal walls to unheated areas (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 AB zid 9cm, termoizolacija 3cm, AB zid 5cm reinforced concrete wall 9cm, thermal insulation 3cm, reinforced concrete wall 5cm	 AB zid 9cm, termoizolacija 3cm, AB zid 5cm, termoizolacija 10cm, fasadni malter 1cm reinforced concrete wall 9cm, thermal insulation 3cm, reinforced concrete wall 5cm, thermal insulation 10cm, facade plaster 1cm	 AB zid 9cm, termoizolacija 3cm, AB zid 5cm, termoizolacija 20cm, fasadni malter 1cm reinforced concrete wall 9cm, thermal insulation 3cm, reinforced concrete wall 5cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,13 W/m^2/K	U = 0,30 W/m^2/K	U = 0,17 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 AB zid 20cm, termoizolacija 2cm, gas-beton 7cm reinforced concrete wall 20cm, thermal insulation 2cm, aerated concrete 7cm	 NEMA IZMJENA NO CHANGES	 AB zid 20 cm, termoizolacija 2cm, gas-beton 7cm, termoizolacija 5cm, malter 1cm reinforced concrete wall 20cm, thermal insulation 2cm, aerated concrete 7cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 0,88 W/m^2/K	U = 0,88 W/m^2/K	U = 0,42 W/m^2/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 gas-beton 20cm, vazduh (dilatacija) 5cm, gas-beton 20cm aerated concrete 20cm	 NEMA IZMJENA NO CHANGES	 NEMA IZMJENA NO CHANGES
U (W/m^2/K)	U = 0,88 W/m^2/K	U = 0,88 W/m^2/K	U = 0,88 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki s spojenim krilima i jednostrukim staklom wooden, with double glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,00 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 Unutra | Inside Spolja | Outside parket 1cm, cementna košuljica 4cm, termoizolacija 1cm, kasetirana AB konstrukcija 22cm parquet 1cm, cement screed 4cm, thermal insulation 1cm, prefabricated concrete slab 22cm	 Unutra | Inside Spolja | Outside parket 1cm, cementna košuljica 4cm, termoizolacija 1cm, kasetirana AB konstrukcija 22cm, termoizolacija 10cm, malter 1cm parquet 1cm, cement screed 4cm, thermal insulation 1cm, prefabricated concrete slab 22cm, thermal insulation 10cm, plaster 1cm	 Unutra | Inside Spolja | Outside parket 1cm, cementna košuljica 4cm, termoizolacija 1cm, kasetirana AB konstrukcija 22cm, termoizolacija 20cm, malter 1cm parquet 1cm, cement screed 4cm, thermal insulation 1cm, prefabricated concrete slab 22cm, thermal insulation 20cm, plaster 1cm
U ($W/m^2/K$)	U = 1,46 $W/m^2/K$	U = 0,32 $W/m^2/K$	U = 0,18 $W/m^2/K$
RAVAN KROV FLAT ROOF	 Spolja | Outside Unutra | Inside betonske ploče 4cm, pijesak 2cm, hidroizolacija, cementna glazura 1cm, padni beton 10cm, bitumenska ljepenka, termoizolacija 5cm, kasetirana AB konstrukcija 22cm, drvene letve/vazduh 5cm, azbest-cementne ploče 0,5cm concrete tiles 4cm, sand 2cm, waterproofing 0.5cm, cement screed 1cm, concrete laid to fall 10cm, bitumen felt 0.5cm, thermal insulation 5cm, prefabricated concrete slab 22cm, wooden slats/air 5cm, asbestos cement boards 0.5cm	 Spolja | Outside Unutra | Inside betonske ploče 4cm, pijesak 2cm, termoizolacija 20cm, hidroizolacija, cementna glazura 1cm, padni beton 10cm, bitumenska ljepenka, termoizolacija 5cm, kasetirana AB konstrukcija 22cm, drvene letve/vazduh 5cm, gips-kartonske ploče 1,2cm concrete tiles 4cm, sand 2cm, thermal insulation 20cm, waterproofing 0.5cm, cement screed 1cm, concrete laid to fall 10cm, bitumen felt 0.5cm, thermal insulation 5cm, prefabricated concrete slab 22cm, wooden slats/air 5cm, gypsum boards 1.2cm	 Spolja | Outside Unutra | Inside betonske ploče 4cm, pijesak 2cm, termoizolacija 30cm, hidroizolacija, cementna glazura 1cm, padni beton 10cm, bitumenska ljepenka, termoizolacija 5cm, kasetirana AB konstrukcija 22cm, drvene letve/vazduh 5cm, gips-kartonske ploče 1,2cm concrete tiles 4cm, sand 2cm, thermal insulation 30cm, waterproofing 0.5cm, cement screed 1cm, concrete laid to fall 10cm, bitumen felt 0.5cm, thermal insulation 5cm, prefabricated concrete slab 22cm, wooden slats/air 5cm, gypsum boards 1.2cm
U ($W/m^2/K$)	U = 0,59 $W/m^2/K$	U = 0,13 $W/m^2/K$	U = 0,10 $W/m^2/K$

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	 0,85	 0,90	 0,95
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ravni krov
4 - Gubici prema negrijanom stepeništu
5 - Zid ka susjednom objektu
6 - Strop prema okolini
7 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Flat roof
4 - To the unheated staircase
5 - Wall to the adjacent building
6 - Ceiling to the surroundings
7 - Through the unheated basement

ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

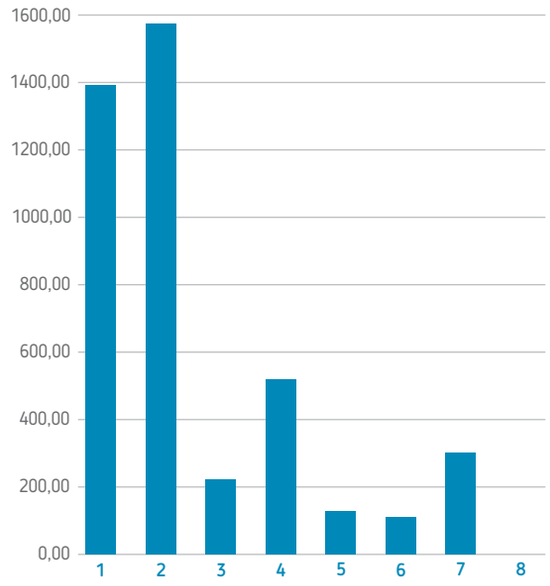
(W/K)

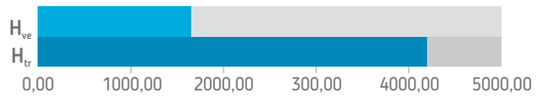
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

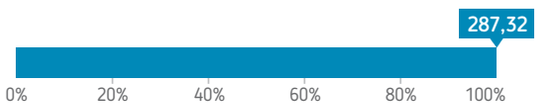
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings

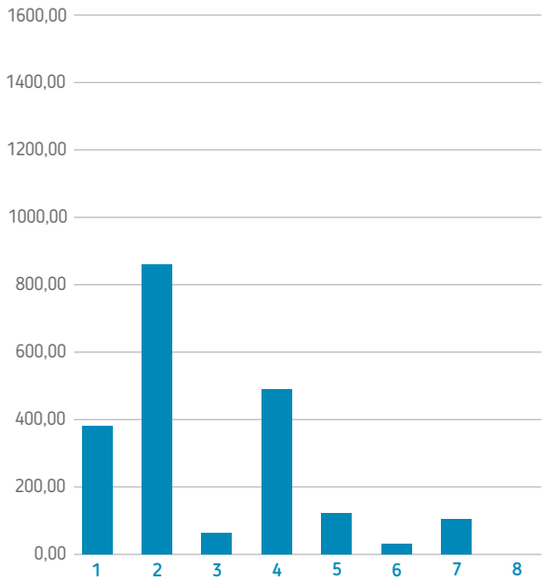
POSTOJEĆE STANJE | CURRENT CONDITION

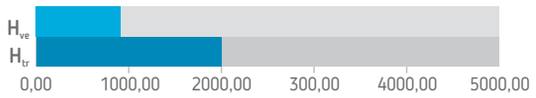


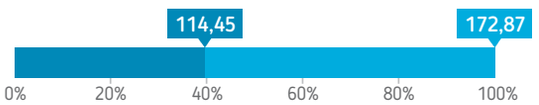




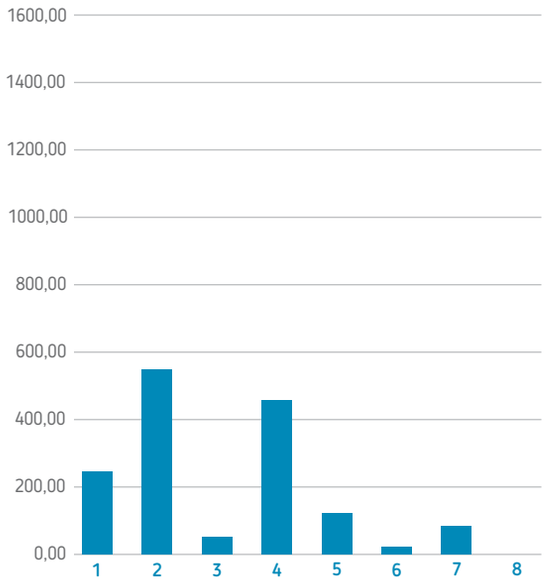
UNAPREĐENJE 1 | IMPROVEMENT 1

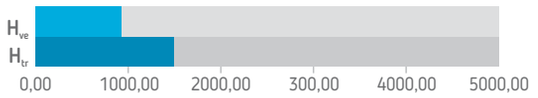


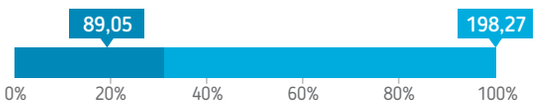


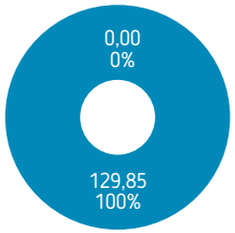
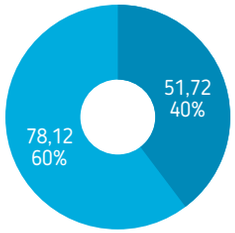
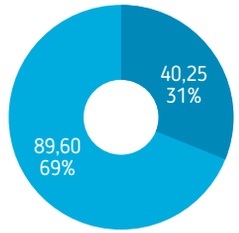
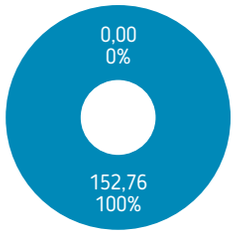
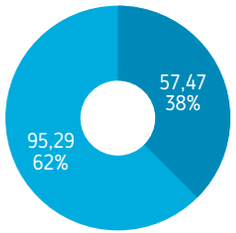
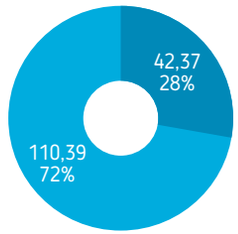
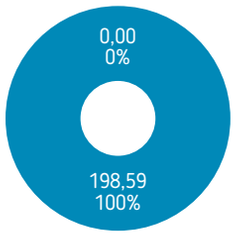
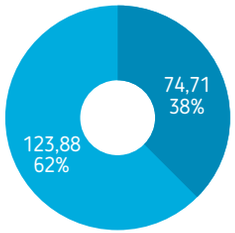
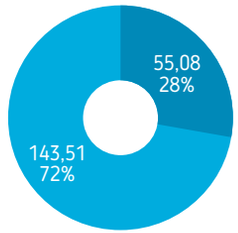
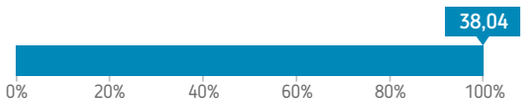
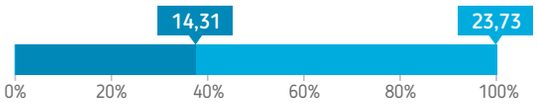
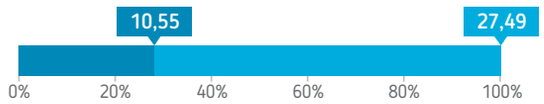


UNAPREĐENJE 2 | IMPROVEMENT 2







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

E5

Kategorija objekta Building category	**STAMBENA LAMELA** **APARTMENT BLOCK**
Godina izgradnje Built in	**1981-1991.**
Broj etaža Number of floors	**9**
Broj stanova Number of apartments	**95**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**1462,1**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**10.682,11**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**26.706,15**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,57**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**110,87**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**146,91**

Stambena lamela je nepravilne osnove s djelimično ravnim prohodnim krovom i jednovodnim kosim krovom. Za objekte iz ovog perioda karakterističan je masivni konstruktivni sistem s horizontalnim i vertikalnim armiranobetonskim serklažima. Vanjski zidovi su izvedeni kao sendvič od porobetonskih blokova debljine 12cm, termoizolacionog sloja debljine 5cm i finalnog sloja od fasadne opeke debljine 12cm. Međuspratne konstrukcije su monolitne armiranobetonske ploče debljine 20cm, dok je konstrukcija kosog krova drvena, s pokrovom od crijepa. Vanjski otvori na objektu su drveni, s dvostrukim termostaklom i ugradbenim roletnama. U suterenu i prizemlju objekta se nalaze grijani poslovni prostori, dok su garaža, stepenišni prostori i ostave, koji su locirani na krovnoj etaži, negrijani.

Termovizijski snimak stambene lamele pokazuje visoke toplotne gubitke uslijed nehomogenosti vanjskog zida. Termički mostovi su vidljivi na horizontalnim armiranobetonskim serklažima, promjenama geometrije objekta, a evidentirani su i linijski (po obimu ugrađenih vanjskih otvora). Stolarija ima različite vrijednosti očitanja zbog različitih karakteristika prozora i vrata, izvornih (loše konstrukcije i s velikim toplotnim gubicima) i zamijenjenih (boljih termičkih) karakteristika.

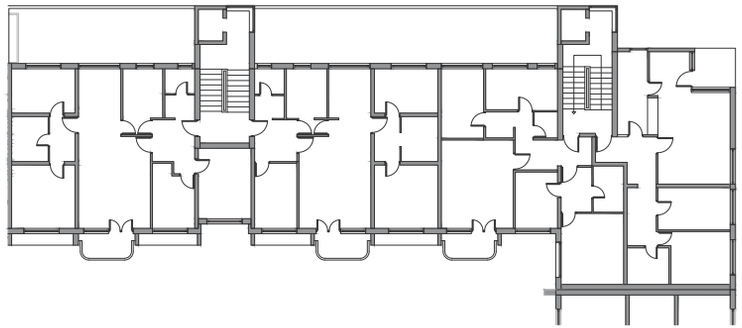
The base of the apartment block is of irregular shape, the building features partially accessible roof and a shed roof. Buildings from that period usually feature massive construction system with horizontal and vertical ring beams made of reinforced concrete. External walls are built as a sandwich of 12cm porous-concrete blocks, 5cm thermal insulation, air pocket, and final layer of 12cm facade brick. Constructions between floors are monolith 20cm layers of reinforced concrete, and the roof is consisted of a wooden framework and roof tiles. External openings on the building are wooden, with double thermal glass and built-in shades. The basement includes heated office space, while the garage, staircase and storage on the roof are unheated.

The thermal vision image of the building shows great loss of heat due to the lack of homogeneity of the external wall. Thermal bridges are visible on horizontal RC ring beams and window arches, as well as on changes in the building geometry, but also align the lines (circumference of installed external openings). The framings show different readings due to different characteristics of doors and windows, both original (poorly constructed with great heat loss) and replaced (better thermal properties).

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida s unutrašnje strane termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave na tavanu) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Na dijelu stambenog potkrovnog prostora izolovati kosi krov termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izolovanim cijevnim vodovima u negrijanim prostorima.

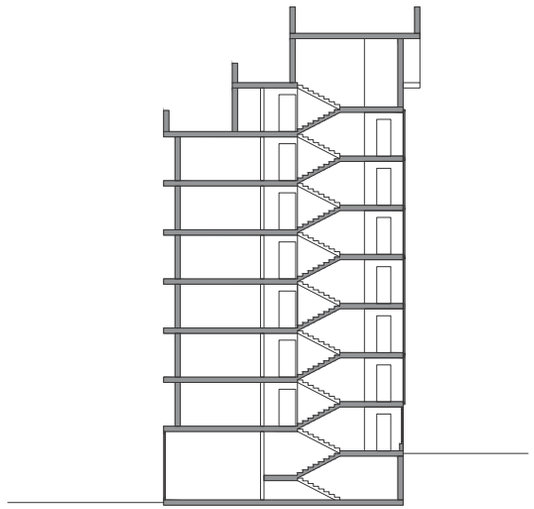
Insulation of external wall on the inside with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the attic) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Insulation of the steep roof with thermal insulation layer of 20cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

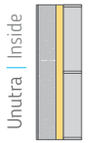
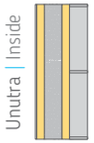
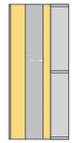
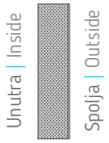
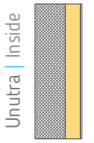
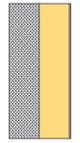
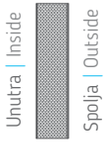
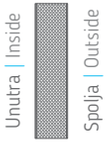


UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida s unutrašnje strane termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje unutrašnjeg zida prema susjednoj lameli termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije prema negrijanim prostorima (ostave na tavanu) s termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Na dijelu stambenog potkrovnog prostora izolovati kosi krov termoizolacionim slojem debljine 30cm (λ=0,041 W/mK). Izolovanje poda na tlu termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

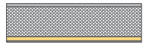
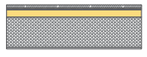
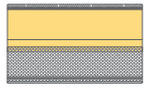
Insulation of external wall on the inside with thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of internal walls in contact with the next building with thermal insulation layer of 5cm (λ=0.041 W/mK). Insulation of construction between the floors towards the unheated spaces (storage in the attic) with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Insulation of the steep roof above the residential space with thermal insulation layer of 30cm (λ=0.041 W/mK). Insulation of the floor on the ground with thermal insulation layer of 10cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 1cm, porobeton 12cm, termoizolacija 5cm, fasadna opeka 12cm plaster 1cm, aerated concrete 12cm, thermal insulation 5cm, facade brick 12cm	 gips-kartonske ploče 1,2cm, termoizolacija 5cm, porobeton 12cm, termoizolacija 5cm, fasadna opeka 12cm gypsum plasterboard 1.2cm, thermal insulation 5cm, aerated concrete 12cm, thermal insulation 5cm, facade brick 12cm	 gips-kartonske ploče 1,2cm, termoizolacija 10cm, porobeton 12cm, termoizolacija 5cm, fasadna opeka 12cm gypsum plasterboard 1.2cm, thermal insulation 10cm, aerated concrete 12cm, thermal insulation 5cm, facade brick 12cm
U (W/m^2/K)	U = 0,49 W/m^2/K	U = 0,30 W/m^2/K	U = 0,22 W/m^2/K
SPOLJAŠNJI ZID EXTERNAL WALL	 AB zid 20cm, malter 3cm reinforced concrete wall 20cm, plaster 3cm	 AB zid 20cm, malter 3cm, termoizolacija 10cm, malter 1cm reinforced concrete wall 20cm, plaster 3cm, thermal insulation 10cm, plaster 1cm	 AB zid 20cm, malter 3cm, termoizolacija 20cm, malter 1cm reinforced concrete wall 20cm, plaster 3cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 1,83 W/m^2/K	U = 0,54 W/m^2/K	U = 0,18 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 1cm, AB zid 20cm, malter 1cm plaster 1cm, reinforced concrete wall 20cm, plaster 1cm	 NEMA IZMJENA NO CHANGES	 malter 1cm, AB zid 20cm, malter 1cm, termoizolacija 5cm, malter 1cm plaster 1cm, reinforced concrete wall 20cm, plaster 1cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U =2,75 W/m^2/K	U = 2,75 W/m^2/K	U = 0,63 W/m^2/K
PROZORI WINDOWS	 PVC s dvostrukim staklom PVC with double glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,00 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

ELEMENTI UNAPREĐENJA OMOTAČA | BUILDING ENVELOPE IMPROVEMENTS ELEMENTS

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	Unutra | Inside  Spolja | Outside keramičke pločice 2cm, AB konstrukcija 20cm, kombi ploča 5cm, malter 1cm ceramic tiles 2cm, reinforced concrete construction 20cm, sandwich insulation panel 5cm, plaster 1cm	Unutra | Inside  Spolja | Outside keramičke pločice 2cm, AB konstrukcija 20cm, kombi ploča 5cm, malter 1cm, termoizolacija 10cm, malter 1cm ceramic tiles 2cm, reinforced concrete construction 20cm, sandwich insulation panel 5cm, plaster 1cm, thermal insulation 10cm, plaster 1cm	Unutra | Inside  Spolja | Outside keramičke pločice 2cm, AB konstrukcija 20cm, kombi ploča 5cm, malter 1cm, termoizolacija 20cm, malter 1cm ceramic tiles 2cm, reinforced concrete construction 20cm, sandwich insulation panel 5cm, plaster 1cm, thermal insulation 20cm, plaster 1cm
U ($W/m^2/K$)	U = 0,51 $W/m^2/K$	U = 0,23 $W/m^2/K$	U = 0,15 $W/m^2/K$
RAVAN KROV FLAT ROOF	Spolja | Outside  Unutra | Inside kulir ploče 4cm, pijesak 3cm, bit. ljepenka, kombi ploče 8cm, nagibni beton 3-5cm, AB konstrukcija 20cm, malter 1cm exposed aggregate concrete tiles 4cm, sand 3cm, bitumen cardboard, sandwich insulation panels 8cm, inclined concrete 3-5cm, reinforced concrete construction 20cm, plaster 1cm	Spolja | Outside  Unutra | Inside kulir ploče 4cm, pijesak 3cm, bit. ljepenka, termoizolacija 20cm, kombi ploče 8cm, nagibni beton 3-5cm, AB konstrukcija 20cm, malter 1cm exposed aggregate concrete tiles 4cm, sand 3cm, bitumen cardboard, thermal insulation 20cm, sandwich insulation panels 8cm, inclined concrete 3-5cm, reinforced concrete construction 20cm, plaster 1cm	Spolja | Outside  Unutra | Inside kulir ploče 4cm, pijesak 3cm, bit. ljepenka, termoizolacija 30cm, kombi ploče 8cm, nagibni beton 3-5cm, AB konstrukcija 20cm, malter 1cm exposed aggregate concrete tiles 4cm, sand 3cm, bitumen cardboard, thermal insulation 30cm, sandwich insulation panels 8cm, inclined concrete 3-5cm, reinforced concrete construction 20cm, plaster 1cm
U ($W/m^2/K$)	U = 0,51 $W/m^2/K$	U = 0,15 $W/m^2/K$	U = 0,11 $W/m^2/K$

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

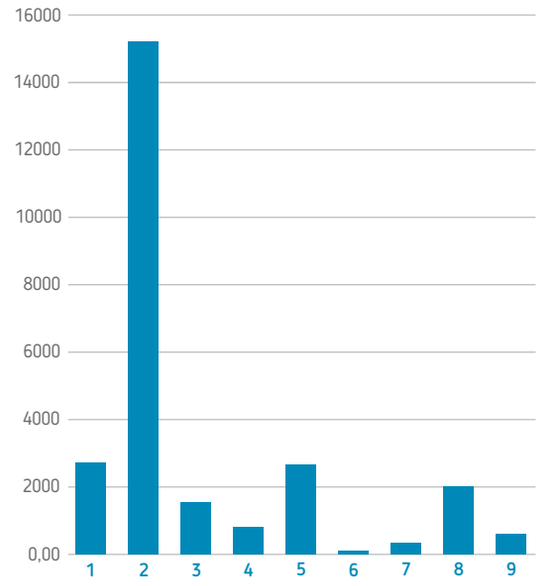
UNAPREĐENJE 2 | IMPROVEMENT 2

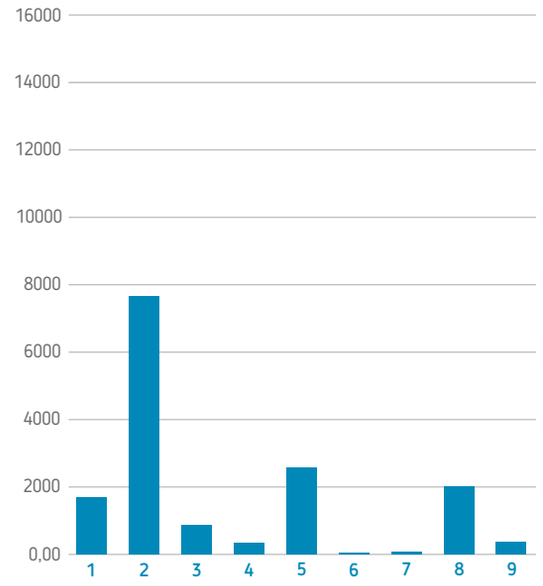
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

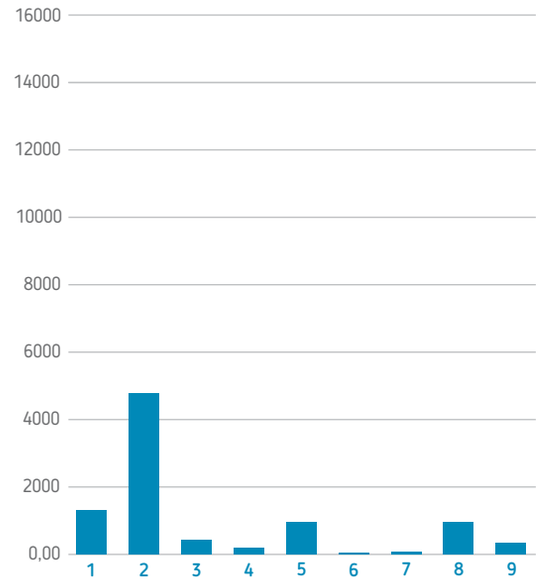
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ulazna vrata
4 - Ravni krov
5 - Gubici prema negrijanom stepeništu
6 - Zid ka susjednoj lameli
7 - Strop prema okolini
8 - Pod na tlu
9 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Entrance door
4 - Flat roof
5 - To the unheated staircase
6 - Wall to the adjacent building block
7 - Ceiling to the surroundings
8 - Floor on the ground
9 - Through the unheated basement

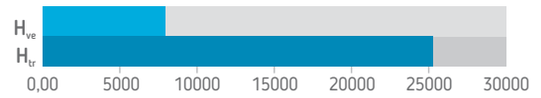


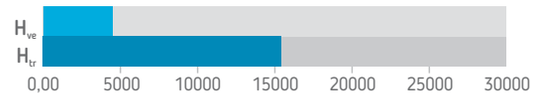


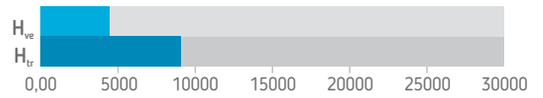


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



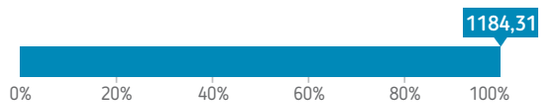


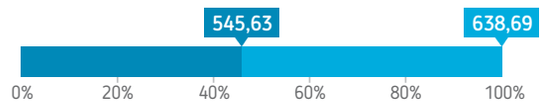


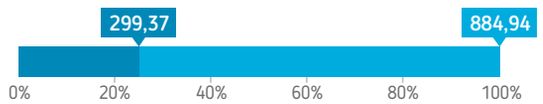
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

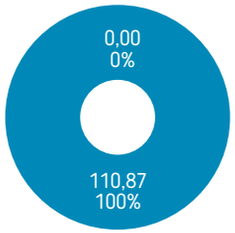
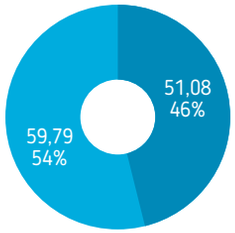
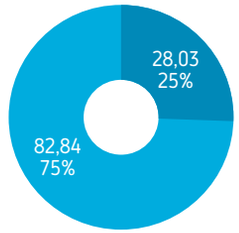
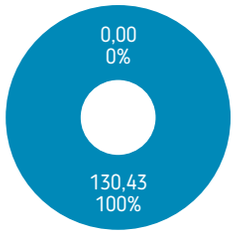
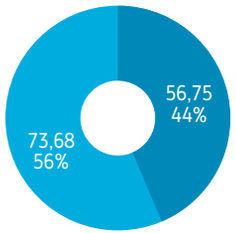
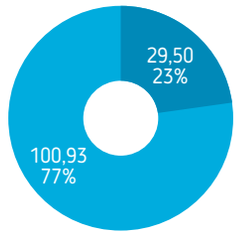
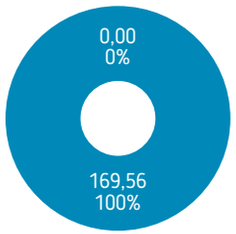
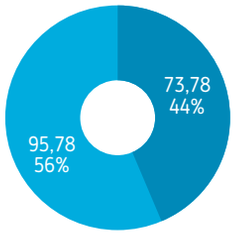
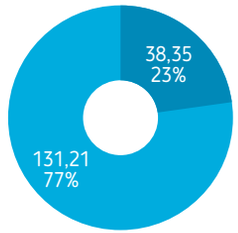
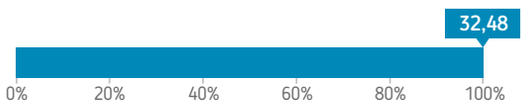
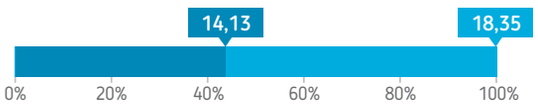
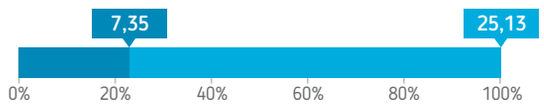
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

F5

Kategorija objekta Building category	**STAMBENA LAMELA** **APARTMENT BLOCK**
Godina izgradnje Built in	**2008.**
Broj etaža Number of floors	**8**
Broj stanova Number of apartments	**20**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**252,25**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**1372,5**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**3587,19**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,40**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ ($kWh/m^2/god$) Specific energy need for intermitted heating $Q_{H,nd,interm}$ ($kWh/m^2/year$)	**54,81**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ ($kWh/m^2/god$) Specific energy need for continuous heating $Q_{H,nd,cont}$ ($kWh/m^2/year$)	**66,76**

Stambena lamela je izdužene osnove s blago razuđenim gabaritom u nizu istovjetnih zgrada u okviru velikih stambenih blokova. Ovakve lamele imaju potpunu dilataciju duž bočnih spoljašnjih zidova. Krov je složen, urađen kombinovano od ravnog neprohodnog krova i kosog krova, jer se potkrovlje koristi za stanovanje. Najčešće spratnosti su Po+P+5+Pk (8 etaža). Karakteriše je mješovita gradnja, livenih armiranobetonskih zidova te armiranobetonskog skeletnog sistema, stubova i greda. Spoljašnji zidovi su od termoblokova opeke debljine 19cm ili od armiranog betona 20cm, i u ovom dugotrajnom periodu građenja (20-togodišnji period) najčešće posjeduju 5cm termoizolacije. Nakon 2010. godine pojavljuje se i 10cm termoizolacije u spoljašnjim zidovima. Međuspratne konstrukcije su armiranobetonske pune ploče i, takođe u pozicijama gdje razdvajaju grijani od negrijanog prostora, posjeduju izolaciju od 5cm. Termoizolacija u krovu javlja se u debljini od 5 do 10cm. Prozori i balkonska vrata su jednostruka drvena krila, s običnim termoizolacionim staklom. Zgrade imaju negrijane prostore stepeništa i podrumske prostore u okviru kojih se pojavljuju i garaže. Podrumski prostori su potpuno ukopani, a u nivou terena je prizemlje stambeno-poslovne namjene.
Termovizijski snimak ukazuje da stambena lamela ovog perioda ima najveće površinske toplotne gubitke na poziciji prozora, fasadnih zidova i ploča unutar lođa. Snimak ukazuje da fasadni zid i ploča s donje strane nisu obloženi termoizolacijom. Veći linijski toplotni gubici su vidni u gornjoj zoni spoljašnjih zidova ispod prodora ploče, kao i pri promjeni gabarita spoljašnjeg zida unutar lođe.

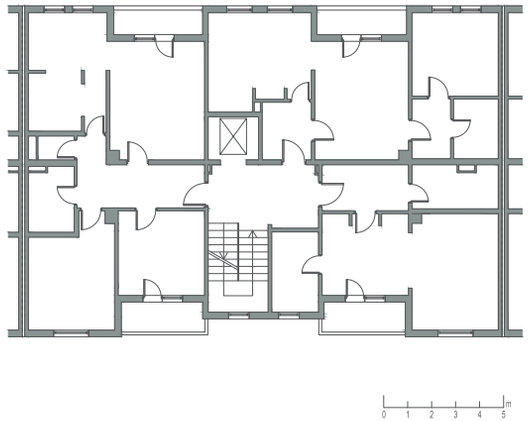
The block is of a long foot with somewhat discontinuous footprint with in a series of identical buildings forming a large building block. These building blocks are fully separated from other buildings on both sides. The roof is complex, a combination of flat inaccessible roof and shed roof, since the attic is used for residential purposes. This type of building usually has a basement, ground floor, +5 floors and the attic (8 floors). Combination of structural elements, casted RC walls and RC skeleton, pillars and beams. External walls are made of 19cm clay thermo-blocks or 20cm reinforced concrete, with 5cm thermal insulation layer typical of that period of twenty years. Since 2010, external walls feature 10cm thermal insulation. Floors are separated by solid RC slabs, with 5cm insulation layer in areas that separate heated from unheated space. Thermal insulation is 5 to 10cm thick. Windows and balcony doors are single-glazed, wooden framing, with standard thermal insulation glass. Buildings have unheated staircases and basement rooms, sometimes used as garages. Basement rooms are fully underground, while the ground floor includes residential and office space.
The thermovision image of the building block from this period shows the highest level of heat loss in the area of windows, facade walls, and deep-set balcony slabs. The image shows that the facade wall and slab on the lower side do not have a thermal insulation envelope. Major heat loss is evident in the upper zone of external walls below the slab protrusion, as well as along the modified external wall in the deep-set balconies.

***Napomena:** pri proračunu energetskih karakteristika reprezentativnog/tipskog objekta, da bi se adekvatno odgovorilo na prosječne statističke vrijednosti koje su karakteristične za ovu kategoriju i period objekata, na konkretnom primjeru povećane su vrijednosti U-koeficijenata elemenata omotača.
***Note:** for the purpose of calculating energy performance of the typical building, in order to properly address average statistics typical of the category and age of the buildings, values of the U-coefficient of the envelope elements.

UNAPREĐENJE 1 | IMPROVEMENT 1

Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 10 cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma/garaža) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog i kosog krova termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smješten u podstanici. Niskotemperaturni sistem grijanja s izolovanim cijevnim vodovima u negrijanim prostorima.

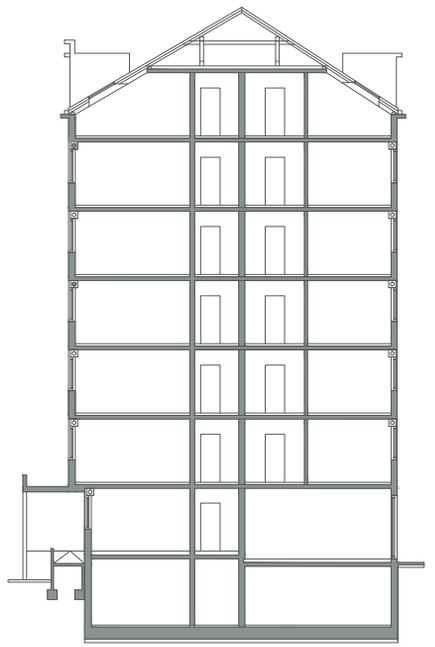
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement/garage) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat and shed roof with thermal insulation layer of 20cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation. Low-temperature heating system with insulated pipeline in unheated spaces.

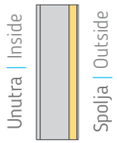
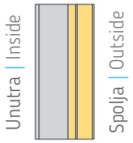
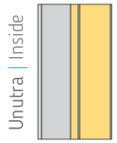
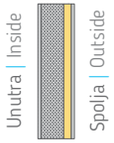
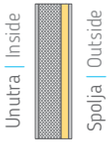
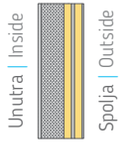
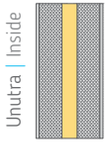
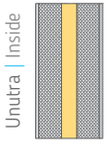
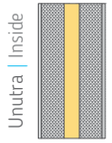


UNAPREĐENJE 2 | IMPROVEMENT 2

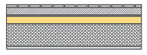
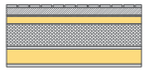
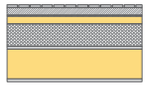
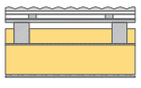
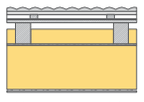
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog podrumskog prostora termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog i kosog krova termoizolacionim slojem debljine 30cm (λ=0,041 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (stepenište) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljati podstanicom s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Centralni sistem pripreme PTV povezati sa sistemom grijanja. Izmjenjivač toplote sa spremnikom smjestiti u podstanicu, s dopunskim sistemom solarnih kolektora za podršku pripreme PTV.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated basement with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat and shed roof with thermal insulation layer of 30cm (λ=0.041 W/mK). Insulation of internal walls to unheated areas (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Central domestic hot water system in conjunction with heating system. Installation of thermostatic radiator valves in apartments. Link the hot water system to the heating system. Place a heat exchanger with a hot water tank at the substation, with additional solar panels supporting the hot water system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 3cm, šuplji opekarski blok 19cm, termoizolacija 5cm, fasadni malter 1cm plaster 3cm, clay block wall 19cm, thermal insulation 5cm, facade plaster 1cm	 malter 3cm, šuplji opekarski blok 19cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 10cm, fasadni malter 1cm plaster 3cm, clay block wall 19cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 10cm, facade plaster 1cm	 malter 3cm, šuplji opekarski blok 19cm, termoizolacija 5cm, fasadni malter 1cm, termoizolacija 20cm, fasadni malter 1cm plaster 3cm, clay block wall 19cm, thermal insulation 5cm, facade plaster 1cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 0,55 W/m^2/K	U = 0,23 W/m^2/K	U = 0,15 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, AB zid 15cm, termoizolacija 5cm, malter 2cm plaster 2cm, reinforced concrete wall 15cm, thermal insulation 5cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, AB zid 15cm, termoizolacija 5cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, reinforced concrete wall 15cm, thermal insulation 5cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U = 0,62 W/m^2/K	U = 0,62 W/m^2/K	U = 0,35 W/m^2/K
ZID PREMA SUSJEDNOM OBJEKTU WALL TO THE ADJACENT BUILDING	 malter 2cm, AB zid 15cm, termoizolacija 10cm, AB zid 15cm, malter 2cm plaster 2cm, reinforced concrete wall 15cm, thermal insulation 10cm, reinforced concrete wall 15cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 NEMA IZMJENA NO CHANGES
U (W/m^2/K)	U =0,34 W/m^2/K	U = 0,34 W/m^2/K	U = 0,34 W/m^2/K
PROZORI WINDOWS	 drveni, jednostruki s dvostrukim staklom wooden, with double glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 2,59 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 5cm, hidroizolacija, termoizolacija 5cm, AB konstrukcija 15cm, malter 2cm parquet 2cm, cement screed 5cm, waterproofing, thermal insulation 5cm, reinforced concrete slab 15cm, plaster 2cm	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 5cm, hidroizolacija, termoizolacija 5cm, AB konstrukcija 15cm, malter 2cm, termoizolacija 10cm, malter 1cm parquet 2cm, cement screed 5cm, waterproofing, thermal insulation 5cm, reinforced concrete slab 15cm, plaster 2cm, thermal insulation 10cm, plaster 1cm	 Unutra | Inside Spolja | Outside parket 2cm, cementni estrih 5cm, hidroizolacija, termoizolacija 5cm, AB konstrukcija 15cm, malter 2cm, termoizolacija 20cm, malter 1cm parquet 2cm, cement screed 5cm, waterproofing, thermal insulation 5cm, reinforced concrete slab 15cm, plaster 2cm, thermal insulation 20cm, plaster 1cm
U (W/m^2/K)	U = 0,56 W/m^2/K	U = 0,23 W/m^2/K	U = 0,15 W/m^2/K
KOSI KROV PITCHED ROOF	 Spolja | Outside Unutra | Inside crijep, letve/vazduh 2*5/3cm, krovna hartija, drvene daske, drveni rogovi 14cm/vazduh 4cm, termoizolacija 10cm, parna brana, podkonstrukcija, gips-kartonske ploče 1,2cm pressed clay roof tile, wooden slats/air 2*5/3cm, roofing paper, battens, plank 14cm/air 4cm, thermal insulation 10cm, substructure, vapor barrier, gypsum boards 1.2cm	 Spolja | Outside Unutra | Inside crijep, letve/vazduh 2*5/3cm, krovna hartija, drvene daske, drveni rogovi 14cm/vazduh 4cm, termoizolacija 10cm, parna brana, termoizolacija 20 cm s podkonstrukcijom, parna brana, gips-kartonske ploče 1,2cm pressed clay roof tile, wooden slats/air 2*5/3cm, roofing paper, battens, plank 14cm/air 4cm, thermal insulation 10cm, vapor barrier, thermal insulation 20cm with substructure, vapor barrier, gypsum boards 1.2cm	 Spolja | Outside Unutra | Inside crijep, letve/vazduh 2*5/3cm, krovna hartija, drvene daske, drveni rogovi 14cm/vazduh 4cm, termoizolacija 10cm, parna brana, termoizolacija 30 cm s podkonstrukcijom, parna brana, gips-kartonske ploče 1,2cm pressed clay roof tile, wooden slats/air 2*5/3cm, roofing paper, battens, plank 14cm/air 4cm, thermal insulation 10cm, vapor barrier, thermal insulation 30cm with substructure, vapor barrier, gypsum boards 1.2cm
U (W/m^2/K)	U = 0,36 W/m^2/K	U = 0,13 W/m^2/K	U = 0,10 W/m^2/K

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR	 0,85	 0,90	 0,95
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with heating system. Heat exchanger with a hot water tank at the substation	 Centralni sistem pripreme PTV povezan sa sistemom grijanja i sistemom solarnih kolektora. Izmjenjivač toplote sa spremnikom u podstanici Central domestic hot water system in conjunction with a heating system and solar collector system. Heat exchanger with a hot water tank at the substation

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

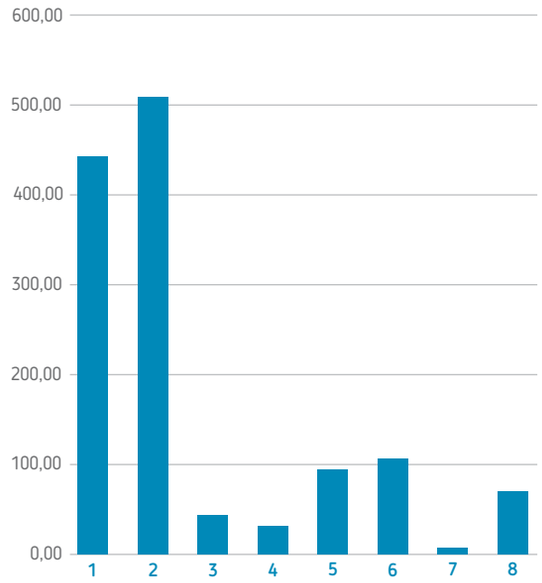
UNAPREĐENJE 2 | IMPROVEMENT 2

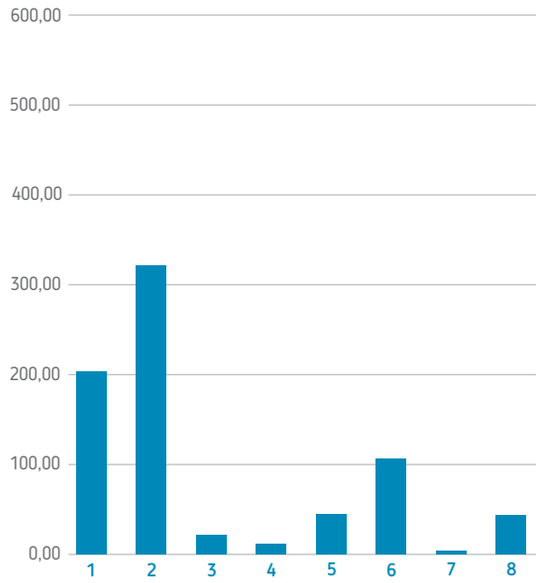
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

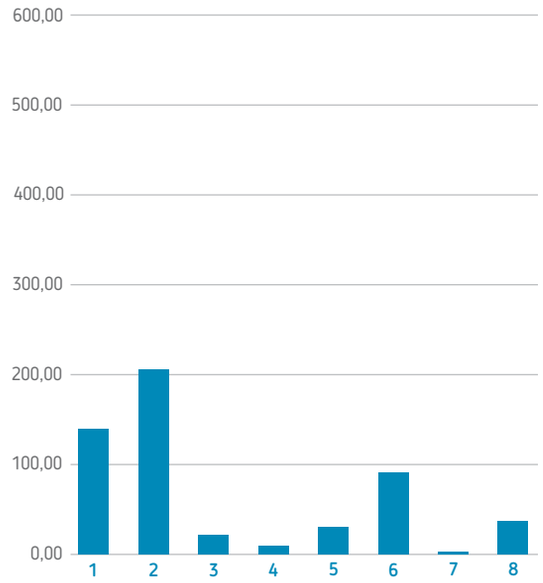
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ravni krov
4 - Kosi krov
5 - Gubici prema negrijanom tavanu
6 - Gubici prema negrijanom stepeništu
7 - Strop prema okolini
8 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Flat roof
4 - Sloping roof
5 - To the unheated attic
6 - To the unheated staircase
7 - Ceiling to the surroundings
8 - Through the unheated basement







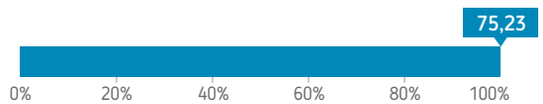
ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

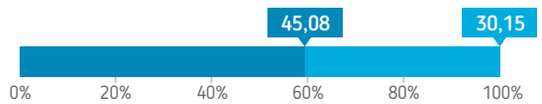
(W/K)

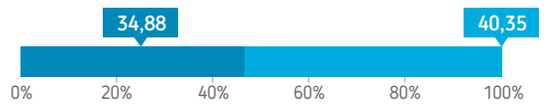
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

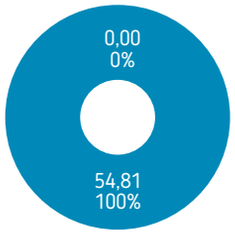
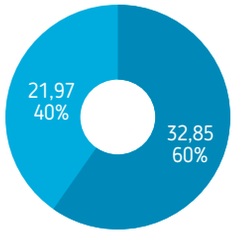
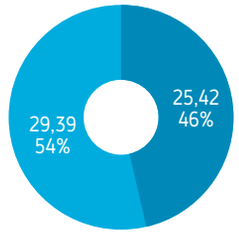
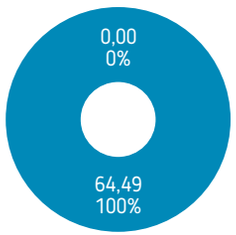
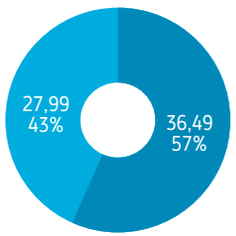
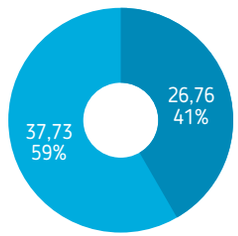
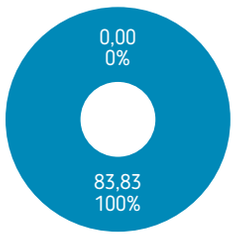
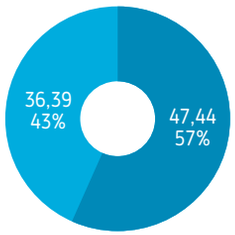
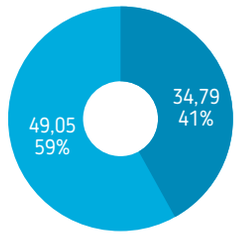
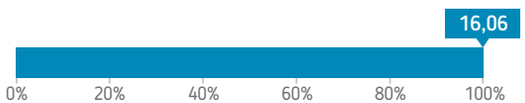
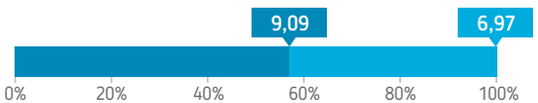
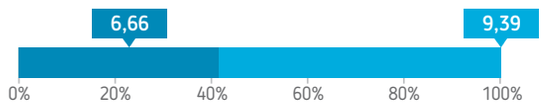
(MWh/god) | (MWh/year)

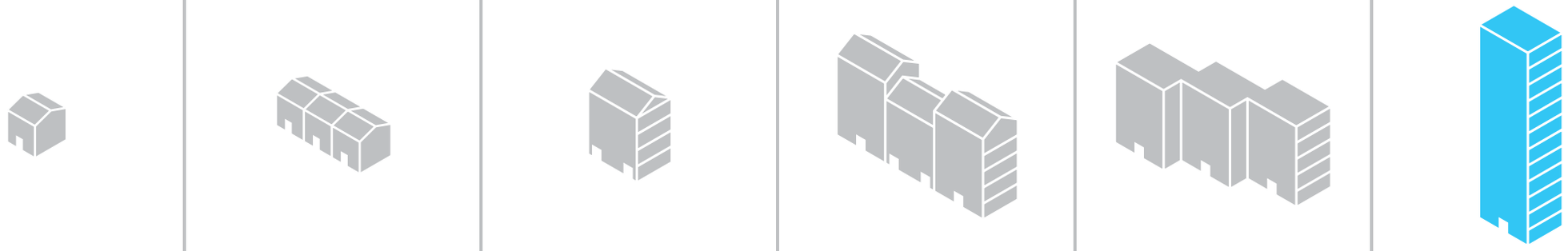
Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

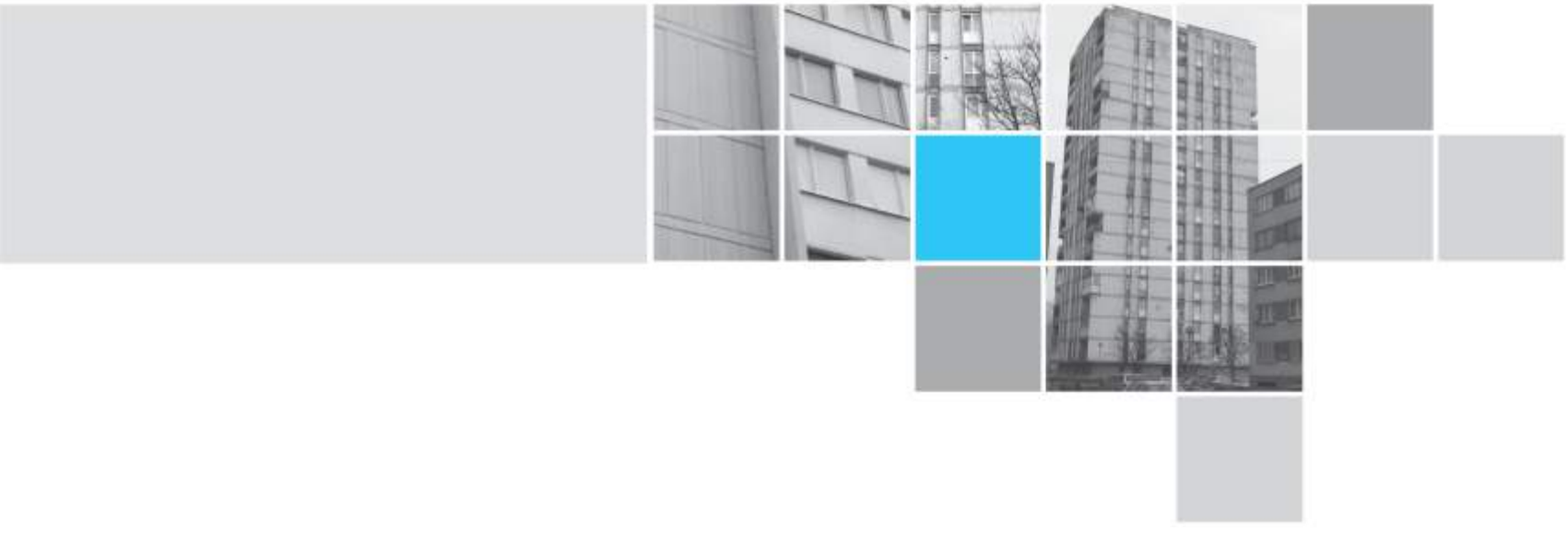


individualno stanovanje
single-family housing

kolektivno stanovanje
collective housing

NEBODERI
HIGH-RISE BUILDINGS

<1945 | 1946-1960 | 1961-1970 | 1971-1980 | 1981-1991 | 1992-2014



OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

C6

Kategorija objekta Building category	**NEBODER** **HIGH-RISE BUILDING**
Godina izgradnje Built in	**1963.**
Broj etaža Number of floors	**14**
Broj stanova Number of apartments	**52**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**319,41**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**3260,66**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**8477,71**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,41**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ (kWh/m^2/god) Specific energy need for intermitted heating $Q_{H,nd,interm}$ (kWh/m^2/year)	**193,37**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ (kWh/m^2/god) Specific energy need for continuous heating $Q_{H,nd,cont}$ (kWh/m^2/year)	**272,99**

Neboder – stambena slobodnostojeća zgrada velike spratnosti je kompaktne kvadratne osnove s ravnim prohodnim krovom. Najčešće spratnosti je Po+P+12 (14 etaža). Karakteriše ga skeletni konstruktivni sistem. Konstrukcija je od livenih armirano-betonskih stubova i greda s armirano-betonskim platnima za ukrućenje. Spoljašnji zidovi su od armiranog betona različitih debljina - 15cm, 19cm, pa i do 38cm, zatim od ošupljene opeke 25cm i opekarskog bloka od 19cm. Sve vrste zidova su obostrano malterisane. Međuspratne konstrukcije su armirano-betonske kasetirane ploče. U ovom periodu niti na jednom segmentu omotača nema termoizolacije. Prozori i balkonska vrata su dvostruka drvena spojena krila koja imaju dva obična jednostruka stakla i posjeduju unutrašnju platnenu roletnu. Neboderi imaju negrijane prostore stepeništa i podrumske prostore, koji su poluukopani.

Termovizijski snimak ukazuje da neboder ima najveće površinske toplotne gubitke na poziciji armirano-betonskih stubova i greda. Veći linijski toplotni gubici su kod postojećih prozora u gornjoj zoni okvira, gdje prvobitno nije postojala vanjska roletna nego samo unutrašnja platnena roletna, te kod postojećih lođa, javljaju se u poziciji spoljašnjeg zida ispod prepuštene ploče lođe i kod promjene gabarita, odnosno prepusta spoljašnjeg zida.

The high-rise building is of square footprint and flat accessible roof. It usually has a basement, ground floor, + 12 floors (14 floors). It is typically constructed on a skeleton steel frame. It includes reinforced concrete pillars and beams with reinforced concrete lining. External walls are consisted of reinforced concrete of 15cm, 19cm, even 38cm, a 25cm thick layer of hollow brick, and 19cm of clay blocks. All walls are plastered on both sides. Floors are separated by rib-cassette reinforced concrete. Buildings from this period do not have thermal insulation on any section of the envelope. Windows and balcony doors are double conjoined wooden frames, with regular single glazing, and built-in fabric shades. Skyscrapers have unheated staircases and basement rooms, which are partially underground.

Thermovision image shows the highest level of heat loss in the area of RC pillars and beams. Major linear heat loss is detected at the upper edge of existing windows, which were originally without external roller blinds, featuring only indoor fabric blinds, as well as at the existing deep-set balconies, in the place of external wall below the protruding deck, at places where the overall dimensions change, and at the nosing of the external wall.

UNAPREĐENJE 1 | IMPROVEMENT 1

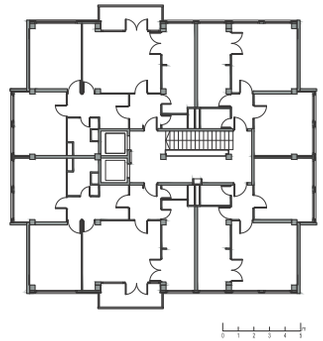
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem pripreme PTV povezan sa sistemom grijanja. Niskotemperaturni sistem grijanja s izlovanim cijevnim vodovima u negrijanim prostorima.

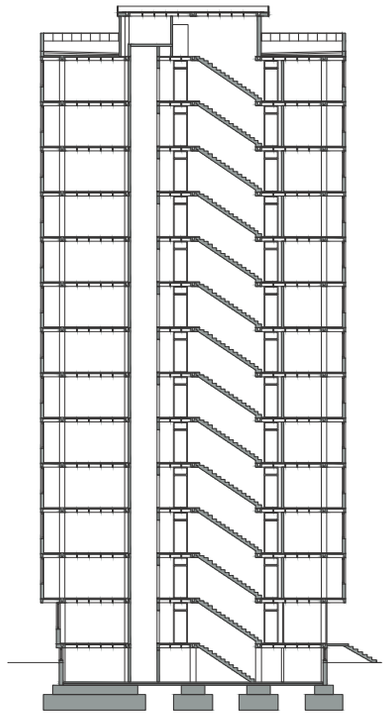
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Low-temperature heating system with insulated pipeline in unheated spaces.

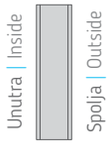
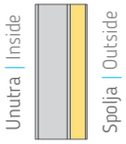
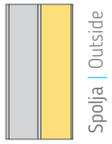
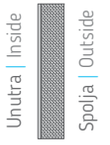
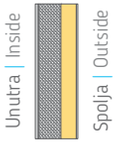
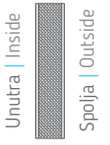
UNAPREĐENJE 2 | IMPROVEMENT 2

Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog podrumskog prostora termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Izolovanje unutrašnjih zidova prema negrijanom prostoru (stepenište) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Sistem pripreme PTV povezan sa sistemom grijanja.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated basement with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Insulation of internal walls to unheated areas (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system.





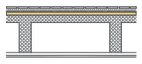
	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, šuplji opekarski blok 19cm, malter 2cm plaster 2cm, clay block wall 19cm, plaster 2cm	 malter 2cm, šuplji opekarski blok 19cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, clay block wall 19cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, šuplji opekarski blok 19cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, clay block wall 19cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 1,71 W/m²/K	U = 0,33 W/m²/K	U = 0,18 W/m²/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, AB zid 15cm plaster 2cm, reinforced concrete wall 15cm	 malter 2cm, AB zid 15cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 15cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, AB zid 15cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, reinforced concrete wall 15cm, thermal insulation 20cm, facade plaster 1cm
U (W/m²/K)	U = 3,86 W/m²/K	U = 0,37 W/m²/K	U = 0,19 W/m²/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, AB zid 15cm, malter 2cm plaster 2cm, reinforced concrete wall 15cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, AB zid 15cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, reinforced concrete wall 15cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m²/K)	U =2,45 W/m²/K	U = 2,45 W/m²/K	U = 0,61 W/m²/K
PROZORI WINDOWS	 drveni, dvostruki sa spojenim krilima i jednostrukim staklom wooden, single frame, connected double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m²/K)	U = 3,09 W/m²/K	U = 1,60 W/m²/K	U = 1,00 W/m²/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA
FLOOR CONSTRUCTION TO UNHEATED AREA

U (W/m²/K)

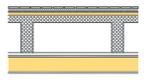
POSTOJEĆE STANJE | CURRENT CONDITION



parket 1cm, cementna košuljica 2cm, PVC folija, termoizolacija 2cm, kasetirana AB konstrukcija 25cm, drvene letve/vazduh 2cm, malter na mrežici 1cm
parquet 1cm, cement screed 2cm, PVC foil, thermal insulation 2cm, ribbed concrete slab 25cm, wooden slats 2cm, plaster on the grid 1cm

U = 0,87 W/m²/K

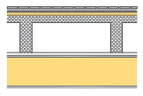
UNAPREĐENJE 1 | IMPROVEMENT 1



parket 1cm, cementna košuljica 2cm, PVC folija, termoizolacija 2cm, kasetirana AB konstrukcija 25cm, drvene letve/vazduh 2cm, malter na mrežici 1cm, termoizolacija 10cm, malter 1cm
parquet 1cm, cement screed 2cm, PVC foil, thermal insulation 2cm, ribbed concrete slab 25cm, wooden slats 2cm, plaster on the grid 1cm, thermal insulation 10cm, plaster 1cm

U = 0,24 W/m²/K

UNAPREĐENJE 2 | IMPROVEMENT 2

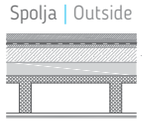


parket 1cm, cementna košuljica 2cm, PVC folija, termoizolacija 2cm, kasetirana AB konstrukcija 25cm, drvene letve/vazduh 2cm, malter na mrežici 1cm, termoizolacija 20cm, malter 1cm
parquet 1cm, cement screed 2cm, PVC foil, thermal insulation 2cm, ribbed concrete slab 25cm, wooden slats 2cm, plaster on the grid 1cm, thermal insulation 20cm, plaster 1cm

U = 0,15 W/m²/K

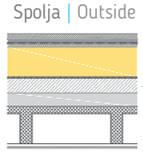
RAVAN KROV
FLAT ROOF

U (W/m²/K)



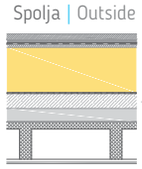
betonske ploče 4cm, pijesak 2cm, hidroizolacija, cementna košuljica 2cm, beton 10cm, šuplja opeka na pjesku 9cm, kasetirana AB konstrukcija 25cm, drvene letve/vazduh 2cm, malter na mrežici 1cm
concrete tiles 4cm, sand 2cm, waterproofing, cement screed 2cm, concrete 10cm, hollow bricks on sand 9cm, tribbed concrete slab 25cm, wooden slats 2cm, plaster on the grid 1cm

U = 1,53 W/m²/K



betonske ploče 4cm, pijesak 2cm, hidroizolacija, cementna košuljica 4cm, termoizolacija 20cm, parna brana, beton 10cm, šuplja opeka na pijesku 9cm, kasetirana AB konstrukcija 25cm, drvene letve/vazduh 2cm, malter na mrežici 1cm
concrete tiles 4cm, sand 2cm, waterproofing, cement screed 4cm, thermal insulation 20cm, vapor barrier, concrete 10cm, hollow bricks on sand 9cm, tribbed concrete slab 25cm, wooden slats 2cm, plaster on the grid 1cm

U = 0,16 W/m²/K



betonske ploče 4cm, pijesak 2cm, hidroizolacija, cementna košuljica 4cm, termoizolacija 30cm, parna brana, beton 10cm, šuplja opeka na pijesku 9cm, kasetirana AB konstrukcija 25cm, drvene letve/vazduh 2cm, malter na mrežici 1cm
concrete tiles 4cm, sand 2cm, waterproofing, cement screed 4cm, thermal insulation 30cm, vapor barrier, concrete 10cm, hollow bricks on sand 9cm, tribbed concrete slab 25cm, wooden slats 2cm, plaster on the grid 1cm

U = 0,11 W/m²/K

ELEMENTI UNAPREĐENJA TEHNIČKIH SISTEMA | TECHNICAL SYSTEMS IMPROVEMENTS ELEMENTS

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

POSTOJEĆE STANJE | CURRENT CONDITION

SISTEM GRIJANJA PROSTORA
HEATING SYSTEM

Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas)
Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)

UNAPREĐENJE 1 | IMPROVEMENT 1

Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote
Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat

UNAPREĐENJE 2 | IMPROVEMENT 2

Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima
Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves

STEPEN ISKORIŠTENJA SISTEMA GRIJANJA
HEATING SYSTEM EFFICIENCY FACTOR

SISTEM PRIPREME POTROŠNE TOPLE VODE
DOMESTIC HOT WATER SYSTEM (DHW)

Električni bojler
Electric water heater

Centralni sistem pripreme PTV povezan sa sistemom grijanja
Central domestic hot water system in conjunction with heating system

Centralni sistem pripreme PTV povezan sa sistemom grijanja
Central domestic hot water system in conjunction with heating system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

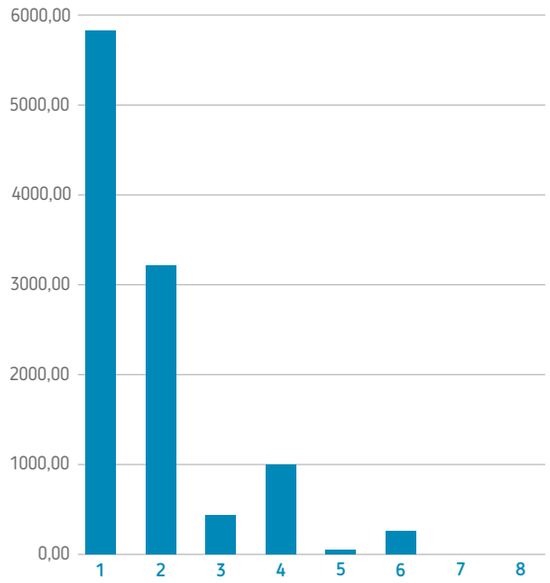
UNAPREĐENJE 2 | IMPROVEMENT 2

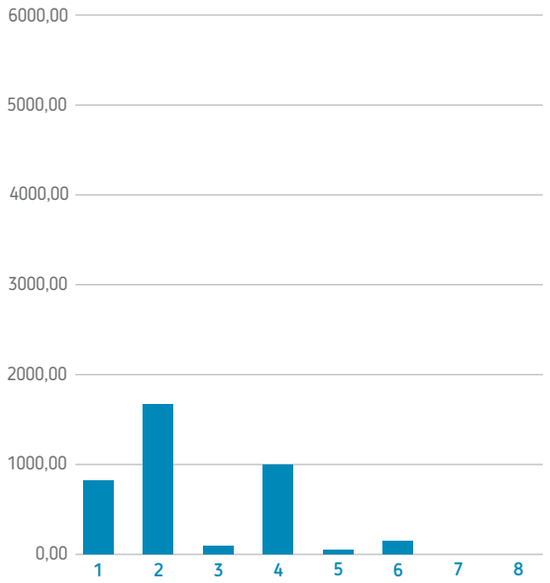
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

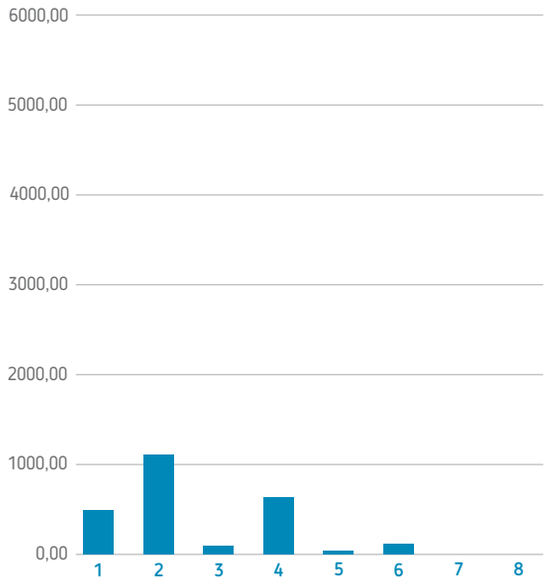
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ravni krov
4 - Gubici prema negrijanom stepeništu
5 - Strop prema okolini
6 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Flat roof
4 - To the unheated staircase
5 - Ceiling to the surroundings
6 - Through the unheated basement

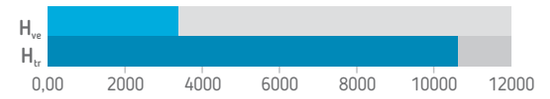


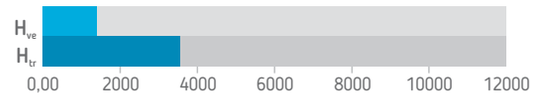


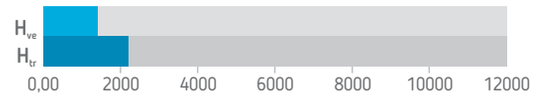


ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)



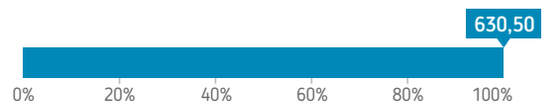


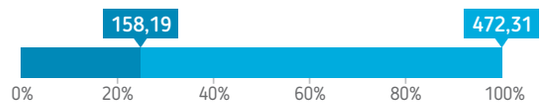


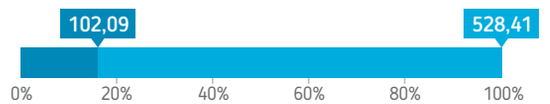
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

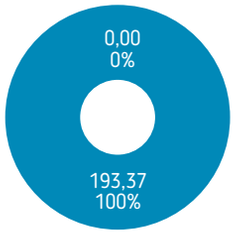
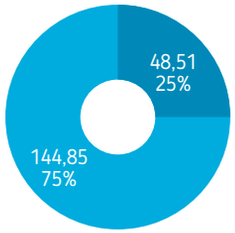
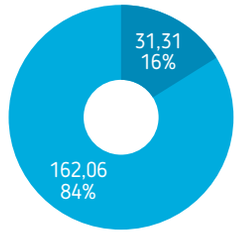
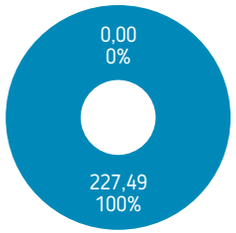
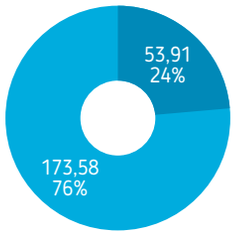
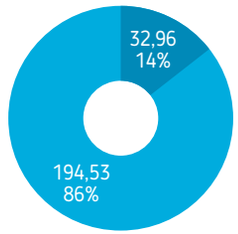
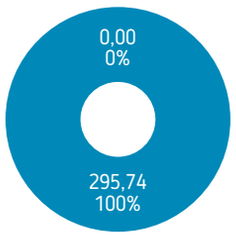
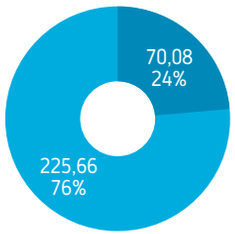
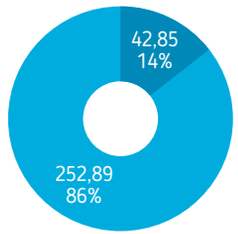
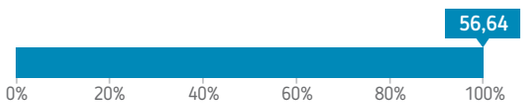
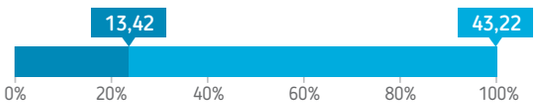
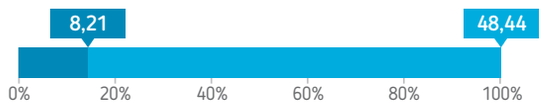
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

OSNOVNI PODACI O OBJEKTU | GENERAL BUILDING DATA

D6

Kategorija objekta Building category	**NEBODER** **HIGH-RISE BUILDING**
Godina izgradnje Built in	**1974.**
Broj etaža Number of floors	**20**
Broj stanova Number of apartments	**94**
Bruto površina osnove objekta (m^2) Gross surface of the building base (m^2)	**472,88**
Neto površina grijanog prostora (m^2) Net surface of the heated space (m^2)	**6679,7**
Volumen grijanog prostora (m^3) Heated space volume (m^3)	**16699,25**
Faktor oblika (m^{-1}) Shape factor (m^{-1})	**0,36**
Specifična godišnja potrebna energija za grijanje s prekidom u grijanju $Q_{H,nd,interm}$ (kWh/m^2/god) Specific energy need for intermitted heating $Q_{H,nd,interm}$ (kWh/m^2/year)	**125,64**
Specifična godišnja potrebna energija za grijanje bez prekida u grijanju $Q_{H,nd,cont}$ (kWh/m^2/god) Specific energy need for continuous heating $Q_{H,nd,cont}$ (kWh/m^2/year)	**175,57**

Neboder – stambena slobodnostojeća zgrada velike spratnosti je kompaktne kvadratne osnove, s ravnim prohodnim krovom. Najčešće spratnosti je Po+P+18 (20 etaža). Karakteriše ga skeletni konstruktivni sistem. Konstrukcija je od prefabrikovanih armirano-betonskih stubova i greda s armirano-betonskim platnima za ukrućenje. Spoljašnji zidovi su od prefabrikovanih panela od gas-betona debljine 20cm, koji su jednostrano omalterisani. Međuspratne konstrukcije su prednapregnute armirano-betonske kasetirane ploče. U ovom periodu termoizolacija od 5cm pojavljuje se u ravnom krovu. Prozori i balkonska vrata su dvostruka drvena spojena krila koja imaju dva obična jednostruka stakla. Neboderi imaju negrijane prostore stepeništa i podrumske prostore, koji su poluukopani.

Termovizijski snimak ukazuje da neboder ima najveće površinske toplotne gubitke na poziciji armirano-betonskih tavanica, jer spoljašnji zidovi, prefabrikovani fasadni paneli, nisu rađeni s prepustom preko tavanice i kod spoljašnjih zidova unutar prvobitnih lođa. Veći linijski toplotni gubici su kod postojećih prozora u gornjoj zoni okvira, te kod postojećih/prvobitnih lođa, javljaju se u poziciji spoljašnjeg zida ispod prepuštene ploče lođe i kod promjene gabarita, prepusta spoljašnjeg zida.

The high-rise building is of square footprint and flat accessible roof. It usually has a basement, ground floor, + 18 floors (20 floors). It is typically constructed on a skeleton steel frame. It includes prefabricated reinforced concrete pillars and beams with reinforced concrete lining. External walls are made of 20cm prefabricated gas-concrete panels, plastered on one side only. Floors are separated by pre-stressed rib-cassette RC slabs. Buildings from this period feature thermal insulation of 5cm in the flat roof. Windows and balcony doors are double conjoined wooden frames, with regular single glazing. Skyscrapers have unheated staircases and basement rooms, which are partially underground.

Thermovision image of the high-rise building shows the highest level of heat loss in the area of RC ceilings, since external walls, prefabricated facade panels, were constructed without nosing over the ceiling, as well as in the area of external walls inside the original deep-set balconies. Major linear heat loss is detected at the upper edge of existing windows, as well as at the existing deep-set balconies, in the place of external wall below the protruding deck, at places where the overall dimensions change, that is, at the nosing of the external wall.

UNAPREĐENJE 1 | IMPROVEMENT 1

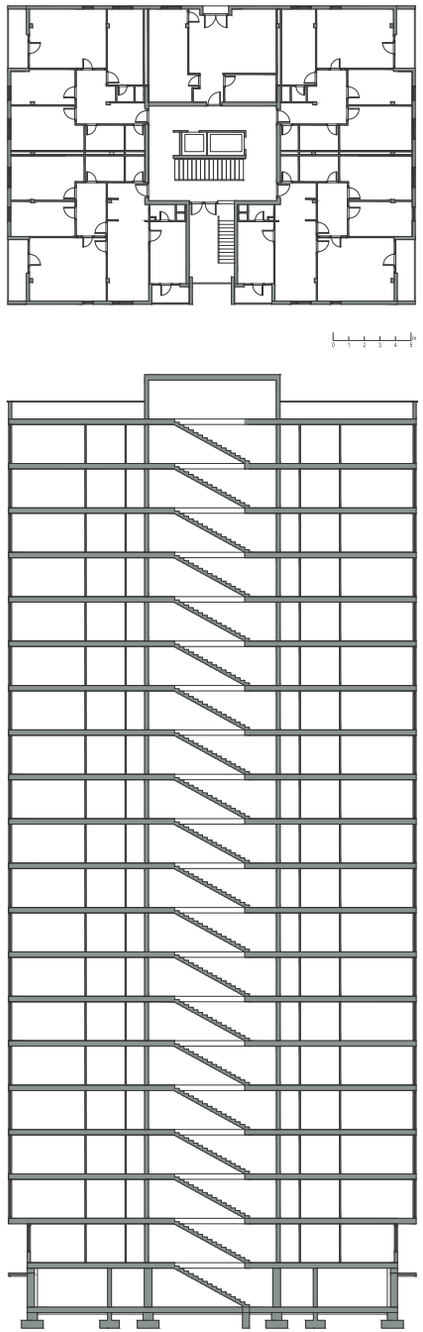
Izolovanje spoljašnjeg zida kontaknom fasadom termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog prostora (podruma) termoizolacionim slojem debljine 10cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 20cm (λ=0,035 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,6 W/m^{2}K (g=0,61). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica mjerenjem isporučene toplote za zgradu. Sistem pripreme PTV povezan sa sistemom grijanja. Niskotemperaturni sistem grijanja izolovanim cijevnim vodovima u negrijanim prostorima.

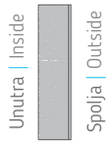
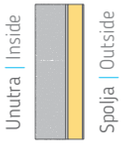
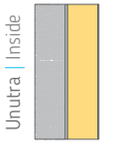
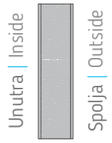
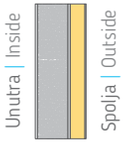
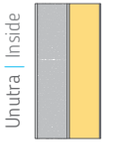
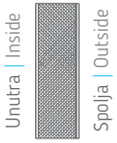
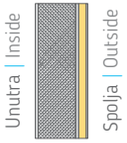
Insulation of external wall with contact facade thermal insulation layer of 10cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated space (basement) with thermal insulation layer of 10cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 20cm (λ=0.035 W/mK). Installing of new windows to reach U-coefficient of 1.6 W/m^{2}K (g=0.61). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Central domestic hot water system in conjunction with heating system. Low-temperature heating system with insulated pipeline in unheated spaces.

UNAPREĐENJE 2 | IMPROVEMENT 2

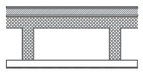
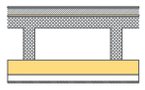
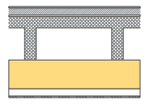
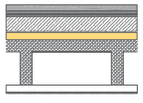
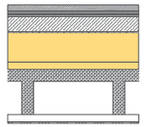
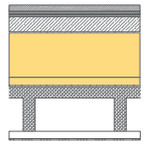
Izolovanje spoljašnjeg zida kontaktnom fasadom termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Izolovanje međuspratne konstrukcije iznad negrijanog podrumskog prostora termoizolacionim slojem debljine 20cm (λ=0,041 W/mK). Dodatno izolovanje ravnog krova termoizolacionim slojem debljine 30cm (λ=0,035 W/mK). Izolovanje inutrašnjih zidova prema negrijanom prostoru (stepenište) termoizolacionim slojem debljine 5cm (λ=0,041 W/mK). Ugradnja novih prozora kako bi se dostigao U-koeficijent od 1,0 W/m^{2}K (g=0,48). • Modernizacija ili ugradnja nove toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi. Ugradnja pumpe s promjenjivim protokom ili visokoefikasne pumpe. Daljinski upravljana podstanica s mjerenjem isporučene toplote za zgradu. Sistem grijanja hidraulički balansiran po krugovima i vertikalama s balans ventilima. Ugradnja ventila s termostatskim glavama na grijaća tijela po stanovima. Sistem pripreme PTV povezan sa sistemom grijanja.

Insulation of external wall with contact facade thermal insulation layer of 20cm (λ=0.041 W/mK). Insulation of construction between the floors above the unheated basement with thermal insulation layer of 20cm (λ=0.041 W/mK). Additional insulation of the flat roof with thermal insulation layer of 30cm (λ=0.035 W/mK). Insulation of internal walls to unheated areas (staircase) with thermal insulation layer of 5cm (λ=0.041 W/mK). Installing of new windows to reach U-coefficient of 1.0 W/m^{2}K (g=0.48). • Modernisation or installing of new heat substation with temperature regulator according to the outside temperature. Installation of pump with variable flow or high-efficiency pump. Remotely controlled substation that measures heat supplied to the building. Heating system hydraulically balanced per heating circuits and vertical lines with balancing valves. Installation of thermostatic radiator valves in apartments. Central domestic hot water system in conjunction with heating system.



	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPOLJAŠNJI ZID EXTERNAL WALL	 gas-beton 20cm, malter 2cm aerated concrete 20cm, plaster 2cm	 gas-beton 20cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm aerated concrete 20cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 gas-beton 20cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm aerated concrete 20cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 0,94 W/m^2/K	U = 0,28 W/m^2/K	U = 0,16 W/m^2/K
SPOLJAŠNJI ZID EXTERNAL WALL	 malter 2cm, blokovi od gas-betona 20cm, malter 2cm plaster 2cm, aerated concrete block 20cm, plaster 2cm	 malter 2cm, blokovi od gas-betona 20cm, malter 2cm, termoizolacija 10cm, fasadni malter 1cm plaster 2cm, aerated concrete block 20cm, plaster 2cm, thermal insulation 10cm, facade plaster 1cm	 malter 2cm, blokovi od gas-betona 20cm, malter 2cm, termoizolacija 20cm, fasadni malter 1cm plaster 2cm, aerated concrete block 20cm, plaster 2cm, thermal insulation 20cm, facade plaster 1cm
U (W/m^2/K)	U = 1,26 W/m^2/K	U = 0,30 W/m^2/K	U = 0,17 W/m^2/K
ZID PREMA NEGRIJANOM STUBIŠTU PARTITION WALL TO UNHEATED STAIRCASE	 malter 2cm, AB zid 15cm, malter 2cm plaster 2cm, reinforced concrete wall 15cm, plaster 2cm	 NEMA IZMJENA NO CHANGES	 malter 2cm, AB zid 15cm, malter 2cm, termoizolacija 5cm, malter 1cm plaster 2cm, reinforced concrete wall 25cm, plaster 2cm, thermal insulation 5cm, plaster 1cm
U (W/m^2/K)	U =2,41 W/m^2/K	U = 2,41 W/m^2/K	U = 0,18 W/m^2/K
PROZORI WINDOWS	 drveni, dvostruki sa spojenim krilima i jednostrukim staklom wooden, single frame, connected double sash with single glazing	 prozor s dvostrukim staklom windows with double glazing	 prozor s trostrukim staklom windows with triple glazing
U (W/m^2/K)	U = 3,14 W/m^2/K	U = 1,60 W/m^2/K	U = 1,00 W/m^2/K

SKLOPOVI TERMIČKOG OMOTAČA | ELEMENTS OF THE THERMAL ENVELOPE

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
MEĐUSPRATNA KONSTRUKCIJA IZNAD NEGRIJANOG PODRUMA FLOOR CONSTRUCTION TO UNHEATED AREA	 parket 1cm, cementna košuljica 4cm, termoizolacija 1cm, kasetirana AB konstrukcija 30cm, drvene letve/vazduh 5cm, azbest cementne ploče 0,5cm parquet 1cm, cement screed 4cm, thermal insulation 1cm, ribbed concrete slab 30cm, wooden slats/air 5cm, asbestos cement board 0.5cm	 parket 1cm, cementna košuljica 4cm, termoizolacija 1cm, kasetirana AB konstrukcija 30cm, termoizolacija 10cm, drvene letve/vazduh 5cm, gips-kartonske ploče 1,2cm parquet 1cm, cement screed 4 m, thermal insulation 1cm, ribbed concrete slab 30cm, thermal insulation 10cm, wooden slats/air 5cm, gypsum boards 1.2cm	 parket 1cm, cementna košuljica 4cm, termoizolacija 1cm, kasetirana AB konstrukcija 30cm, termoizolacija 20cm, drvene letve/vazduh 5cm, gips-kartonske ploče 1,2cm parquet 1cm, cement screed 4 m, thermal insulation 1cm, ribbed concrete slab 30cm, thermal insulation 20cm, wooden slats/air 5cm, gypsum boards 1.2cm
U ($W/m^2/K$)	U = 1,17 $W/m^2/K$	U = 0,30 $W/m^2/K$	U = 0,17 $W/m^2/K$
RAVAN KROV FLAT ROOF	 betonske ploče 4cm, pijesak 2cm, hidroizolacija, cementna glazura 1cm, padni beton 10cm, bitumenska ljepenka 0,5cm, termoizolacija 5cm, kasetirana AB konstrukcija 30cm, drvene letve/ vazduh 5cm, azbest cementne ploče 0,5cm concrete tiles 4cm, sands 2cm, waterproofing, screed 1cm, concrete laid to fall 10cm, bitumen felt 0.5cm, thermal insulation 5cm, ribbed concrete slab 30cm, wooden slats 5cm, asbestos cement board 0.5cm	 betonske ploče 4cm, pijesak 2cm, hidroizolacija, cementna glazura 1cm, padni beton 10cm, bitumenska ljepenka 0,5cm, termoizolacija 20cm, termoizolacija 5cm, kasetirana AB konstrukcija 30cm, drvene letve 5cm, gips-kartonske ploče 1,2cm concrete tiles 4cm, sands 2cm, waterproofing, screed 1cm, concrete laid to fall 10cm, bitumen felt 0.5cm, thermal insulation 20cm, thermal insulation 5cm, ribbed concrete slab 30cm, wooden slats/air 5cm, gypsum board 1.2cm	 betonske ploče 4cm, pijesak 2cm, hidroizolacija, cementna glazura 1cm, padni beton 10cm, bitumenska ljepenka 0,5cm, termoizolacija 30cm, termoizolacija 5cm, kasetirana AB konstrukcija 30cm, drvene letve 5cm, gips-kartonske ploče 1,2cm concrete tiles 4cm, sands 2cm, waterproofing, screed 1cm, concrete laid to fall 10cm, bitumen felt 0.5cm, thermal insulation 30cm, thermal insulation 5cm, ribbed concrete slab 30cm, wooden slats/air 5cm, gypsum board 1.2cm
U ($W/m^2/K$)	U = 0,59 $W/m^2/K$	U = 0,13 $W/m^2/K$	U = 0,10 $W/m^2/K$

SISTEMI GRIJANJA I PRIPREME POTROŠNE TOPLE VODE | HEATING AND DOMESTIC HOT WATER SYSTEM

	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SISTEM GRIJANJA PROSTORA HEATING SYSTEM	 Daljinski sistem grijanja na fosilno gorivo s toplotnim podstanicama (ugalj, mazut, gas) Remote heating system based on fossil fuel with heat substations (coal, fuel oil, gas)	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat	 Ugradnja toplotne podstanice s regulacijom temperature prema spoljnjoj temperaturi, pumpa s promjenjivim protokom, daljinski upravljana podstanica i mjerenje isporučene toplote, s hidrauličkim balansiranjem mreže i termostatskim ventilima Installing of heat substation with temperature regulated according to the outside temperature, variable flow pump, remote substation control, and measuring of supplied heat, with hydraulic system balancing and thermostatic valves
STEPEN ISKORIŠTENJA SISTEMA GRIJANJA HEATING SYSTEM EFFICIENCY FACTOR			
SISTEM PRIPREME POTROŠNE TOPLE VODE DOMESTIC HOT WATER SYSTEM (DHW)	 Električni bojler Electric water heater	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system	 Centralni sistem pripreme PTV povezan sa sistemom grijanja Central domestic hot water system in conjunction with heating system

POSTOJEĆE STANJE | CURRENT CONDITION

UNAPREĐENJE 1 | IMPROVEMENT 1

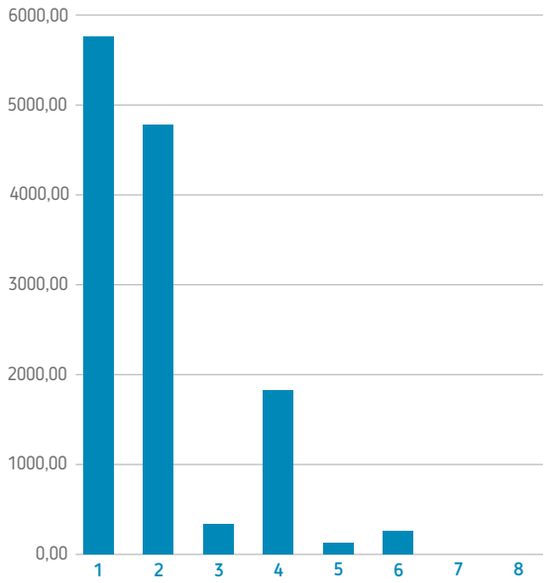
UNAPREĐENJE 2 | IMPROVEMENT 2

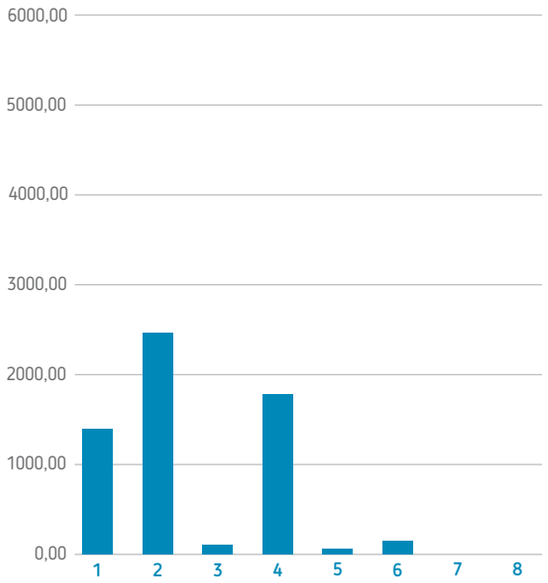
TOPLOTNI GUBICI ELEMENATA TERMIČKOG OMOTAČA ZGRADE
HEAT TRANSFER COEFFICIENT

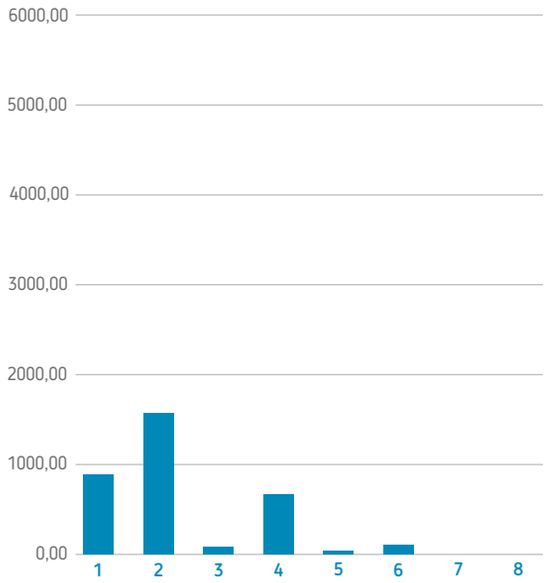
(W/K)

1 - Spoljašnji zid
2 - Prozori i balkonska vrata
3 - Ravni krov
4 - Gubici prema negrijanom stepeništu
5 - Strop prema okolini
6 - Gubici kroz negrijani podrum

1 - External wall
2 - Windows and balcony doors
3 - Flat roof
4 - To the unheated staircase
5 - Ceiling to the surroundings
6 - Through the unheated basement

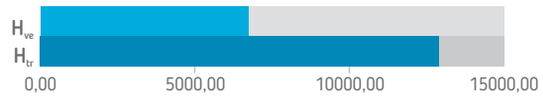


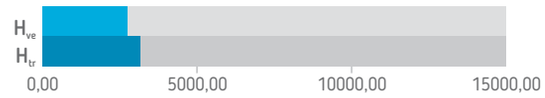




ODNOS KOEFICIJENTA TRANSMISIONOG TOPLOTNOG GUBITKA H_{tr} I VENTILACIONOG GUBITKA H_{ve}
RATIO OF HEAT TRANSFER COEFFICIENT BY TRANSMISSION H_{tr} AND BY VENTILATION H_{ve}

(W/K)

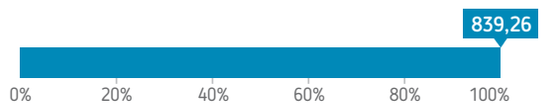


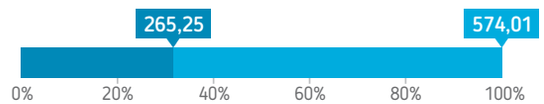


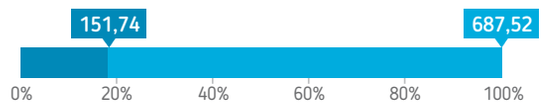
GODIŠNJA POTREBNA TOPLOTNA ENERGIJA ZA GRIJANJE
ENERGY NEED FOR HEATING

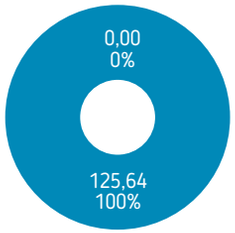
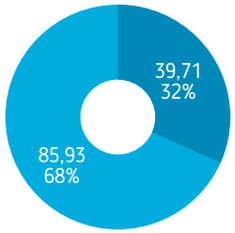
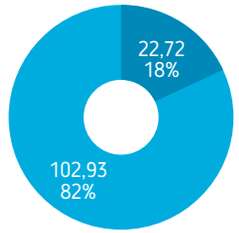
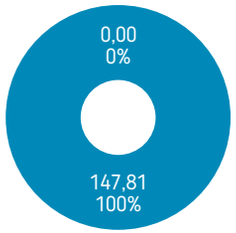
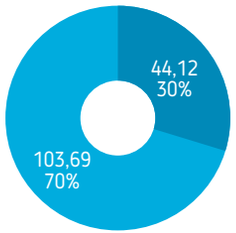
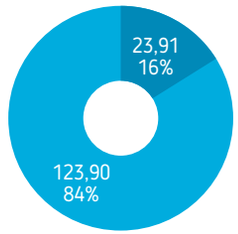
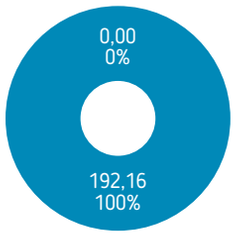
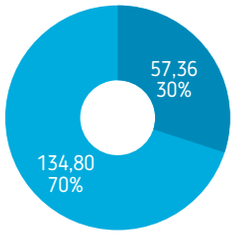
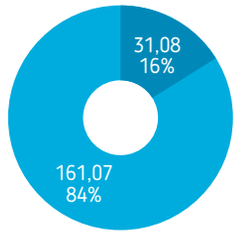
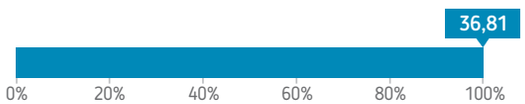
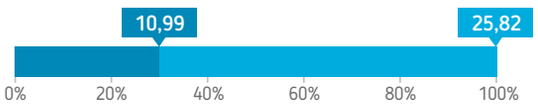
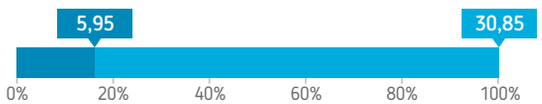
(MWh/god) | (MWh/year)

Potrebna energija | Energy need
Ušteda | Savings







	POSTOJEĆE STANJE | CURRENT CONDITION	UNAPREĐENJE 1 | IMPROVEMENT 1	UNAPREĐENJE 2 | IMPROVEMENT 2
SPECIFIČNA GODIŠNJA POTREBNA ENERGIJA ZA GRIJANJE SPECIFIC ENERGY NEED FOR HEATING (kWh/m²/god) | (kWh/m²/year) Potrebna energija | Energy need Ušteda | Savings			
SPECIFIČNA ISPORUČENA ENERGIJA ZA GRIJANJE SPECIFIC DELIVERED ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Isporučena energija | Delivered energy Ušteda | Savings			
ENERGENT FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL	FOSILNO GORIVO FOSSIL FUEL
SPECIFIČNA PRIMARNA ENERGIJA ZA GRIJANJE SPECIFIC PRIMARY ENERGY FOR HEATING (kWh/m²/god) | (kWh/m²/year) Primarna energija | Primary energy Ušteda | Savings			
EMISIJA CO_2 CO_2 EMISSION (t/god) | (t/year) Emisija CO_2 | CO_2 emission Smanjenje emisije CO_2 Reduction CO_2			

ZAKLJUČAK | CONCLUSION

IV. ZAKLJUČAK

Projektom Tipologija stambenih zgrada u Bosni i Hercegovini po prvi put su prikupljeni i sistematizovani podaci o energetskim, ali i drugim karakteristikama stambenog fonda u Bosni i Hercegovini koji imaju uticaj na energetsku efikasnost zgrada (oblik i spratnost zgrade, urbanistički parametri, materijalizacija zgrade i dr.). Društveno-ekonomski odnosi i tradicija građenja rezultovali su specifičnostima tipologije stambenih zgrada u Bosni i Hercegovini.

Rezultati istraživanja pokazuju da individualne porodične stambene zgrade čine najveći dio stambenog fonda, 93,36% od broja svih stambenih zgrada, te unapređenje njihovih energetskih karakteristika može da dovede do značajnog smanjenja potrošene energije za grijanje u Bosni i Hercegovini.

Jedna od specifičnosti Bosne i Hercegovine je da se ne grije cijeli stambeni prostor individualnih porodičnih kuća, te rezultati dobijeni u projektu koji se odnose na potrebnu toplotnu energiju značajno odstupaju od statističkih podataka o utrošenoj godišnjoj količini različitih vrsta energenata u Bosni i Hercegovini.

Individualne porodične zgrade griju se ogrevnim drvetom kao dominantnim energentom, te je potencijal za smanjivanje emisije CO_2 manji nego kod zgrada za kolektivno stanovanje. Najveći potencijal za smanjivanje emisija CO_2 predstavljaju kolektivne stambene zgrade koje se griju putem centralizovanih sistema gradskih toplana koje kao energent koriste lož ulje.

U ovom projektu razmatrano je kako se može postići smanjenje emisija unapređenjem energetskih performansi zgrada, tj. smanjivanjem potrošene energije bez razmatranja uticaja promjene energenata. Međutim, zbog regulative i složenih svojinskih odnosa provođenje projekata energetske sanacije kolektivnih stambenih zgrada teško je izvodljivo ukoliko ne dođe do značajnije promjene regulative u ovoj oblasti.

Rezultati projekta treba da budu osnova za kreiranje novih projekata koji će istovremeno doprinijeti smanjivanju potrošnje energije, ali i unapređenju komfora stanara zgrada pošto su zgrade velike starosti. Jedan dio stambenog fonda, koji potiče iz perioda 1992-2014, čine individualne porodične kuće čija izgradnja nije završena, te njihovo završavanje može da predstavlja i unapređenje energetskih karakteristika, ali i rješavanje problema socijalno ugroženog stanovništva (izbjegla i raseljena lica).

Projektnom su prikupljeni brojni podaci o stambenom fondu koji mogu da budu polazna osnova za dalje projekte, čiji rezultat treba da bude stvaranje registra postojećih i novih stambenih objekata na nivou Bosne i Hercegovine, ali i na nivou lokalnih zajednica, a sve s ciljem da se smanji potrošnja energije.

IV. CONCLUSION

For the purpose of the Residential Building Typology of Bosnia and Herzegovina Project, data on energy performance and other characteristics of the residential building stock of Bosnia and Herzegovina (building shape and number of floors, urban planning parameters, construction materials used, etc.) have been collected and organised for the first time. Social and economic relations and traditional construction practice resulted in specific types of residential buildings in Bosnia and Herzegovina.

Results of research show that single-family houses dominate the residential building stock with 93.36%, and that improvementsin those buildings may result in significantly reduced consumption of energy used for heating in Bosnia and Herzegovina.

One of the peculiarities of Bosnia and Herzegovina is that these single-family houses are only partially heated, so the results produced by the project concerning required energy for heating significantly differ from statistical data on consumed quantities of fuels in Bosnia and Herzegovina per year.

Majority of single-family houses is heated using wood, which means that potential for CO_2 reduction is smaller than in case of collective housing. The greatest potential for CO_2 reduction is found in apartment buildings heated by centralised communal heating systems that use fuel oil.

This project considered potential for reduction of emissions by improving energy performance of the buildings, without any considerations on possible changes in fuel and effects they may have. However, due to applicable regulations and complex ownership relations, implementation of energy refurbishment projects in collective housing units is difficult unless relevant regulations are substantially modified.

Project results should serve as a basis for creation of new projects that will reduce consumption of energy and improve comfort in very old buildings. Buildings built in 1992-2014 are single-family houses that have not yet been finished, and once they are, it could be regarded as improvement of their energy performance, but also a solution for sensitive social categories (refugees and displaced persons).

The project collected numerous data on the residential building stock that can be used as a basis for future projects the results of which should be creation of a register of the existing and new residential buildings on the level of Bosnia and Herzegovina, but also on the level of local communities, all for the purpose of reducing energy consumption.

Special focus should be put on the need for future research of the residential building stock on the level of local communities for the purpose of reducing energy consumption in the existing buildings, but also planning and building of new residential blocks and their energy supply.

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