ENERGETSKA CERTIFIKACIJA ZGRADA I SUVREMENI ENERGETSKI KONCEPTI

ENERGY CERTIFICATION OF BUILDINGS AND MODERN ENERGY CONCEPTS

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Uvođenje energetske certifikacije zgrada u hrvatsko zakonodavstvo i podjele zgrada u energetske razrede prema godišnjoj potrebnoj toplinskoj energiji za grijanje donosi niz ključnih promjena u graditeljstvu, koje će odigrati značajnu ulogu kako u povećanju kvalitete gradnje i osmišljavanju suvremenog energetskog koncepta novih zgrada te osuvremenjivanju postojećih zgrada, tako i u značajnom doprinosu smanjenju energetske potrošnje u sektoru zgradarstva, kao najvećem pojedinačnom potrošaču energije.

U radu se prikazuje novi zakonodavni okvir i metodologija provedbe energetskih pregleda i energetske certifikacije zgrada u Republici Hrvatskoj (RH), te očekivani utjecaj na razvoj integralnog pristupa projektiranju i dugoročnog pristupa analizi zgrade, uzimajući u obzir njezin cijeli životni vijek. Energetskim certificiranjem zgrada dobivaju se transparentni podaci o potrošnji energije u zgradama na tržištu, energetska učinkovitost prepoznaje se kao znak kvalitete, potiču se ulaganja u nove inovativne koncepte i tehnologije, potiče se korištenje alternativnih sustava za opskrbu energijom u zgradama, razvija se tržište novih nisko energetskih zgrada i modernizira sektor postojećih zgrada, te se doprinosi ukupnom smanjenju potrošnje energije i zaštiti okoliša.

The introduction of energy certification of buildings in Croatian legislature and the classification of buildings in energy classes in accordance with their annual thermal energy requirements for heating purposes introduces a number of key changes in construction. They will play a considerable role in the improvement of construction quality, creation of a modern energy concept for new buildings, modernisation of existing buildings, and will significantly contribute to the reduction of energy consumption in the building construction sector, the latter being the largest individual energy consumer.

This paper presents the new legislative framework and the implementation methodology for energy audits and energy certification of buildings in the Republic of Croatia (RH), and it elaborates on the expected influence on the development of the integral approach to design and the long term approach to building analysis, taking into consideration the entire lifespan of the building. Energy certification of buildings provides us with transparent data on energy consumption in buildings on the market, energy efficiency is recognised as an indication of quality, investments in new and innovative concepts and technologies are encouraged, as is the use of alternative energy supply systems in buildings, the market for new low-energy buildings develops, the existing buildings sector is modernised, and a contribution is made towards a general reduction of energy consumption and towards environment protection.

Ključne riječi: energetska certifikacija zgrada; energetska učinkovitost; energetski koncept; integralno projektiranje

Keywords: energy certification of buildings; energy concept; energy efficiency; integral design

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1 UVOD

Implementacijom EU Direktive 2002/91/EC o energetskim svojstvima zgrada (EPBD) [1] u hrvatsko zakonodavstvo se uvodi obvezna energetska certifikacija zgrada za nove i postojeće zgrade. EPBD se implementira na temelju Akcijskog plana za implementaciju [2] izrađenog u Ministarstvu zaštite okoliša, prostornog uređenja i graditeljstva (MZOPUG) i usvojenog u travnju 2008. godine, kroz Zakon o prostornom uređenju i gradnji (NN 76/2007 i 38/2009 članak 15.) [3] te putem niza tehničkih propisa i pravilnika, od kojih su do sada usvojeni: Tehnički propis o racionalnoj uporabi energije i toplinskoj zaštiti zgrada (NN 110/2008 i 89/2009) [4], Tehnički propis o sustavima grijanja i hlađenja zgrada (NN 110/2008) [5], Pravilnik o energetskom certificiranju zgrada (NN 113/2008 i 91/2009) [6] i Pravilnik o uvjetima i mjerilima za osobe koje provode energetske preglede i energetsko certificiranje zgrada (NN 113/2008 i 89/2009) [7]. U lipnju 2009. godine usvojena je i nacionalna Metodologija provođenja energetskog pregleda zgrada [8], u skladu s člankom 28. Pravilnika [6], čime su ostvareni osnovni preduvjeti za početak energetske certifikacije zgrada.

2 FORMIRANJE ZAKONODAVNOG OKVIRA ZA ENERGETSKE PREGLEDE I ENERGETSKU CERTIFIKACIJU ZGRADA

Energetski certifikat zgrade jest dokument koji predočuje energetska svojstva zgrade i koji ima propisani sadržaj i izgled prema pravilniku [6], a izdaje ga ovlaštena osoba. Vrijednosti koje su istaknute na energetskom certifikatu odražavaju energetska svojstva zgrade i potrošnju energije izračunatu na temelju pretpostavljenog režima korištenja zgrade i ne moraju nužno izražavati realnu potrošnju u zgradi ili njezinoj samostalnoj uporabnoj jedinici, jer ona uključuje i ponašanje korisnika. Energetski pregled zgrade jest dokumentirani postupak koji se provodi s ciljem utvrđivanja energetskih svojstava zgrade i stupnja ispunjenosti tih svojstava u odnosu na zahtjeve propisane posebnim propisima i sadrži prijedlog mjera za ekonomski povoljno poboljšanje energetskih svojstava zgrade, a provodi ga ovlaštena osoba. Temeljem provedenog energetskog pregleda i izračunatih energetskih potreba zgrade izrađuje se energetski certifikat.

Ujedno, energetski certifikat jest i jaki marketinški instrument s ciljem promocije energetske učinkovitosti i nisko energetske gradnje i postiza-

1 INTRODUCTION

With the implementation of the EU Directive 2002/91/EC on the energy performance of buildings (EPBD) [1] the obligatory energy certification of new and existing buildings is introduced into Croatian legislature. EPBD is implemented on the basis of the Implementation Action Plan [2] compiled by the Ministry of Environmental Protection, Physical Planning and Construction (MZOPUG) and adopted in April 2008 with the Physical Planning and Building Act (Official Gazette of the Republic of Croatia 76/07 and 38/09 Article 15) [3] and through a series of technical regulations and ordinances adopted so far: the Technical Regulation on Energy Economy and Heat Retention in Buildings (Official Gazette of the Republic of Croatia 110/08 and 89/09) [4], the Technical Regulations on the Heating and Cooling Systems of Buildings (Official Gazette of the Republic of Croatia 110/08) [5], the Ordinance on Energy Certification of Buildings (Official Gazette of the Republic of Croatia 113/08 and 91/09) [6], the Ordinance on the Requirements and Criteria to be met by Energy Auditors and Energy Certifiers of Buildings (Official Gazette of the Republic of Croatia 113/08 and 89/09) [7]. In June 2009, the national Implementation Methodology for the Energy Audits of Buildings [8] was also adopted, in accordance with Article 28 of the Ordinance [6], which realised the basic preconditions for the start of the energy certification of buildings.

2 THE FORMATION OF THE LEGISLATIVE FRAMEWORK FOR ENERGY AUDITS AND ENERGY CERTIFICATION OF BUILDINGS

The energy certificate of a building is a document which presents the energy performance of a building, which has the content and appearance prescribed by the Ordinance [6], and is issued by an authorised person. The values presented in the energy certificate reflect the energy performance of a building and the energy consumption calculated on the basis of an assumed regime of building use. They do not necessarily need to reflect the real consumption of the building or its independent usage unit because the latter also includes the behaviour of the users. The energy audit of a building is a documented procedure implemented to determine the energy performance of a building and the degree of performance fulfilment in relation to the requirements prescribed by special regulations. It contains a suggestion of the measures for a financially favourable improvement of the energy performance of a building and it is performed by an authorised person. The energy certificate is compiled based on the performed energy audit and the nja višeg komfora života i boravka u zgradama. Energetskim certificiranjem zgrada dobivaju se transparentni podaci o potrošnji energije u zgradama na tržištu, energetska učinkovitost prepoznaje se kao znak kvalitete, potiču se ulaganja u nove inovativne koncepte i tehnologije, potiče se korištenje alternativnih sustava za opskrbu energijom u zgradama, razvija se tržište novih nisko energetskih zgrada i modernizira sektor postojećih zgrada, te se doprinosi ukupnom smanjenju potrošnje energije i zaštiti okoliša.

Pravilnik [6] propisuje zgrade za koje je potrebno izdati energetski certifikat, energetske razrede zgrada, sadržaj i izgled energetskog certifikata, energetsko certificiranje novih i postojećih zgrada, obveze zgrada javne namjene, postupak energetskog certificiranja, te vođenje registra izdanih energetskih certifikata. Temeljem izračuna specifične godišnje potrebne toplinske energije za grijanje Q_{Hndref} zgrada se svrstava u razred energetske potrošnje, od A+ razreda s najmanjom potrošnjom toplinske energije za grijanje ($Q_{Hndref} \leq 15$ kWh/(m²a)), do G razreda zgrade s najvećom energetskom potrošnjom ($Q_{Hndref} > 250$ kWh/(m²a)) i to u dvije referentne klime: 2 900 stupanj dana grijanja za kontinentalnu Hrvatsku i 1 600 stupanj dana grijanja za primorsku Hrvatsku, s granicom na 2 200 stupanj dana grijanja. Pri tome je važno napomenuti da zgrade projektirane u skladu s tehničkim propisom [4] ulaze u razred energetske potrošnje C, te da je potrebno značajno poboljšanje energetskih svojstava zgrade kako bi zgrada bila svrstana u energetski razred A ili A+.

calculated energy requirements of the building.

The energy certificate is also a strong marketing instrument with the purpose of promoting energy efficiency, low-energy construction and the achievement of greater comfort of living and residing in buildings. Transparent data on energy consumption in buildings on the market are gained by energy certification of buildings, energy efficiency is recognised as an indication of quality, investments in new and innovative concepts and technologies are encouraged, as is the use of alternative energy supply systems in buildings, the market for new low-energy buildings develops, the existing buildings sector is modernised, and a contribution is made to a general reduction of energy consumption and to environment protection.

The Ordinance [6] prescribes the buildings for which it is necessary to issue the energy certificate, the energy classes of buildings, the contents and the appearance of the energy certificate, energy certification of new and existing buildings, the obligations of public use buildings, the procedure of energy certification and the management of the registry of issued energy certificates. Based on the calculations of specific yearly thermal energy requirements for heating $Q_{H,nd,ref}$ buildings are classified in energy consumption classes, from the A+ class with the smallest thermal energy consumption for heating ($Q_{H,nd,ref} \leq 15$ kWh/(m²a)), to the G class with the greatest energy consumption ($Q_{H,nd,ref} > 250$ kWh/(m²a)) in two reference climates: 2 900 heating degree days for inland Croatia and 1 600 heating degree days for seaboard Croatia, with a 2 200 heating degree days limit. It is important to point out that the buildings designed in accordance with the technical regulations [4] belong to the energy consumption class C, and a significant improvement of the energy performance of the buildings is necessary for the building to be classified in the energy class A or A+.

Tablica 1 – Energetski razredi zgrada utvrđeni Pravilnikom [6]
Table 1 – Energy classes of buildings determined by the Ordinance [6]

Energetski razred / Energy class	$Q_{H,nd,ref}$ – specifična godišnja potrebna toplinska energija za grijanje / – specific yearly thermal energy required for heating, 250 kWh/(m²a)
A+	≤ 15
A	≤ 25
B	≤ 50
C	≤ 100
D	≤ 150
E	≤ 200
F	≤ 250
G	> 250

Energetskim certificiranjem zgrada uvodi se:

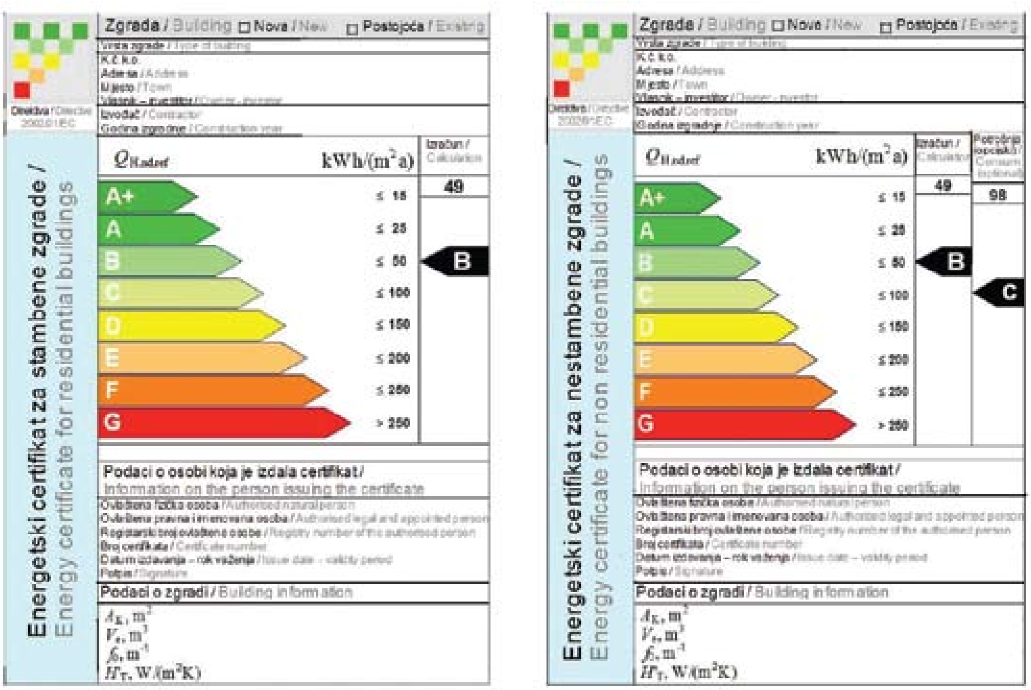
- obveza vlasnika zgrade da prigodom izgradnje, prodaje ili iznajmljivanja zgrade predoči budućem vlasniku odnosno potencijalnom kupcu ili najmoprimcu certifikat o energetskim svojstvima zgrade kojemu rok valjanosti nije duži od deset godina,
- obveza izdavanja i izlaganja energetskog certifikata ne starijeg od 10 godina na jasno vidljivom mjestu, za zgrade javne namjene ukupne korisne površine veće od 1 000 m^2 koje koriste tijela javne vlasti i zgrade institucija koje pružaju javne usluge velikom broju ljudi.

Investitor nove zgrade dužan je osigurati energetski certifikat zgrade prije obavljanja tehničkog pregleda, odnosno priložiti ga zahtjevu za izdavanje uporabne dozvole. Ta se obveza odnosi na sve nove zgrade za koje se nakon 31. ožujka 2010. godine podnosi zahtjev za izdavanje akta temeljem kojega se može graditi (građevinske dozvole ili potvrde glavnog projekta), odnosno na sve nove zgrade čija građevinska (bruto) površina nije veća od 400 m^2 i zgrade za obavljanje isključivo poljoprivrednih djelatnosti čija građevinska (bruto) površina nije veća od 600 m^2, za koje je prijavljen početak građenja nakon 31. ožujka 2010. godine.

The energy certification of buildings introduces:

- the obligation of the building owner to present the energy performance certificate of the building, with a validity period of up to ten years, to the future owner, potential buyer or tenant during construction, sale or leasing of the building,
- the obligation, for public use buildings with a total useful area larger than 1 000 m^2 used by public authorities, and buildings of institutions providing public services to a large number of people, to issue and display the energy certificate not older than 10 years in a clearly visible place.

The investor in a new building is obliged to ensure the energy certificate of the building before the technical inspection is performed, or enclose it with the request for the issuing of the building inspection certificate. The obligation applies to all new buildings for which the request for the issuing of the document on the basis of which construction can begin (building permit or validation of the main project) is submitted after March 31st 2010, or for all new buildings with a construction (gross) area under 400 m^2 and buildings for exclusively agricultural activities with a construction (gross) area under 600 m^2, for which the start of construction work has been reported after March 31st 2010.



Slika 1 — Prva stranica energetskog certifikata za stambene i nestambene zgrade
Figure 1 — The first page of the energy certificate for residential and non residential buildings

Vlasnik postojeće zgrade dužan je prilikom prodaje ili iznajmljivanja zgrade u cjelini ili njezinog dijela koji je samostalna uporabna cjelina (pojedini stan, pojedinačni uredski prostor i sl.), odnosno lizinga (engl. *leasing*), osigurati energetski certifikat zgrade odnosno njezinog dijela i dati ga na uvid potencijalnom kupcu ili unajmljivaču zgrade. Kod prodaje zgrade ili njezinog dijela koji je samostalna uporabna cjelina, energetski certifikat mora biti na uvidu prigodom sklapanja ugovora o kupoprodaji i sastavni je njegov dio. Sve postojeće zgrade koje se prodaju, iznajmljuju ili daju na lizing moraju imati energetski certifikat dostupan na uvid kupcu ili najmoprimcu najkasnije danom pristupanja Republike Hrvatske u članstvo EU.

Zgrade javne namjene koje imaju ukupnu korisnu površinu veću od $1\ 000\ m^2$ moraju imati energetski certifikat izložen na mjestu jasno vidljivom posjetiteljima zgrade. Energetski certifikat se izrađuje uvećan na format A3, zaštićen od eventualnih oštećenja i pričvršćen na siguran način. Javno se izlaže prva strana energetskog certifikata koja sadrži osnovne podatke o zgradi i skalu energetskih razreda, te treća strana certifikata koja sadrži preporuke za poboljšanje energetskih svojstava zgrade. Zgrade javne namjene, za koje je obvezno javno izlaganje energetskog certifikata, moraju imati izrađen i javno izložen energetski certifikat i popis mjera za povećanje energetske učinkovitosti u roku od najdulje 36 mjeseci od donošenja Metodologije provođenja energetskih pregleda zgrade [8], dakle najkasnije do lipnja 2012. godine.

Energetski certifikat zgrade (stambene i nestambene) sadrži ukupno pet stranica, od kojih prva (slika 1) sadrži osnovne podatke o zgradi te grafičku skalu energetskih razreda od A+ do G s navedenim iznosom specifične godišnje potrebne toplinske energije za grijanje Q_{Hndref} ,$\mathrm{kWh/(m^2a)}$. Druga stranica certifikata sadrži klimatske podake, podatke o svim ugrađenim tehničkim sustavima u zgradi, te rezultate izračuna energetskih potreba zgrade s navedenim vrijednostima koeficijenata prolaska topline za pojedine građevne dijelove zgrade. Treća stranica sadrži prijedlog mjera za poboljšanje energetskih svojstava zgrade koje su ekonomski opravdane. Četvrta stranica energetskog certifikata zgrade sadrži objašnjenje tehničkih pojmova, a peta stranica energetskog certifikata zgrade sadrži detaljan opis propisa, normi i proračunskih postupaka za određivanje podataka navedenih u energetskom certifikatu.

The owner of an existing building must ensure the energy certificate of the building or its parts for the sale or rental of the building as a whole, of its part which is an independently usable unit (an individual apartment, an individual office space, etc.), or for leasing, and present it to the potential buyer or renter of the building. During the sale of a building or its part which is an independently usable unit, the energy certificate must be made available for the stipulation of the sales contract and be its integral part. All existing buildings for sale, rent or leasing must have the energy certificate and be able to present it to a buyer or renter at the latest by the date when the Republic of Croatia joins the EU.

Public use buildings with a total useful area larger than $1\ 000\ m^2$ must display the energy certificate in a place clearly visible to all the building visitors. The energy certificate is enlarged into the A3 format, protected from possible damage and fastened in a secure manner. The publicly displayed pages of the energy certificate are the first page, containing the basic data on the building and the energy classes scale, and the third page, containing recommendations for improvements of the energy performance of the building. The public use buildings, for which the public display of the energy certificate is obligatory, must have their energy certificate and the list of measures for increasing energy efficiency compiled and publicly displayed within, at the most, 36 months from the adoption of the Implementation Methodology for the Energy Audits of Buildings [8], that is by June 2012 at the latest.

The energy certificate of a building (residential and non residential) contains a total of five pages, the first of which (figure 1) contains the basic information on the building and the graphic scale of energy classes from A+ to G with the given amount of specific yearly thermal energy requirements for heating $Q_{\mathrm{H,nd,ref}}$ in $\mathrm{kWh/(m^2a)}$. The second page of the certificate contains climate information, information on all technical systems installed in the building, and the calculation results of the building's energy requirements with the given values of the heat transfer coefficient for certain structural elements of the building. The third page contains the proposed measures for the improvement of the economically justified energy performances of the building. The fourth page of the energy certificate of the building contains the explanation of technical notions, and the fifth page of the energy certificate of the building contains a detailed description of the regulations, standards and calculation procedures to determine the information given in the energy certificate.

3 METODOLOGIJA ENERGETSKIH PREGLEDA ZGRADA

Postupak energetskog certificiranja zgrade sastoji se od:

- energetskog pregleda zgrade,
- vrjednovanja i/ili završnog ocjenjivanja radnji energetskog pregleda zgrade,
- izdavanja energetskog certifikata zgrade.

Radi ujednačavanja kvalitete i metoda provedbe energetskih pregleda zgrada, u lipnju 2009. godine usvojena je nacionalna metodologija [8]. Prema toj metodologiji, energetski pregled zgrade obvezno uključuje:

- analizu građevinskih karakteristika zgrade u smislu toplinske zaštite (analizu toplinskih karakteristika vanjske ovojnice zgrade),
- analizu energetskih svojstava sustava grijanja i hlađenja,
- analizu energetskih svojstava sustava klimatizacije i ventilacije,
- analizu energetskih svojstava sustava za pripremu potrošne tople vode,
- analizu energetskih svojstava sustava potrošnje električne energije – sustav elektroinstalacija, rasvjete, kućanskih aparata i drugih podsustava potrošnje električne energije,
- analizu upravljanja svim tehničkim sustavima zgrade,
- potrebna mjerenja gdje je to nužno za ustanovljavanje energetskog stanja i /ili svojstava,
- analizu mogućnosti promjene izvora energije,
- analizu mogućnosti korištenja obnovljivih izvora energije i učinkovitih sustava,
- prijedlog ekonomski povoljnih mjera poboljšanja energetskih svojstava zgrade, ostvarive uštede, procjenu investicije i jednostavni period povrata,
- izvješće s preporukama za optimalni zahvat i redoslijed prioritetnih mjera koje će se implementirati kroz jednu ili više faza.

Energetski pregled zgrade opcionalno može uključivati i druge radnje, ovisno o namjeni i vrsti zgrade, kao npr. analizu potrošnje sanitarne vode i preporuke za smanjenje potrošnje sanitarne vode.

Osnovna karakteristika energetskog pregleda stambene zgrade je prikupljanje podataka o zgradi i izračun godišnjih energetskih potreba za grijanje i potrošnu toplu vodu, prema HRN EN 13790:2008 [9]. Za stambene zgrade nije obvezno mjerenje niti prikupljanje podataka o potrošnji i troškovima za

3 THE METHODOLOGY FOR THE ENERGY AUDITS OF BUILDINGS

The energy certification procedure of a building consists of:

- the energy audit of the building,
- the valuation and/or final assessment of the energy audit of the building,
- the issuing of the energy certificate of the building.

National methodology [8] was adopted in June 2009 to standardise the quality and methods of the implementation of energy audits of buildings. In accordance with the methodology, the energy audit of a building must include:

- the analysis of the construction characteristics of the building in the sense of heat retention (the analysis of the thermal characteristics of the external envelope of the building),
- the analysis of the energy performance of heating and cooling systems,
- the analysis of the energy performance of air condition and ventilation,
- the analysis of the energy performance of the consumable hot water preparation system,
- the analysis of the energy performance of the electricity consumption system – the system of electrical installations, lighting, household appliances and other subsystems of electricity consumption,
- the analysis of the management of all technical systems of the building,
- the necessary measurements where they are essential to determine energy conditions and/or performances,
- the analysis of possibilities of energy source changes,
- the analysis of the possibilities of energy usage from renewable sources and efficient systems,
- the proposal of economically favourable measures for the improvement of the energy performance of a building, feasible savings, investment estimates and a simple pay back period,
- the report containing recommendations for the optimal intervention and the order of priority measures which will be implemented through one or more phases.

The energy audit of a building can optionally include other actions, depending on the use and type of the building, for example, the consumption analysis for the water for sanitary use and recommendations for the reduction of the consumption of water for sanitary use.

The basic characteristic of the energy audit of a residential building is the gathering of data on the energiju, već se cijeli energetski pregled temelji na prikupljanju ulaznih podataka i izračunu. Ukoliko postoje podaci, moguće je opcionalno analizirati i potrošnju i troškove za energiju te provesti određena mjerenja radi utvrđivanja kvalitete izvedbe kod novih zgrada, odnosno identifikacije problema i točnijeg utvrđivanja energetskih svojstava kod postojećih zgrada.

Kod energetskog pregleda nestambenih zgrada treba voditi računa o karakteristikama potrošnje energije u zgradama određene namjene. Kao i kod stambenih zgrada, prikupljaju se potrebni ulazni podaci radi utvrđivanja energetskih svojstava zgrade, te se temeljem prikupljenih podataka provodi izračun godišnjih energetskih potreba za grijanje i potrošnu toplu vodu, prema [9]. Za nestambene zgrade mogu se analizirati troškovi za energiju i po potrebi modelirati energetska potrošnja i to:

— troškovi za električnu energiju i karakteristike potrošnje,
— troškovi za toplinsku energiju i karakteristike potrošnje,
— troškovi za sanitarnu vodu i karakteristike potrošnje.

Optimalno se analiza troškova provodi za period od tri godine, odnosno 36 mjeseci.

Za preciznije utvrđivanje postojećih energetskih svojstava zgrade i svih tehničkih sustava u zgradi često je potrebno provesti određena mjerenja. Kada postoji opravdana sumnja u točnost ulaznih podataka potrebnih za izračun energetskih svojstava vanjske ovojnice i tehničkih sustava, mogu se provoditi mjerenja:

— toplinskih gubitaka kroz vanjsku ovojnicu (slike 2 i 3) korištenjem infracrvene termografije (ICT), te mjerenje zrakopropusnosti (Blower Door Test), mjerenje toplinskog otpora,
— u sustavima klimatizacije, grijanja, hlađenja, ventilacije,
— elektroenergetskih parametara potrošnje električne energije – po trošilima ili podsustavima.

building and the calculation of yearly energy requirements for heating and consumable hot water, in accordance with HRN EN 13790:2008 [9]. The measuring or collecting data on consumption and energy costs is not obligatory for residential buildings, since the entire energy audit is based on gathering input data and calculations. If data exist, it is optionally possible to analyse both the consumption and the energy costs and undertake certain measurements to ascertain the quality of execution in new buildings, or identify the problems and more accurately determine the energy performances of existing buildings.

When performing energy audits of non residential buildings, the energy consumption characteristics in buildings for specific use should be taken into consideration. As with residential buildings, the necessary input data are gathered to determine the energy performances of the building, and a calculation of the yearly energy requirements for heating and consumable hot water is performed on the basis of the gathered data, in accordance with [9]. Energy costs can be analysed for non residential buildings, and energy consumption can be modelled according to need, in particular:

— electricity costs and consumption characteristics,
— thermal energy costs and consumption characteristics,
— costs of water for sanitary use and consumption characteristics.

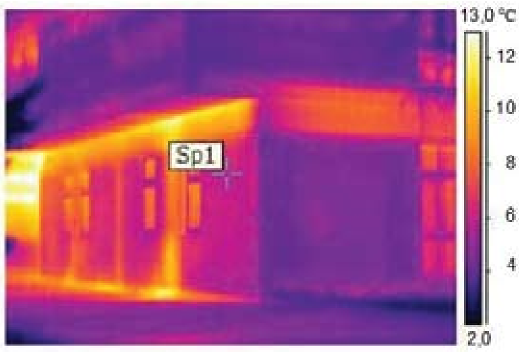
Cost analysis is optimally performed for the period of three years, or 36 months.

It is often necessary to perform additional measurements to precisely determine the existing energy performance of a building and all the technical systems in the building. When there is reasonable doubt in the accuracy of input data needed to calculate the energy performance of the external envelope and the technical systems, the following measurements can be implemented:

— measuring thermal losses through the external envelope (figures 2 and 4) using infrared thermography (IRT), and measuring airtightness (Blower Door Test), measuring thermal resistance,
— in air conditioning, heating, cooling and ventilation systems,
— electrical power parameters of electricity consumption – per energy-using device or subsystem.

Slika 2 — ICT snimka napravljene prilikom energetskog pregleda u svrhu vizualizacije toplinskih mostova i nehomogenosti vanjskog zida, karakteristični katovi bez toplinske zaštite, EIHP, 2008.

Figure 2 — IRT image made during an energy audit with the purpose of visualising thermal bridges and inhomogeneity of the outer wall, characteristic floors without heat retention, EIHP, 2008.



Slika 3 — ICT snimka napravljene prilikom energetskog pregleda u svrhu vizualizacije toplinskih mostova i nehomogenosti vanjskog zida, spoj prizemnog dijela zgrade s terenom, EIHP, 2008.

Figure 3 — IRT image made during an energy audit with the purpose of visualising thermal bridges and inhomogeneity of the outer wall, the connection of the ground part of the building with the terrain, EIHP, 2008.

Osnovni elementi energetskog pregleda postojećih zgrada za potrebe energetskog certificiranja su:

- — analiza energetskih svojstava zgrade i karakteristika upravljanja potrošnjom i troškovima energije,
- — analiza i izbor mogućih mjera poboljšanja energetskih svojstava zgrade,
- — energetsko, ekonomsko i ekološko vrjednovanje predloženih mjera,
- — završno izvješće o energetskom pregledu s preporukama i redoslijedom prioritetnih mjera.

Osnovni elementi energetskog pregleda novih zgrada za potrebe energetskog certificiranja su:

- — analiza energetskih svojstava zgrade i karakteristika upravljanja potrošnjom i troškovima energije – prema podacima iz

The basic elements of an energy audit of existing buildings for the purpose of energy certification are:

- — the analysis of energy performances of the building and the characteristics of consumption and energy costs management,
- — the analysis and selection of possible measures for the improvement of the energy performance of the building,
- — energy, economic and environmental valuation of proposed measures,
- — the final report on the energy audit containing recommendations and the sequence of priority measures.

The basic elements of an energy audit of new buildings for the purpose of energy certification are:

- — the analysis of energy performances of the building and the characteristics of energy consumption and costs management – according to the data

projektne dokumentacije i uvidom u izvedeno stanje,
- završno izvješće o energetskom pregledu s iskazom podataka za izradu energetskog certifikata.

Energetskim pregledom se za potrebe energetskog certificiranja analiziraju svi tehnički sustavi zgrade, a računaju se godišnja potrebna toplinska energija za grijanje Q_{Hnd} i godišnja potrebna toplinska energija za zagrijavanje potrošene tople vode Q_W za stvarne klimatske uvjete te se za sada obvezno unose u energetski certifikat, dok je unos ostalih energetskih potreba opcionalan. U konačnosti, energetski certifikat bi trebao sadržavati podatke o ukupnoj primarnoj energiji E_{prim}, kWh/a, odnosno podatke o računski određenoj količini energije za potrebe zgrade tijekom jedne godine, koja obuhvaća ukupnu primarnu energiju za grijanje, pripremu potrošne tople vode, hlađenje i rasvjetu, te energiju za pomoćne uređaje i regulaciju. Uz to trebaju biti iskazane i CO_2 emisije prema utrošku pojedinog izvora energije.

Analiza mogućih mjera poboljšanja energetskih svojstava i povećanja energetske učinkovitosti obvezno uključuje:

- poboljšanje toplinskih karakteristika vanjske ovojnice,
- poboljšanje energetskih svojstava sustava grijanja prostora,
- poboljšanje energetskih svojstava sustava hlađenja prostora,
- poboljšanje energetskih svojstava sustava ventilacije i klimatizacije,
- poboljšanje energetskih svojstava sustava pripreme potrošne tople vode,
- poboljšanje energetskih svojstava sustava potrošnje električne energije – rasvjeta, uređaji i ostala trošila,
- poboljšanje energetskih svojstava specifičnih podsustava,
- analiza mogućnosti zamjene energenta ili korištenja obnovljivih izvora energije za
- proizvodnju toplinske i/ili električne energije,
- poboljšanje sustava regulacije i upravljanja,
- poboljšanje sustava opskrbe vodom i potrošnje (opcionalno),
- potrebne procjene i izračuni ušteda za odabrane mjere.

Mogućnosti poboljšanja energetskih svojstava zgrade možemo podijeliti u dvije skupine:

- mjere uz male troškove i brzi povrat investicije, prema prilogu 4 Pravilnika [6],

from the project documentation and insight into the derived condition,
- the final report on the energy audit with the information presented for the compilation of the energy certificate.

The energy audit, for the needs of energy certification, analyses all the technical systems of a building. The yearly thermal energy required for heating $Q_{H,nd}$ and the yearly thermal energy required for consumable hot water preparation Q_W are calculated for real climate conditions and now must be entered into the energy certificate, while the input of other energy requirements is optional. In its final version, the energy certificate should contain information on total primary energy E_{prim}, kWh/a, or information on the calculated quantity of energy for the requirements of the building during one year, which encompasses the total primary energy for heating, consumable hot water preparation, cooling and lighting, and the energy for auxiliary appliances and regulation. The CO_2 emissions should also be displayed in accordance with the consumption of an individual energy source.

The analysis of possible energy performance improvement measures and the increase of energy efficiency must include:

- the improvement of thermal characteristics of the external envelope,
- the improvement of energy performance of the space heating system,
- the improvement of energy performance of the space cooling system,
- the improvement of energy performance of the ventilation and air condition systems,
- the improvement of energy performance of the consumable hot water preparation system,
- the improvement of energy performance of the electricity consumption system – lighting, appliances and other energy-using devices,
- the improvement of energy performance of specific subsystems,
- the analysis of the possibilities for the substitution of energy sources or the usage of renewable energy sources for the production of thermal energy and/or electricity,
- the improvement of the regulation and management systems,
- the improvement of the water supply and consumption systems (optional),
- the necessary evaluations and calculations of savings for the chosen measures.

The possibilities for the improvement of energy performances of a building can be divided into two groups:

- the measures with small expenses and a quick return of the investment, in accordance with Annex 4 of the Ordinance [6],

— mjere uz veće troškove i dulji povrat investicije, prema prilogu 4 Pravilnika [6].

Radi postizanja veće energetske učinkovitosti potrebno je evaluirati mogućnosti korištenja različitih vrsta izvora energije s gledišta investicije, ušteda i zaštite okoliša. Provedena analiza svake predložene mjere mora dati sljedeće odgovore:

— koje su godišnje uštede energije i smanjenje emisije ugljičnog dioksida (HRK, kWh, t CO_2),
— koliki su investicijski troškovi, troškovi projektiranja, troškovi montaže i demontaže,
— troškovi puštanja u pogon, vijek trajanja i potrebne dozvole (procjene),
— koliki je period povrata investicije,
— specifikaciju opreme i radova,
— održavanje.

Analiza mjera obvezno se provodi pri energetskim pregledima postojećih zgrada svih vrsta i namjena.

Pri provedbi energetskog pregleda posebno je važno završno izvješće o rezultatima provedenog energetskog pregleda. Završno izvješće sadrži sve prethodno navedene elemente energetskog pregleda i specifikaciju potrebnih podataka za izradu energetskog certifikata zgrade. Također, izvješće može služiti kao podloga za poslovno odlučivanje ključnim ljudima. Energetski certifikat se izrađuje u skladu sa završnim izvješćem. U završnom izvješću, uz sve prikupljene podatke o energetskim svojstvima zgrade, potrebno je specificirati sljedeće podatke:

3.1 Podaci koji se unose u završno izvješće o energetskom pregledu

3.1.1 Opći podaci o zgradi

vrsta zgrade prema namjeni (prema podjeli iz članka 5. stavka 2. PECZ, NN 113/2008)
— lokacija zgrade (katastarska čestica, ulica, kućni broj, mjesto s poštanskim brojem)
— ime i prezime vlasnika, odnosno investitora zgrade
— naziv izvođača radova
— godina završetka izgradnje

3.1.2 Podaci o zgradi

— ploština korisne površine zgrade A_{K_3}, m^2,
— opseg grijanog dijela zgrade V_e, m^3,
— faktor oblika f_0, m^{-1}.
— koeficijent transmisijskog toplinskog gubitka (po jedinici oplošja grijanog dijela zgrade) H'_T, W/(m^2K).

— the measures with larger expenses and a longer return of the investment, in accordance with Annex 4 of the Ordinance [6].

To achieve greater energy efficiency it is necessary to evaluate the possibilities of usage of different kinds of energy sources from the viewpoint of the investment, savings and environment protection. The analysis implemented for each proposed measure must yield the following answers:

— what are the yearly energy savings and the reduction of carbon dioxide emissions (HRK, kWh, t CO_2),
— what are the investment costs, engineering costs, assembling and dismantling costs,
— the start of operations costs, lifespan and necessary permits (evaluations),
— what is the period for the return of investments,
— specification of equipment and works,
— maintenance.

The analysis of measures must be performed with the energy audits of existing buildings of all types and uses.

When performing an energy audit, the final report on the results of the performed energy audit is of special importance. The final report contains all the previously stated elements of the energy audit and the specifications of necessary data for the compilation of the energy certificate of a building. Moreover, the report can serve as the basis for executive decisions by key people. The energy certificate is complied in accordance with the final report. In the final report, along with all the gathered data on the energy performances of the building, it is also necessary to specify the following pieces of information:

3.1 Information entered in the final report on the energy audit

3.1.1 General information on the building

type of building according to use (in accordance with the classification from Article 5, Paragraph 2 of the Ordinance on Energy Certification of Buildings, Official Gazette of the Republic of Croatia 113/2008),
— the location of the building (cadastral plot, street, house number, town and postal code),
— name and surname of the building's owner or investor,
— name of the contractor,
— end of construction year.

3.1.2 Information on the building

— surface of the useful area of the building A_{K_3}, m^2,
— volume of the heated part of the building V_e, m^3,
— form factor f_0, m^{-1}.
— transmission heat loss coefficient (per surface unit of the heated part of the building) H'_T, W/(m^2K).

3.1.3 Klimatski podaci

- broj stupanj dana grijanja SD, Kd/a,
- broj dana sezone grijanja Z, d,
- srednja vanjska temperatura u sezoni grijanja θ_e, °C,
- unutarnja projektna temperatura u sezoni grijanja θ_i, °C.

3.1.4 Podaci o tehničkim sustavima zgrade

- način grijanja i pripreme potrošne tople vode (lokalno, etažno, centralno, daljinski izvor),
- izvori energije koji se koriste za grijanje,
- izvori energije koji se koriste za pripremu potrošne tople vode,
- način hlađenja (lokalno, etažno, centralno, daljinski izvor),
- izvori energije koji se koriste za hlađenje,
- vrsta ventilacije (prirodna, prisilna bez povrata topline, prisilna s povratom topline),
- vrsta i namjena korištenja sustava s obnovljivim izvorima energije,
- udio obnovljivih izvora energije u potrebnoj toplinskoj energiji za grijanje u postocima.

3.1.5 Podaci o potrebnoj energiji

- godišnja potrebna toplinska energija za grijanje Q_H, kWh/a, kWh/(m²a) i najveća dopuštena vrijednost,
- godišnji toplinski gubici sustava grijanja Q_{Hls}, kWh/a, kWh/(m²a),
- godišnja potrebna toplinska energija za zagrijavanje potrošne tople vode, Q_W, kWh/a, kWh/(m²a),
- godišnji toplinski gubici sustava za zagrijavanje potrošne tople vode Q_{Wls}, kWh/a, kWh/(m²a),
- godišnja potrebna toplinska energija za hlađenje Q_C, kWh/a, kWh/(m²a),
- godišnji gubici sustava hlađenja Q_{Cls}, kWh/a, kWh/(m²a),
- godišnja potrebna energija za ventilaciju u sustavu prisilne ventilacije, djelomične klimatizacije i klimatizacije za stvarne klimatske podatke za definirani profil korištenja Q_{Ve}, kWh/a, kWh/(m²a),
- godišnja potrebna energija za rasvjetu za stvarne klimatske podatke za definirani profil korištenja E_l, kWh/a, kWh/(m²a),
- godišnja isporučena energija E_{del}, kWh/a, kWh/(m²a),
- godišnja primarna energija E_{prim}, kWh/a, kWh/(m²a),
- godišnja emisija CO_2 za stvarne klimatske podatke, kg/a, kg/(m²a),

3.1.6 Koeficijenti prolaska topline za pojedine građevne dijelove zgrade

Građevni dio:

- stvarni U_{stv}, W/(m²K),
- maksimalni U_{max}, W/(m²K).

3.1.3 Climate data

- the number of heating degree days SD, Kd/a,
- the number of heating season days Z, d,
- the mid external temperature during the heating season θ_e, °C,
- the projected internal temperature during the heating season θ_i, °C,

3.1.4 Data on the technical systems of the building

- method for heating and preparation of consumable hot water (local, by floor, central, remote source),
- energy sources used for heating,
- energy sources used for consumable hot water preparation,
- cooling mode (local, by floor, central, remote source),
- energy sources used for cooling,
- ventilation type (natural, forced without heat return, forced with heat return),
- type of renewable energy source systems usage, and their purpose,
- share of renewable energy sources in thermal energy necessary for heating purposes, %.

3.1.5 Data on energy requirements

- yearly thermal energy requirements for heating purposes Q_H, kWh/a, kWh/(m²a) and the maximum allowed value,
- yearly heat losses in heating systems Q_{Hls}, kWh/a, kWh/(m²a),
- yearly thermal energy required for consumable hot water preparation, Q_W, kWh/a, kWh/(m²a)
- yearly heat losses in consumable hot water preparation systems Q_{Wls}, kWh/a, kWh/(m²a),
- yearly thermal energy requirements for cooling Q_C, kWh/a, kWh/(m²a),
- yearly losses in cooling systems Q_{Cls}, kWh/a, kWh/(m²a),
- yearly energy requirements for ventilation in forced ventilation systems, partial air-conditioning and air-conditioning for real climate data for the defined usage profile Q_{Ve}, kWh/a, kWh/(m²a),
- yearly energy requirements for lighting for real climate data for the defined usage profile E_l, kWh/a, kWh/(m²a),
- yearly delivered energy E_{del}, kWh/a, kWh/(m²a),
- yearly primary energy E_{prim}, kWh/a, kWh/(m²a),
- yearly CO_2 emissions for real climate data, kg/a, kg/(m²a).

3.1.6 Heat transfer coefficients for certain structural elements of the building

Structural element:

- U real, W/(m²K),
- U max, W/(m²K).

3.1.7 Redoslijed prioritetnih mjera za poboljšanje energetskih sustava

3.1.7 Order of priority measures for the improvement of energy systems

Tablica 2 – Specifikacija mjera energetskih ušteda u završnom izvješću o energetskom pregledu
Table 2 – Specification of energy-saving measures in the final report on the energy audit

Mjere / Measures	Opis mjere / Measure description	Procjena investicije / Investment estimate (*x*)	Procijenjene uštede / Estimated savings		Procijenjene uštede / Estimated savings (*y*)	Jednostavan period povrata / Simple return period *x*/*y*	Smanjenje emisije / Emission reduction CO_2
		HRK	kWh/a	Energent / Energy source	HRK/a	Godina / Year	t/a
1							
2							
3							
4							
5							
6							
Ukupno / Total							

4 PROGRAM IZOBRAZBE STRUČNJAKA I OVLAŠTENJA ZA PROVOĐENJE ENERGETSKIH PREGLEDA I ENERGETSKU CERTIFIKACIJU ZGRADA

Pravilnikom [7] definirani su uvjeti i mjerila za davanje ovlaštenja osobama za provođenje energetskih pregleda i energetsko certificiranje zgrada. Također su definirani uvjeti i mjerila za davanje suglasnosti institucijama za provođenje Programa izobrazbe za osobe koje provode energetske preglede i energetsko certificiranje zgrada. Prema Pravilniku, osobe koje provode energetske preglede i energetsko certificiranje zgrada moraju imati ovlaštenje Ministarstva zaštite okoliša, prostornog uređenja i graditeljstva. Ovlaštenje se izdaje fizičkoj ili pravnoj osobi za energetske preglede i energetsko certificiranje stambenih i nestambenih zgrada s jednostavnim tehničkim sustavom, te za energetske preglede zgrada sa složenim tehničkim sustavom.

Pri tome je definirano da su zgrade s jednostavnim tehničkim sustavom:

4 EDUCATION PROGRAM FOR EXPERTS, AUTHORISATIONS FOR THE IMPLEMENTATION OF ENERGY AUDITS AND THE ENERGY CERTIFICATION OF BUILDINGS

The Ordinance [7] defines the conditions and measures for the authorisation of persons for the implementation of energy audits and the energy certification of buildings. It also defines the conditions and measures for granting consent to institutions for the implementation of the education program for the persons performing the energy audits and the energy certification of buildings. In accordance with the Ordinance, the persons performing the energy audits and the energy certification of buildings must be authorised by the Ministry of Environmental Protection, Physical Planning and Construction. The authorisation is issued to a natural or legal person for energy audits and the energy certification of residential and non residential buildings with simple technical systems, and for energy audits of buildings with a complex technical system.

Buildings with a simple technical system are defined as being:

- stambene ili nestambene zgrade bez sustava grijanja, hlađenja, ventilacije te s individualnim sustavima pripreme potrošne tople vode,
- zgrade s pojedinačnim i centralnim izvorima topline za grijanje bez posebnih sustava za povrat topline, s razdiobom toplinske energije i s centralnim ili individualnim sustavima za pripremu potrošne tople vode bez korištenja alternativnih sustava te pojedinačnim rashladnim uređajima, sustavima ventilacije bez povrata topline i ograničenjem buke u ventilacijskim sustavima bez dodatne obrade zraka,

Zgrade sa složenim tehničkim sustavom su:

- stambene ili nestambene zgrade s postrojenjima s centralnim izvorima topline za grijanje i/ili hlađenje zgrade, s centralnom pripremom potrošne tople vode, sa sustavima za mjerenje i razdiobu toplinske i rashladne energije, centralnim rashladnim sustavima, sustavima ventilacije i klimatizacije s povratom topline i ograničenjem buke te dodatnom obradom zraka,
- zgrade sa složenim sustavima za grijanje i hlađenje s korištenjem alternativnih sustava opskrbe energijom, centrale za daljinsko zagrijavanje i hlađenje, rashladna postrojenja, ventilacijski uređaji s reguliranim grijanjem i hlađenjem zraka i klima uređaji, uključujući i pripadajuće rashladne uređaje i druge zgrade koje nisu navedene kao jednostavni tehnički sustavi.

Uvjet za dobivanje ovlaštenja je najmanje završen preddiplomski i diplomski sveučilišni studij ili integrirani preddiplomski i diplomski sveučilišni studij kojim se stječe akademski naziv magistar inženjer arhitektonske, građevinske, strojarske ili elektrotehničke struke, odnosno završen specijalistički diplomski studij kojim se stječe stručni naziv specijalist građevinske, strojarske ili elektrotehničke struke, najmanje pet godina radnog iskustva u struci na poslovima projektiranja, stručnog nadzora građenja, održavanja, odnosno ispitivanja građevinskog dijela zgrade vezano na uštedu energije i toplinsku zaštitu, provođenja energetskih pregleda zgrade, ispitivanja funkcije energetskih sustava u zgradi, ili ispitivanja funkcije sustava automatskog reguliranja i upravljanja u zgradi, te uspješno završen Program osposobljavanja.

Ovlaštena osoba može provoditi samostalno sve energetske preglede zgrada s jednostavnim tehničkim sustavima. Za provođenje energetskih pregleda zgrada sa složenim tehničkim sustavima preporuča se oformiti tim stručnjaka od najmanje tri stručne osobe, pri čemu osoba strojarske struke vrši energetski pregled strojarskog dijela tehničkog sustava zgrade, osoba elektrotehničke

- residential or non residential buildings without heating, cooling or ventilation systems, and with individual consumable hot water preparation systems,
- buildings with individual and central thermal sources for heating without special heat return systems, with a division of thermal energy and central or individual consumable hot water preparation systems without the usage of alternative systems and individual cooling devices, ventilation systems without heat return and noise limitation in ventilation systems without additional air processing,

Buildings with a complex technical system are:

- residential or non residential buildings containing plants with central thermal sources for heating and/or cooling of the building, central consumable hot water preparation systems, systems for the measurement and division of heating and cooling energy, central cooling systems, ventilation and air conditioning systems with heat returns, noise limitation and additional air processing,
- buildings with complex heating and cooling systems using alternative energy supply systems, remote heating and cooling plants, cooling plants, ventilation devices with regulated air heating and cooling and air conditioning devices, including the pertaining cooling devices, and other buildings not listed as simple technical systems.

The conditions for obtaining the authorisation are: completed undergraduate and graduate university studies or integrated undergraduate and graduate university studies with which one obtains the Master in Engineering title in architecture, construction, engineering or electrical engineering, or completed specialist graduate studies with which one obtains the title of a construction, engineering or electrical engineering specialist, at least five years of work experience in the chosen vocation in the areas of engineering, expert supervision of construction, maintenance, testing the structural parts of buildings in connection with energy savings and heat retention, performing energy audits of buildings, testing the functions of energy systems of buildings, testing the functions of automatic regulation and control systems of buildings, and a successfully completed Training Program.

An authorised person can independently perform all energy audits of buildings with simple technical systems. For the implementation of energy audits of buildings with complex technical systems it is recommended to form a professional team of at least three experts where the engineer performs the energy audit of the engineering part of the technical system of the building, the electrical en-struke vrši energetski pregled elektrotehničkog dijela tehničkog sustava zgrade, a osoba arhitektonske ili građevinske struke vrši energetski pregled u dijelu koji se odnosi na građevinske karakteristike zgrade u smislu racionalne uporabe energije i toplinske zaštite. Za provođenje energetskih pregleda i energetsku certifikaciju zgrada može se ovlastiti i pravna osoba koja ima zaposlene stručne kvalificirane osobe odgovarajućih struka. Ovlaštene osobe dužne su se redovito usavršavati.

Stručno osposobljavanje i obvezno usavršavanje osoba koje provode energetske preglede i/ili energetsko certificiranje zgrada provode sveučilišta, veleučilišta, instituti, strukovne organizacije koji imaju suglasnost Ministarstva zaštite okoliša, prostornog uređenja i graditeljstva za obavljanje tih poslova. Trenutačna situacija u rujnu 2009. je ukupno pet ovlaštenih institucija, koje pripremaju prve tečajeve prema Programu izobrazbe definiranom u pravilniku [7]. Program izobrazbe za stručno osposobljavanje i obvezno usavršavanje osoba koje provode energetske preglede i energetsko certificiranje zgrada sastoji se od Modula 1 i Modula 2, te periodičkog stručnog usavršavanja.

Modul 1 obvezno pohađaju:

— fizičke osobe koje se ovlašćuju za provođenje energetskih pregleda i energetsko certificiranje zgrada s jednostavnim tehničkim sustavom,
— osobe zaposlene u pravnoj osobi koja se ovlašćuje za provođenje energetskih pregleda i/ili energetsko certificiranje zgrada s jednostavnim tehničkim sustavom koje provode energetske preglede i energetsko certificiranje zgrada,
— osobe koje u svojstvu imenovane osobe u ovlaštenoj pravnoj osobi potpisuju izvješća o energetskim pregledima i energetske certifikate zgrada s jednostavnim tehničkim sustavom.

Modul 2 obvezno pohađaju:

— fizičke osobe koje se ovlašćuju za provođenje energetskih pregleda zgrada sa složenim tehničkim sustavom,
— osobe zaposlene u pravnoj osobi koja se ovlašćuje za provođenje energetskih pregleda i/ili energetsko certificiranje zgrada sa složenim tehničkim sustavom, koje provode energetske preglede i energetsko certificiranje zgrada,
— osobe koje u svojstvu imenovane osobe u ovlaštenoj pravnoj osobi potpisuju izvješća o energetskim pregledima i energetske certifikate zgrada sa složenim tehničkim sustavom.

gineer performs the energy audit of the electrical engineering part of the technical system of the building, and the architecture or construction expert performs the energy audit in the part related to the construction characteristics of the building in the sense of rational energy use and heat retention. A legal person who employs experts qualified in the pertaining professions can also be authorised for the implementation of energy audits and the energy certification of buildings. The authorised persons are required to regularly participate in professional improvement programs.

Vocational training and the required professional improvement programs for persons implementing energy audits and/or energy certification of buildings are undertaken by universities, polytechnics, institutes and vocational organisations approved by the Ministry of Environmental Protection, Physical Planning and Construction. The current situation in September 2009 is five authorised institutions preparing their first courses in accordance with the Education Program defined in the Ordinance [7]. The Education Program for vocational training and the required professional improvement program for persons implementing energy audits and energy certification of buildings are comprised of Module 1 and Module 2 with recurrent professional improvement.

Module 1 must be attended by:

— natural persons authorised for the implementation of energy audits and the energy certification of buildings with a simple technical system,
— persons implementing energy audits and the energy certification of buildings employed by a legal person authorised for the implementation of energy audits and/or energy certification of buildings with a simple technical system,
— persons who, acting as appointed persons with the authorised legal person, sign reports on energy audits and the energy certification of buildings with a simple technical system.

Module 2 must be attended by:

— natural persons authorised for the implementation of energy audits of buildings with a complex technical system,
— persons implementing energy audits and the energy certification of buildings employed by a legal person authorised for the implementation of energy audits and/or energy certification of buildings with a complex technical system,
— persons who, acting as appointed persons with the authorised legal person, sign reports on energy audits and the energy certification of buildings with a complex technical system.

Program osposobljavanja utvrđen u Modulu 2 mogu pohađati samo osobe koje su uspješno završile Program osposobljavanja utvrđen u Modulu 1.

Ovlaštene osobe nakon uspješno završenog Programa osposobljavanja moraju:

— razumjeti ključne postavke i ciljeve direktive [1],
— imati osnovna znanja o drugim izvorima europskog prava koji se odnose na energetsku učinkovitost zgrada,
— dobro poznavati važeće propise kojima se implementira direktiva [1],
— biti sposobne za samostalno prikupljanje podataka o zgradi potrebnih za energetsku ocjenu prema metodologiji propisanoj posebnim propisom,
— primjenjivati računalne programe namijenjene za provođenje potrebnih proračuna radi dobivanja podataka koji se iskazuju kod provedenog energetskog pregleda i energetskog certificiranja zgrade,
— ocijeniti građevinske karakteristike zgrade u smislu racionalnog korištenja energije i toplinske zaštite,
— ocijeniti tehničke sustave zgrade:
— sustav ventilacije,
— sustav za grijanje, hlađenje,
— sustav za pripremu potrošne tople vode,
— sustav rasvjete,
— sustav za automatsku regulaciju i upravljanje,
— interpretirati podatke o zgradi, naročito u odnosu na dimenzije i tip građevnih dijelova zgrade,
— izvesti potrebne proračune vezane uz podatke potrebne za provođenje energetskog pregleda i energetsko certificiranje zgrade,
— dati preporuke za poboljšanje energetskih svojstava zgrade,
— izraditi energetski certifikat zgrade.

Broj potrebnih ovlaštenih osoba za provođenje energetskih pregleda i energetsko certificiranje zgrada ovisi o stambenom i nestambenom fondu zgrada kao i o brzini uvođenja certifikacije. U Akcijskom planu [2] procijenjen je broj od minimalno 500 potrebnih stručnih osoba za provedbu energetske certifikacije zgrada. To je u skladu i s procjenom EU da je potrebno minimalno 100 stručnjaka na milijun stanovnika za kvalitetnu provedbu energetske certifikacije zgrada.

The Training Program determined in Module 2 can only be attended by persons who have successfully completed the Training Program determined in Module 1.

After successful completion of the Training Program, authorised persons must:

— understand the key postulates and goals of the directive [1],
— have the basic knowledge of other sources of european law pertaining to energy efficiency of buildings,
— be well acquainted with the valid regulations which implement the directive [1],
— be capable to independently gather data on the building necessary for the energy evaluation in accordance with the methodology prescribed by special regulations,
— apply computer programs intended for performing necessary calculations to gain data presented in an implemented energy audit and energy certification of a building,
— evaluate construction characteristics of a building in the sense of rational energy use and heat retention,
— evaluate the technical systems of a building:
— the ventilation system,
— the heating and cooling systems,
— the consumable hot water preparation system,
— the lighting system,
— the automatic regulation and management system,
— interpret the data on the building, especially in relation to the dimensions and the type of structural elements of a building,
— derive necessary calculations in relation to data required for the implementation of the energy audit and energy certification of a building,
— give recommendations for the improvements of energy performances of a building,
— compile the energy certificate of a building.

The number of authorised persons needed for the implementation of energy audits and energy certification of buildings depends on the residential and non residential building fund and on the rate of certificate introduction. The Action Plan [2] estimates that a minimum of 500 experts are needed for the implementation of energy certification of buildings. That is also in accordance with the EU estimate that a minimum of 100 experts are required per million inhabitants for a quality implementation of energy certification of buildings.

5 INTEGRACIJA ALTERNATIVNIH SUSTAVA ZA OPSKRBU ENERGIJOM U ZGRADE

Implementacija direktive EPBD [1] donosi i obvezu razmatranja suvremenog energetskog koncepta zgrada, te primjene alternativnih sustava za opskrbu energijom u novim i postojećim zgradama. U Hrvatskoj je ta obveza implementirana kroz tehnički propis [4], članak 52, gdje se navodi:

za zgrade s ploštinom korisne površine veće od 1 000 m² zahtjevu za izdavanje građevinske dozvole, odnosno potvrdi glavnog projekta obvezno se prilaže Elaborat tehničke, ekološke i ekonomske izvedivosti alternativnih sustava za opskrbu energijom, naročito decentraliziranih sustava opskrbe energijom korištenjem obnovljivih izvora energije, kogeneracijskih sustava, daljinskog/blokovskog grijanja, sustava s dizalicama topline te sustava s gorivnim ćelijama.

Ovaj se elaborat obvezno prilaže uz glavni projekt šest mjeseci nakon objave Studije primjenjivosti alternativnih sustava za opskrbu energijom kod novih i postojećih zgrada [10] na službenim internetskim stranicama Ministarstva zaštite okoliša, prostornog uređenja i graditeljstva.

Takvo suvremeno razmatranje energetskog koncepta zgrada vodi razvoju integralnog procesa projektiranja i nužnosti uske suradnje svih projektanata na razmatranju energetskog koncepta zgrade od samog početka projektiranja. Ovakav pristup projektiranju i gradnji vodi konstantnom poboljšanju i unaprjeđenju graditeljstva, povećava kvalitetu korištenih energetskih izvora te potiče korištenje obnovljivih izvora energije. Također se potiče korištenje novih tehnologija i višefunkcionalnih konstruktivnih elemenata zgrade.

Postupak izrade Elaborata [10] započinje određivanjem toplinskog opterećenja zgrade tj. izračunom potrebne toplinske energije za grijanje i hlađenje za odabrano arhitektonsko i građevinsko rješenje i to kod standardne vanjske i unutarnje temperature (slika 4). Za zgradu se zatim definiraju tehnički sustavi (grijanje, hlađenje, ventilacija, priprema tople vode i rasvjeta) te eventualni dodatni parametri energetske potrošnje. Pri tome se analiziraju varijante u kojima se koriste alternativni sustavi. Ukoliko predviđene varijante zahtijevaju izmjene u arhitektonskom i/ili građevinskom rješenju iste se provode u suradnji s nosiocima arhitektonskog i /ili građevinskog rješenja i za novo rješenje se ponavlja proračun toplinskog opterećenja. Na temelju vršnih opterećenja određuju se nazivne snage uređaja termotehničkih sustava, odnosno vrši se izbor opreme.

5 INTEGRATION OF ALTERNATIVE SYSTEMS FOR THE ENERGY SUPPLY OF BUILDINGS

The implementation of the EPBD Directive [1] also imposes the obligation to consider the modern energy concept of buildings, and the application of alternative systems for the energy supply of new and existing buildings. In Croatia that obligation was implemented through the technical regulations [4], Article 52, where it is stated that:

for buildings with the useful area surface larger than 1 000 m², the request for the issuing of the building permit, or the validation of the main project, must be enclosed with a study of technical, environmental and economic feasibility of alternative energy supply systems, particularly decentralised energy supply systems using renewable energy sources, cogeneration systems, remote/block heating, heat pump systems and fuel cells systems.

This study must be enclosed with the main project six months after the publication of the Feasibility Study of Alternative Energy Supply Systems of New and Existing Buildings [10] on the official web site of the Ministry of Environmental Protection, Physical Planning and Construction.

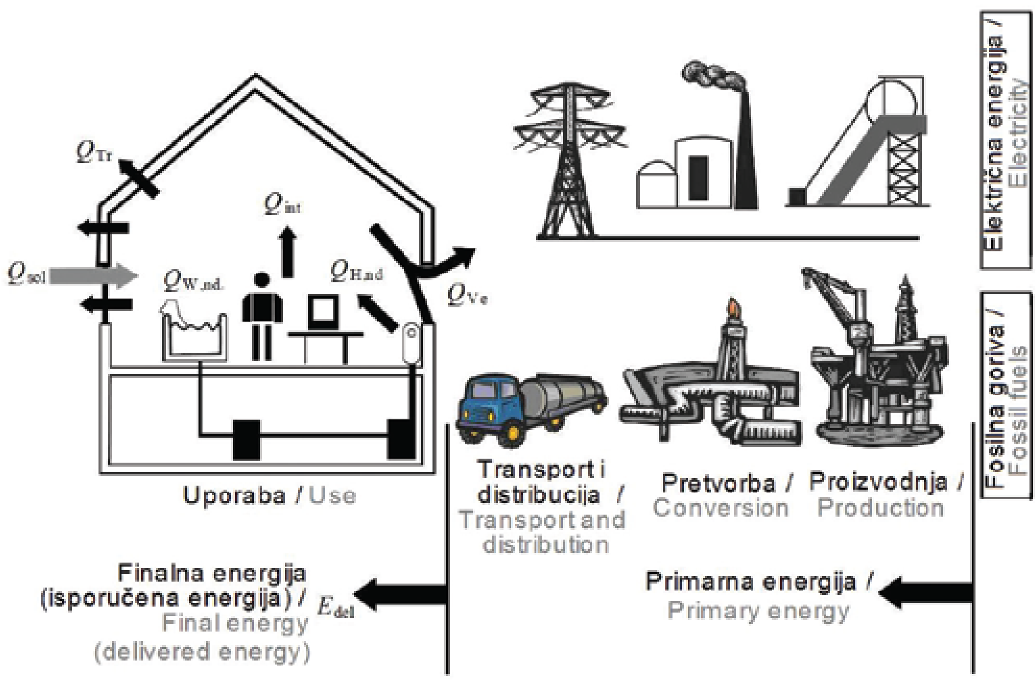
Such a modern consideration of the energy concept of buildings leads towards the development of an integral design process and the necessity for close cooperation of all the engineers on considering the energy concept of a building from the very start of the design process. Such an approach to engineering and construction leads towards a continuous improvement and advancement of construction, increases the quality of the energy sources used and encourages the usage of renewable energy sources. It also encourages the usage of new technologies and multifunctional constructive elements of buildings.

The process of the compilation of the Study [10] begins with the determination of the thermal load of a building, i.e. the calculations of the thermal energy required for heating and cooling of the chosen architectural and construction solution with the standard external and internal temperature (figure 4). The definitions of the technical systems of the building follow (heating, cooling, ventilation, hot water preparation and lighting) together with the possible additional energy consumption parameters. Varieties which use alternative systems are analysed thereat. If the predicted varieties demand changes in the architectural and/or construction solution, they are implemented in cooperation with the holder of the architectural and/or construction solution, and the thermal load calculation is repeated for the new solution. The nominal power of thermotechnical sy-

Za svaki se pojedini sustav potom određuju potrebna toplinska energija za grijanje, klimatizaciju, ventilaciju i hlađenje za stvarne klimatske podatke po mjesecima, zatim toplinska energija za pripremu potrošne tople vode, gubici samih izvora topline i gubici transporta medija nosioca topline te potrebna električna energija za rad pomoćnih uređaja termotehničkih sustava. Elementi termotehničkih sustava grupiraju se prema izvoru energije (plin, električna energija, tekuće gorivo, kruto gorivo) te se određuje ukupna potrebna isporučena energija po energentu i skupno. Koristeći faktore primarne energije određuje se potrebna godišnja primarna energija za zgradu (slika 5), koeficijent utroška sustava i emisija CO_2. Na osnovi izabranih komponenata termotehničkih sustava radi se ekonomska analiza investicijskih troškova te jednostavni period povrata investicije.

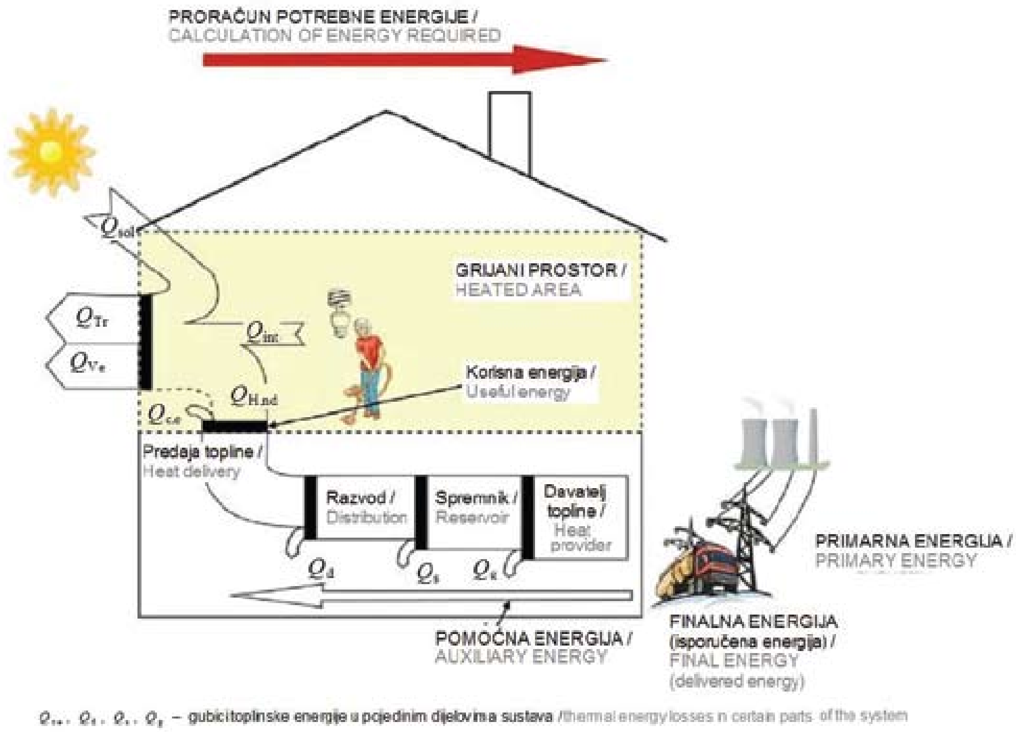
stem devices, or equipment selection, is determined on the basis of peak loads.

The required thermal energy for heating, air-conditioning, ventilation and cooling for real climate data by month, the thermal energy required for consumable hot water preparation, losses of heat sources themselves, transport losses of the heat conducting medium and the electricity required for the functioning of auxiliary devices of thermotechnical systems are then determined for each individual system. The thermotechnical system elements are grouped by energy source (gas, electricity, liquid fuel, solid fuel) and the total required delivered energy is determined per energy source and in total. The required yearly primary energy for the building (figure 5), the system consumption coefficient and CO_2 emissions are determined using the primary energy factors. The economic analysis of investment costs and the simple period for the return of investments is made on the basis of the chosen thermotechnical system components.



Slika 4 — Isporučena energija E_{del} i primarna energija E_{prim} za zgradu [10]

Figure 4 — Delivered energy E_{del} and primary energy E_{prim} for the building [10]



Slika 5 — Energetski tok kroz zgradu s termotehničkim sustavom za grijanje [10]
Figure 5 — Energy flow through a building with a thermotechnical heating system [10]

6 SUVREMENI ENERGETSKI KONCEPTI I INTEGRALNI PRISTUP PROJEKTIRANJU

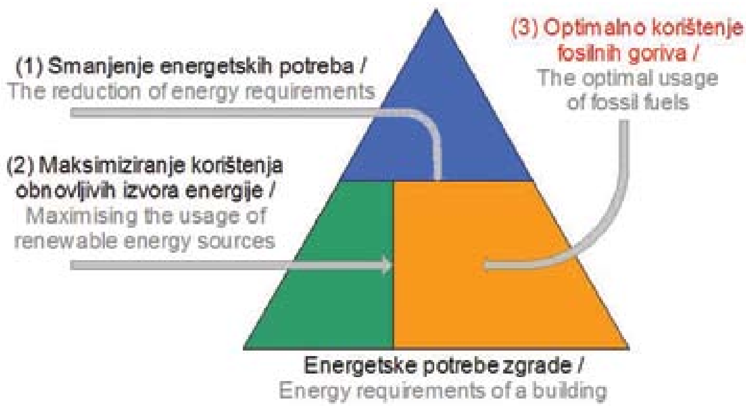
Energetski koncept je integralno i optimalno rješenje u smislu opskrbe energijom i potrošnje energije u projektiranim građevinama. Koncepcija cjelovitog ili integralnog energetski učinkovitog projektiranja podrazumijeva istodobno razmatranje svih aspekata građevine, od arhitekture, pročelja i funkcije, preko konstrukcije, protupožarne zaštite, akustike, pa do potrošnje energije i ekološke kvalitete zgrade, te gospodarenje otpadom. Osnovne metode integralnog projektiranja energetski učinkovite zgrade (slika 6) uključuju tri bitna elementa:

— smanjenje potreba za energijom (energetske uštede),
— maksimiziranje korištenja obnovljivih izvora energije te
— korištenje fosilnih goriva na optimalan način u pogledu zaštite okoliša.

6 MODERN ENERGY CONCEPTS AND AN INTEGRAL APPROACH TO DESIGN

An energy concept is an integral and optimal solution in the sense of energy supply and energy consumption in engineered buildings. The concept of complete or integral energy efficient engineering implies the contemporaneous consideration of all aspects of the building, from architecture, facade and function, through construction, fire protection, acoustics, to energy consumption, environmental quality of the building and waste management. The basic methods of integral design of an energy-efficient building (figure 6) include three key elements:

— reduction of energy requirements (energy savings),
— maximising the usage of renewable energy sources, and
— optimal usage of fossil fuels in view of environment protection.



Slika 6 — Osnovni elementi integralnog projektiranja energetski učinkovite zgrade, prema IEA ECBCS Annex 44, Integrating Environmentally Responsive Elements in Buildings [11]

Figure 6 — The basic elements of integral engineering of an energy efficient building, in accordance with IEA ECBCS Annex 44, Integrating Environmentally Responsive Elements in Buildings [11]

U razmatranje energetskog koncepta treba uključiti [12]:

— kvalitetnu analizu lokacije, orijentacije i oblika zgrada,
— primjenu visokog nivoa toplinske zaštite cijele vanjske ovojnice,
— izbjegavanje toplinskih mostova,
— iskorištavanje toplinskog dobitka od sunca i zaštita od pretjeranog osunčanja,
— korištenje energetski učinkovitih sustava klimatizacije, grijanja, hlađenja i ventilacije (KGHV), te suvremenih alternativnih sustava za opskrbu zgrade energijom,
— korištenje energije iz obnovljivih izvora energije,
— korištenje višefunkcionalnih konstruktivnih elemenata zgrade s integriranim sustavima za proizvodnju energije.

Integralni pristup projektiranju definira se kao pristup koji sve bitne arhitektonske i građevne elemente te sve energetske sustave zgrade povezuje u jedan sustav kako bi se postigle optimalne karakteristike u smislu energetske učinkovitosti, ekološkog utjecaja i unutarnje kvalitete i standarda. Integralno planiranje temelji se na [13]:

— cjelovitom pristupu i integriranju tehničkih, energetskih, ekonomskih, ekoloških i društvenih parametara,
— visokom nivou komunikacije između članova projektnog tima,
— dugoročnom pristupu analizi zgrade, uzimajući u obzir cijeli životni vijek zgrade, uključivo grad-

The following needs to be included in the consideration of the energy concept [12]:

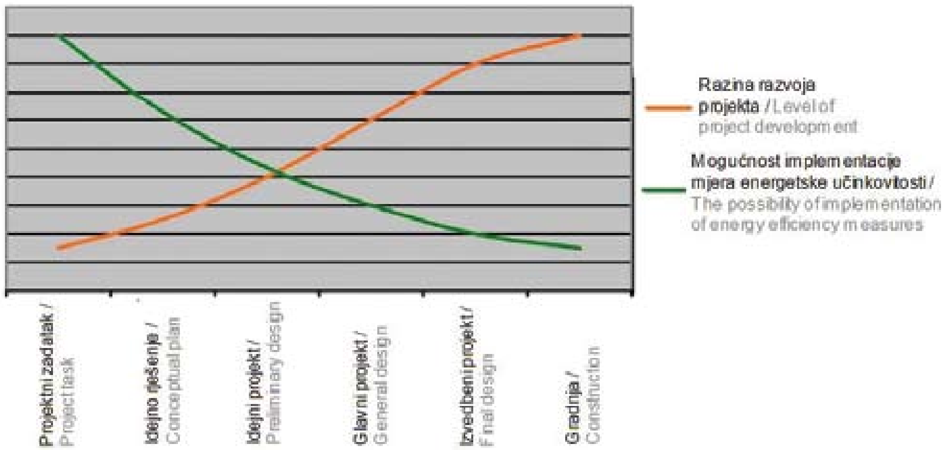
— a quality analysis of the location, orientation and shape of the building,
— the application of a high level of heat retention for the entire external envelope,
— the avoidance of thermal bridges,
— the usage of solar thermal gains and protection against excessive exposure to the sun
— the usage of energy efficient air-conditioning, heating, cooling and ventilation systems (HVAC), and modern alternative energy supply systems for the building,
— the usage of energy from renewable energy sources,
— the usage of multifunctional constructive elements of the building with integrated energy production systems.

The integral approach to design is defined as an approach which connects all relevant architectural and construction elements and all energy systems of a building into one system, in order to achieve optimal characteristics in the sense of energy efficiency, environmental impact, internal quality and standards. Integral planning is based on [13]:

— an integral approach and the integration of technical, energy, economic, environmental and social parameters,
— a high level of communication among the members of the engineering team,
— a long term approach to building analysis, taking into consideration the entire lifespan of a building, including construction, usage, maintenance, reconstruction and demolition.

nju, korištenje, održavanje, obnovu i rušenje. Integralno planiranje je najučinkovitije ako je započeto u ranoj fazi projektiranja (slika 7). Ukoliko se održive tehnologije počnu primjenjivati u kasnijoj fazi projektiranja, rezultat će biti skromna integracija mjera koje će vjerojatno biti preskupe za implementaciju [14].

Integral planning is most effective if started in an early design phase (figure 7). If the application of sustainable technologies begins in a later engineering phase, it will result in a modest integration of measures which will probably be too expensive to implement [14].



Slika 7 — Mogućnost implementacije mjera energetske učinkovitosti i suvremenog energetskog koncepta u odnosu na nivo razvoja projekta

Figure 7 — The possibility of implementation of energy efficiency measures and a modern energy concept in relation to the level of project development

Za integralni pristup projektiranju zgrade potrebno je u fazi idejnog rješenja (kod novih zgrada) odnosno kod planiranja zahvata za rekonstrukciju (kod postojećih zgrada) odrediti karakteristike građevinskih i energetskih sustava zgrade i analizirati potencijal uštede energije, odnosno definirati jedinstveni energetski koncept koji je dio projektnog zadatka. Energetski koncept treba biti podloga za određivanje razine potrošnje svih vrsta energije, vrste korištenih energenata i energetskih sustava. Svako ulaganje u primjenu energetski učinkovitih tehnologija, obnovljive izvore energije i mjere za povećanje toplinske zaštite zgrada potrebno je izraziti kroz energetske, ekološke i ekonomske doprinose. Analizom svih elemenata zgrade moguće je smanjiti potrebe za energijom, odrediti optimalne karakteristike vanjske ovojnice i energetskih sustava. Na taj način se osim troškova za izvedbu zgrade planiraju i troškovi za energiju i održavanje koji imaju značajnu ulogu u ukupnoj vrijednosti zgrade kroz cijelo razdoblje korištenja.

Moguće smjernice pri osmišljavanju suvremenog energetskog koncepta [15] su, npr.:

— u projektiranju je potrebno poštivati principe niskoenergetske arhitekture,

For an integral approach to building design it is necessary to determine the characteristics of the construction and energy systems of a building, analyse the energy saving potential, and define a unique energy concept as a part of the project task in the conceptual plan phase (with new buildings), or when planning reconstruction interventions (with existing buildings). The energy concept should be the basis for determining the consumption levels of all energy types, types of energy sources used and energy systems. Each investment in the application of energy efficient technologies, renewable energy sources and measures for the increase of heat retention of buildings needs to be expressed through energy, environmental and economic contributions. With the analysis of all the elements of a building it is possible to reduce energy requirements, determine optimal characteristics of the external envelope and the energy systems. In such a manner the energy and maintenance costs, which have a significant role in the total value of the building throughout its usage period, are planned in addition to the construction costs.

Possible guidelines for the creation of a modern energy concept [15] are, for example:

— it is necessary to respect the principles of low-energy architecture in the designs,

— toplinska zaštita zgrada treba biti takva da u energetskom certifikatu koji će se izraditi nakon izgradnje, a prije uporabne dozvole, zgrade budu klasificirane u A razred $Q_{Hndref} \leq 25$ kWh/(m²a),
— sustav grijanja, hlađenja, ventilacije i klimatizacije treba centralizirati i dati prijedlog rješenja koje će u konačnosti rezultirati najmanjom energetskom potrošnjom uz prihvatljive financijske pokazatelje,
— potrebno je razmotriti mogućnost proizvodnje energije iz obnovljivih izvora energije s posebnim naglaskom na korištenju Sunčeve energije - integracija elemenata za korištenje obnovljivih izvora energije u arhitekturu,
— visoki nivo toplinske zaštite cijele vanjske ovojnice,
— rješavanje detalja potencijalnih toplinskih mostova,
— kontrola toplinskog zračenja od Sunca kako bi se smanjile potrebe za rashladnom energijom,
— maksimalan ulazak dnevnog osvjetljenja kako bi se smanjila potreba za električnom energijom,
— korištenje prirodnog zasjenjenja gdje je to moguće,
— integralno planirati rješenja svih tehničkih sustava zgrade, kako bi se omogućila centralizacija, visoka energetska učinkovitost, te jednostavno upravljanje potrošnjom za svakog korisnika.

6 ZAKLJUČAK

Energetska certifikacija zgrada, kvalitetno provedena i implementirana, mogla bi odigrati ključnu ulogu u podizanju kvalitete gradnje i kvalitetnom osmišljavanju energetskog kocepta novih zgrada, pokretanju sustavne obnove i osuvremenjivanja postojećeg sektora zgrada, te značajno doprinijeti razvoju integralnog projektiranja, uzimajući u obzir cijeli životni vijek zgrade [16] .

Ključni faktori kojima se projektanti trebaju posvetiti su: integracija alternativnih sustava i obnovljivih izvora energije u arhitekturu i urbanizam, rješavanje višefunkcionalnih konstruktivnih elemenata zgrada, integralno projektiranje i inovativne tehnologije, uz poznavanje financijskih mogućnosti i rizika te unaprjeđenje kvalitete života u zgradama uz smanjenje njihovog ekološkog otiska. Pri tome je posebno važna edukacija i interdisciplinarno razmatranje zgrade kao kompleksnog sustava.

Dobro planiran energetski koncept ima veliki potencijal u smislu održivosti i povećanja energetske učinkovitosti. Najbolji rezultati postižu se integralnim planiranjem poboljšanja standarda, povećanja

— heat retention of buildings must be such that the buildings are classified in the A class $Q_{H,nd,ref} \leq 25$ kWh/(m²a) in the energy certificate compiled after construction, and prior to the issuing of the building inspection certificate,
— the heating, cooling, ventilation and air-conditioning system must be centralised, and a proposal for a final solution, which will result with the smallest possible energy consumption with acceptable financial indicators, must be given,
— it is necessary to consider the possibility of energy production from renewable energy sources with special emphasis on solar energy use – the integration of elements for the use of renewable energy sources into architecture,
— a high level of heat retention for the entire external envelope,
— resolving details of potential thermal bridges,
— controlling solar thermal radiation to reduce requirements for cooling energy,
— maximum entry of daylight to reduce electricity requirements,
— usage of natural shade wherever possible,
— integral planning of solutions for all the technical systems of the building, in order to enable centralisation, high energy efficiency and simple consumption management for each user.

7 CONCLUSION

Energy certification of buildings, if performed and implemented in a quality manner, could play a key role in raising the level of quality in construction, creating a quality energy concept of new buildings, launching a systematic reconstruction and modernisation of the existing building sector, and it could significantly contribute to the development of integral design, taking into consideration the entire lifespan of a building [16].

The key factors the designers should consider are: the integration of alternative systems and renewable energy sources into architecture and urban planning, resolving multifunctional constructive elements of buildings, integral design and innovative technologies, with the awareness of financial options and risks, and the improvement of the quality of living in buildings while reducing their environmental footprint. In that respect, education and interdisciplinary consideration of a building as a complex system is especially important.

A well planned energy concept has great potential in the sense of sustainability and the increase of energy efficiency. The best results can be achieved when integrally planning the improvement of standards, the increase in flexibility, reduction of energy fleksibilnosti, smanjenja potrošnje energije, a time i troškova održavanja, te povećanja korištenja više-funkcionalnih elemenata i obnovljivih izvora energije.

consumption (and consequently maintenance costs), and increased usage of multifunctional elements and renewable energy sources.

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