*INTERNACIONALNI NAUČNO-STRUČNI SKUP*
*GRAĐEVINARSTVO - NAUKA I PRAKSA*

**ŽABLJAK, 15-19. FEBRUARA 2010.**

*Dunja Mikulić[1], Bojan Milovanović[2], Damir Kolić[3], Ana Sokačić[4], Tomislav Šimunović[5]*

# POTENTIAL OF IMPROVING ENERGY EFFICIENCY OF RESIDENTIAL BUILDINGS IN CROATIA

***Summary***

In this time of great price increases of energy sources, global warming and greenhouse effect, energy efficiency and sustainable construction along with the possibility of using renewable energy sources are becoming a priority when one is considering contemporary construction and the energy industry. This paper investigates the potential for energy and $CO_2$ emissions reduction when an insulation layer is increased on existing houses in Croatia. The calculations are based on a computer model representing national standards and the best European practice in construction.

***Key words***

Energy consumption, energy efficiency, $CO_2$ emission, insulation increase.

# POTENCIJAL U POBOLJŠANJU ENERGETSKE EFIKASNOSTI STAMBENIH ZGRADA U HRVATSKOJ

***Rezime***

U današnje vrijeme povećanja cijena energenata, globalnog zatopljenja i efekta staklenika, energetska efikasnost i održivi razvoj zajedno s mogućnosti povećanja obnovljivih izvora energije postaje prioritet u promišljanju suvremene gradnje i energetike. U ovom radu predstavljeno je istraživanje potencijala smanjenja emisije $CO_2$ ukoliko se poveća debljina sloja toplinske izolacije postojećih stambenih zgrada u Hrvatskoj. Proračun se temelji na računalnom modelu koji obuhvaća nacionalne standarde i europske postupke u gradnji.

***Ključne riječi***

Potrošnja energije, energetska efikasnost, emisija $CO_2$, povećanje izolacije.

[1] *Prof.dr.sc., dipl.ing.fizike, Građevinski fakultet, Sveučilišta u Zagrebu, Kačićeva 26, 10000 Zagreb, Hrvatska dmikulic@grad.hr*

[2] *Dipl.ing.građ., Građevinski fakultet, Sveučilišta u Zagrebu, Kačićeva 26, 10000 Zagreb, bmilovanovic@grad.hr*

[3] *Građevinski fakultet, Sveučilišta u Zagrebu, Kačićeva 26, 10000 Zagreb, damir.kolic1967@gmail.com*

[4] *Građevinski fakultet, Sveučilišta u Zagrebu, Kačićeva 26, 10000 Zagreb, anchy87@gmail.com*

[5] *Građevinski fakultet, Sveučilišta u Zagrebu, Kačićeva 26, 10000 Zagreb, tomo.simunovic@gmail.com*

# 1. INTRODUCTION

The term "Energy Efficiency" implies the efficient use of energy in all of the final energy consumption sectors like industry, transport, service industry, agriculture and residential buildings. Nowadays, in the age of increased energy prices and emission excesses, the efficient use of energy is becoming more and more important. It is no longer solely an environmental consideration, but also a financial one. It is clear that the reduced energy consumption, due to its more efficient use, brings proportional financial savings [1].

## 1.1. ENERGY USE

Some 40% of annual primary energy consumption in the European Union (EU) countries is used in buildings. In Croatia, the share of energy consumption in residential buildings is for space heating (50 to 60 %), Figure 1. It could be concluded that in residential buildings, energy consumption for heating purposes takes 80 to 90 % of the total energy needs of a building. In non-residential buildings, the largest share of energy consumption is for space heating (50 to 55 %), (Figure 2).

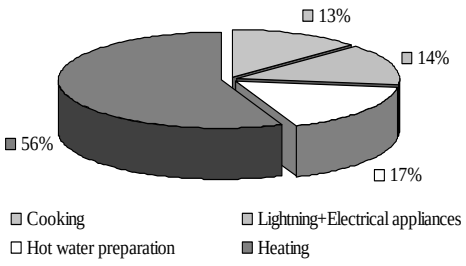


*Figure 1: Energy consumption in residential buildings of Croatia [2]*

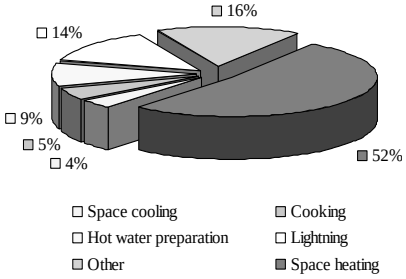


*Figure 2: Energy consumption in non-residential buildings of Croatia [2]*

Existing buildings are representative of the vast potential for energetic and economic savings, all because of the fact that there are a considerable number of buildings with insufficient thermal insulation. Therefore, the EU countries have decided to implement plans for improving energy efficiency in their energy strategies and to develop a legal framework for the realization of these plans. The Republic of Croatia, as the EU accession candidate country, is in the process of harmonizing its legislation with the EU directives and fulfilling the accepted obligations. For example, 83 % of buildings in Croatia have the heating energy consumption from 150 kWh/m$^2$ up to 200 kWh/m$^2$.

In the period from 2008 to 2012, the Republic of Croatia has to meet the requirements of Kyoto Protocol [6,7], which are, to reduce the $CO_2$ emission by 5 % from the 1990 level. Bearing in mind the fact that Croatia has a GDP that is 58 % smaller than the current EU countries (EU 27) and plans to achieve the level of an EU 27 country in near future, a question has to be asked. Is it possible to increase the GDP without increasing the $CO_2$ emission? The answer is simple. The annual energy consumption in the building sector must be reduced to offset the energy consumption increases in industry and transportation, thus keeping the total energy consumption at the same level.

From all of the above, it is obvious that buildings are one of the biggest energy consumers and have a great impact on the environment and economy. Therefore, the energy efficiency, sustainable construction and the use of renewable energy sources are becoming priorities of contemporary construction process.

## 2. METHODOLOGY

The tool used in this study is a computer based model, developed by the Institute IGH according to the Technical regulations about thermal energy savings and thermal protection in buildings [3]. The model was used to predict the space heating energy consumption and $CO_2$ emission of housing with the typical floor area of 80 $m^2$ located in Zagreb area. Using this model, $CO_2$ emission was determined regarding the energy source used for space heating in a typical housing located in the continental area of Croatia. For this purpose, conversion factors found in Table 1 were used.

*Table 1: Conversion factors by the unit of effective heat [2]*

| Energy Source | Conversion factor ($kgCO_2/kWh$) |
|---|---|
| Electricity | 0,383 |
| Natural gas | 0,236 |
| LNG | 0,264 |
| Brown coal | 0,446 |
| Oil | 0,332 |
| Public heating - Zagreb | 0,257 |
| Boiler house - Croatian average | 0,300 |

According to the Census 2001, [4] this assumption there are 932 000 family houses in Croatia. With the predicted rise of 1.6 % in the year 2010, the number of family houses in Croatia will be 1 066 000. If 83 % of them have insufficient thermal insulation, this comes to approximately 885 000 family houses. Three scenarios representing different levels of thermal insulation increase in family houses are presented (Table 2).

*Table 2: Scenarios of improving energy efficiency of family houses*

| Application | Percentage of houses with increased thermal insulation (%) | Number of houses |
|---|---|---|
| Low | 10 | 88 500 |
| Medium | 50 | 442 500 |
| High | 75 | 663 750 |

## 3. CALCULATION RESULTS

In the model, a typical house has been assumed with only a ground floor, without a basement and with an unheated attic, while all of the useful floor area of the house was heated. All structural elements of the building were composite, consisting of most common

materials that are being used in Croatia. It has to be said that the structural parts and finishing surfaces were kept constant in all cases, only insulation thickness varies. Thermal transmittance, the U-value of outer walls, ceiling and floor structures of the house are were calculated depending on the insulation thickness.

Windows and doors are chosen with the $U_w$ = 1,1 W/m$^2$K because it has been assumed that the old ones will be replaced with new ones as a first step of the energy efficiency improvement process. Air exchange has been resolved with air-condition devices contrary to current practice, when air exchange is resolved by opening the windows. Using the described model, annual heat demand for heating by unit of useful floor area of the building ($Q_h´´$) for all thermal insulation levels is calculated [3], Table 3.

*Table 3: Annual heat demand for heating by unit and total useful floor area*

| Thermal insulation level | Annual heat demand for heating by unit of useful floor area $Q_h´´$ (kWh/m$^2$a) | Annual heat demand for heating by total area (kWh/a) |
|---|---|---|
| Insufficient | 200,00 | 16 000 |
| 5 cm | 78,35 | 6 268 |
| 10 cm | 49,25 | 3 940 |
| 15 cm | 39,01 | 3 121 |
| 20 cm | 31,96 | 2 557 |
| 25 cm | 28,95 | 2 316 |

## 3.1. ENERGY SAVING POTENTIAL

The change of required energy for space heating depending on the thermal insulation level, and consequently the reduction of the required energy are presented in Figure 3. All calculations have been made regarding the insufficient thermal insulation level and energy improvement scenarios.

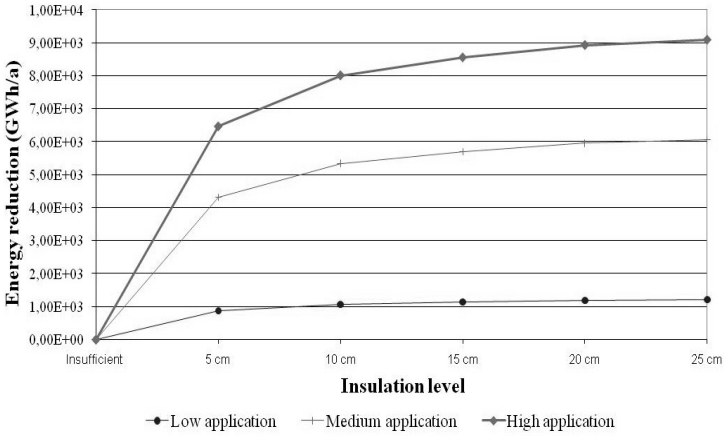


*Figure 3: Energy reduction, regarding the insulation level*

## 3.2. $CO_2$ EMISSION RESULTS

Annual $CO_2$ emission of a single building regarding the energy source could be calculated when annual heat demand for space heating by total useful floor area is gained, (Figure 4). The results have been calculated by multiplying the annual heat demand for heating by total area (table 3) with conversion factors by unit of effective heat that are being used in Croatia. $CO_2$ emission is presented for different energy sources, regarding the thermal insulation level.

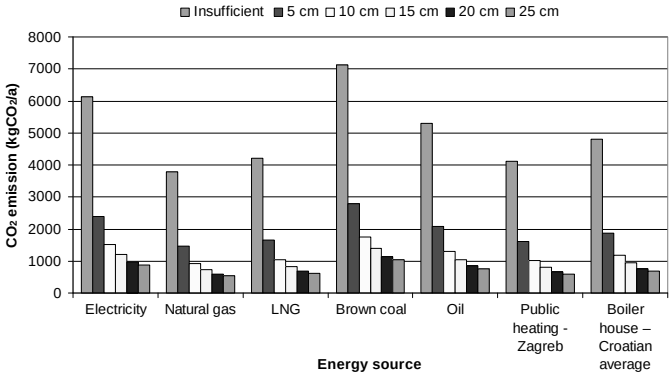


*Figure 4: Annual $CO_2$ emission of a single building*

From Figure 4, it is evident that out of the conventional energy sources, natural gas is the most environmentally friendly, while brown coal should be used as little as possible. If thermal insulation thickness is increased, it logically follows that $CO_2$ emission is reduced to some extent. In Figure 5, the percentage of $CO_2$ emission after the increase of thermal insulation levels by 5, 10, 15 and 20 cm are presented. All results are given with regard to the initial insulation level, before the increase.

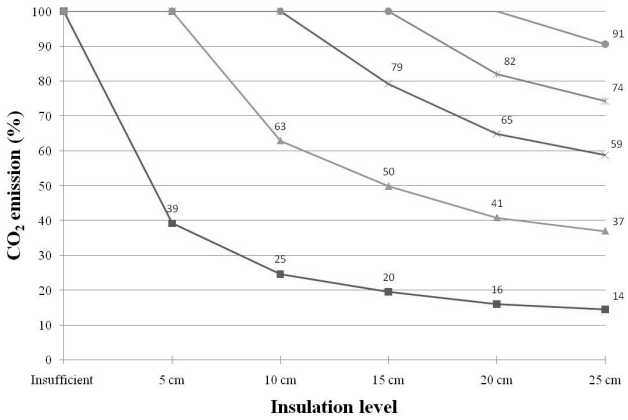


*Figure 5: $CO_2$ reduction, regarding the initial insulation level*

## 4. CONCLUSIONS

In recent years, Croatia has tightened up its regulations concerning the energy performance of buildings, as a result of the EU directives [5] and harmonization of legislation with environmental, energy and building performance issues. With Croatia still lagging behind its Kyoto Protocol requirements and the need of "more emissions" to develop its economy, it is an ideal time for the application of energy efficiency in buildings, following the EPBD directive. This will require the improvement of thermal insulation level of existing residential and non-residential buildings and building of new, energy more efficient buildings. In this paper, clear indications of the advantages of the thermal insulation increase are given. This is only a basic analysis and further steps will be needed to take into account the energy used for space cooling, appliances, lighting and all other possible energy gains. Among the energy sources used, the renewable energy sources should be considered, not only in energy strategy of Croatia but also individually. Measures presented in this paper will reduce non-renewable energy demand, increase the comfort conditions for people and, after some initial investment, become cost effective. The biggest obstacle to achieve presented goals is public awareness.

## 5. ACKNOWLEDGMENTS

This research was performed within scientific program "New materials in construction" and scientific project "From Nano to Macro-structure of Concrete", 082-0822161-2990, funded by Croatian Ministry of Education, Science and Sport.

## REFERENCES:

[1] V. Bukarica, D. Dović, V. Hrs Borković, V. Soldo, B. Sučić, S. Švaić, V.Zanki: "Priručnik za energetske savjetnike", Program Ujedinjenih naroda za razvoj (UNDP) u Hrvatskoj, Zagreb, (in Croatian), 2008.

[2] Ž. Hrs Borković: "Studija primjenjivosti alternativnih izvora energije kod novih i postojećih zgrada", Energy Institute Hrvoje Požar (EIHP), Zagreb, (in Croatian), 2008.

[3] Technical regulations about thermal energy savings and thermal protection in buildings, Ministry of Environmental Protection, Physical Planning and Construction, The official paper NN 79/2005, 2005.

[4] Census http://www.dzs.hr/hrv/censuses/census2001/census.htm (in Croatian), 2001.

[5] Directive 2002/91/EC, "Energy Performance of Buildings Directive", OJ L1 of 4.1.2003.

[6] UNFCCC (United Nations Framework Convention on Climate Change), Kyoto protocol, http://unfccc.int/kyoto_protocol/items/2830.php

[7] D. Bjegović: „Sustainability as a Condition for Development in Croatia", Proceedings of International Conference on Sustainability in the Cement and Concrete Industry, Lillehammer, 2007. 2-16