Jelena Nikolić[1)]
Zoran Končalović[1)]

1) Faculty of Engineering, University of Kragujevac, Serbia
nikolicj269@gmail.com, zkoncalovic@gmail.com

THE PRESERVATION OF ENVIROMENTAL QUALITY WITH REDUCTION OF CARBON DIOXIDE EMISSIONS DURING THE HEATING OF EXISTING BUILDING

Abstract: *The crucial question of the 21st century is based on the preservation of environmental quality. Climate change and global warming have led to the fact that environmental quality and sustainable development today represent the two most important elements in the formation of energy policy of many countries in the world. It is believed that the main causer of the greenhouse effect is carbon dioxide, whose emission is especially connected with the combustion of fossil fuels. Since the housing sector is a large consumer of energy, it also represents a great potential for saving energy and reducing harmful greenhouse gases. Part of this potential can be achieved by switching from conventional fuels to renewable energy sources in the process of heating facilities. In this paper analysis of CO_2 emissions was performed during the heating of the existing family fouse by using energy source which are most common in the territory of the Republic of Serbia. For conducting analysis RETScreen software package was used. The results show that during the heating season, the use of coal broadcasts 11,4 tons of CO_2, diesel broadcasts 8,7 tons of CO_2, current/propane broadcasts 6,4 tons of CO_2, while the combustion of natural gas releasing 8 tons of CO_2. On the basis of economic analysis, it was found that the current price of coal is less then price of biomass, the authors of this paper are proposing introduction of a hypothetical "English" scenario. By this scenario, the owners of households would be obligated to pay the reimbursement for carbon dioxide emissions. The introduction of such taxes would increase prices of widely available and currently very favorable conventional fuels. At the same time, CO_2 neutral biomass would become the most accessible energy source, and it can be assumed that it will, over time, come to its dominance in the energy market. It is assumed that the application of this method, on a global scale, leads to significant reduction in carbon dioxide emissions.*

Keywords: *emission of carbon dioxide, biomass, conventional fuels, heating, payment of CO_2 emission.*

1. INTRODUCTION

A continuous increase in population results in increased energy requirements and energy sources, which would temporarily satisfy those needs. With the development of industrialization on a global scale, significant energy consumption is fueled by the use of cheap fossil fuels, primarily oil, coal and natural gas. In addition to the supply of these energy sources being limited, their use affects the environment, because they produce greenhouse gases, which are believed to be the main cause of global warming. A major cause of the aforementioned effect is carbon-dioxide (CO_2) that makes 0,037% of the earth's atmosphere. Unlike fossil fuels, renewable energy sources (RES) are the so-called "clean fuel", which can provide energy independence to the consumer**.** Biomass is in the RES group

and it is considered to be CO_2 neutral, because during it's combustion it produces the same quantity of carbon dioxide that plants bind in photosynthesis during its life cycle. CO_2 neutrality is achieved only when the logging is controlled and when it's being followed by afforestation, otherwise it adopts the value of intensity of carbon dioxide the 109.6 $kgCO_2/GJ$ [1]. Although the use of RES is nowadays a frequent topic of discusssion, we still can not talk about the cessation of the use of fossil fuels, because their initial price is quite low, and the developing countries most frequently decide to use them, and the technological sector support for renewable energy is still at a very low level. In order to encourage an increase in the share of RES in gross final energy consumption to 36% by 2030, the United Nations have started a campaign called "Sustainable Energy for All (SE4ALL)" [2], and the European Union in 2008 adopted a directive on increasing the share of renewable energy from 8 to 20% by the year 2020, as well as the reduction of CO_2 emissions by 20% [3].

The buildings, of any kind, spend a large percentage amount of the energy produced worldwide. In Serbia, out of the total final energy produced, 36,2% is used in the residential sector. In EU countries this percentage share is 24,8%, Russia 30,0%, China 22,2%, while in the United States to buildings goes 19,6% of total energy produced [4]. On the basis of these data, it is clear that the housing sector has a large share when it comes to the emission of carbon dioxide and therefore is very important to implement measures that would lead to a reduction in energy consumption, and therefore CO_2 emissions. In [5], a Program of the Energy Strategy of Serbia in the field of renewable sorce of energy is given, with focus on the adventages of using biomass, which is CO_2 neutral.

This paper presents the changes in the quantity of broadcasts of CO_2, which is released during heating an existing building, using different types of fuels, including biomass.

2. MATHEMATICAL MODEL

2.1 Description of the house

The subject of analysis in this paper is an existing family house that is shown in Figure 1.

The house is designed for residential single family and consists of 10 rooms distributed in two floors.

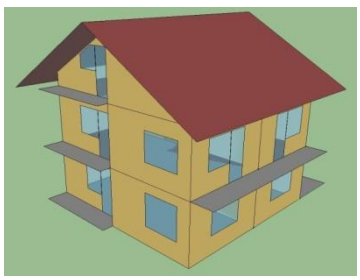

Figure 1 – Analyzed object

The total area of the analyzed building is 252 m^2 and useful heating area is 140 m^2. The basement has the area of 36 m^2, while the attic covers the area of 72 m^2, which represent unheated space. Ground floor of the building contains 6 rooms and two terrace (gray colored), as shown in Figure 2, while the first floor with the layout of rooms is presented in Figure 3. The total height of the rooms is 2,6 m.

Figure 2 – The base of ground floor

Figure 3 – The base of the first floor

The exterior walls are composed of styrofoam 8 cm, 19 cm of hollow block and 2 cm of lime mortar (viewed from the outside to the inside of the unit, from the external facade). The heat transfer coefficient of the envelope is U = 0,350 W/(m^{2}K). The windows are made of aluminum, with double glazing and their value of heat transfer coefficient is U = 3,1 W/(m^{2}K). Observed house is located in Kragujevac, a city with a moderate climate temperature and with four seasons. As part of the RETScreen software package, weather data for the city of Kraljevo has been used, due to the inability of choice for exact location. The justification for this choice lies in the fact that the climate of these two cities very slightly differs. For heating purposes, observed house has central heating system, with the boiler for coal combustion.

3. RESULTS AND DISCUSSION

For the calculation and analysis of building model RETScreen program was used, the world's leading software for energy efficiency, renewable energy and cogeneration project feasibility analysis as well as ongoing energy performance analysis [5]. The program consists of a number of worksheets that a user fills by himself. For heating project data for surface of the object that being heated, data of the thermal load, data of percentage needs of hot water and the seasonal efficiency were entered (Figure 4).

Heating project

		Base case	Proposed case
Heated floor area for building	m²	140	
Energy efficiency measures			0%
Heating load for building	W/m²	64	64
Domestic hot water heating base demand	%	10%	10%
Total heating	MWh	20	20
Base load heating system			
Technology		Kotao	Biomass system
Capacity	kW	9.0	0.0
Heating delivered	MWh	19.5	0.0
Fuel type		Coal	Biomass
Seasonal efficiency	%	60%	
Fuel consumption - annual	t	4	0
Fuel rate	€/t	137.500	
Fuel cost	€	495	0
Peak load heating system			
Technology			
Suggested capacity	kW		9.0
Capacity	kW		
Fuel type			Natural gas - m³
Seasonal efficiency	%		
Fuel consumption - annual	m³		0
Heating delivered	MWh		0.0
Fuel rate	€/m³		
Fuel cost	€		0

Figure 4 – Heating project

Based on the data entered in the software, it is determined that for a given house required boiler has the power of 9 kW. After entering the data on the type of fuel that is used, the software provides information on the required amount of fuel and the annually emission of carbon dioxide. In this paper the cases of using different types of fuel available in the Republic of Serbia are discussed, which are commonly used in households as a fuel during the heating season.

Case one-the use of coal

When coal is selected as a fuel, the softwere has calculated that for the warming of observed family house during the heating season is necessary to provide 4 t of this fuel. Since the price of coal called *Resavica* per ton is 17 000 RSD [7], the annual costs for heating is 68 000 RSD, or 550 €, converted at the current exchange rate of the euro (1€=123,5 RSD). The next part of the analysis relating to the emission of carbon dioxide into the atmosphere, and of Figure 5. it can be seen that the use of coal, 11,4 tons of CO_2 annually are broadcast into the atmosphere.

Emission Analysis

GHG emission		
Base case	tCO2	11.4
Proposed case	tCO2	0.0
Gross annual GHG emission reduction	tCO2	11.4
GHG credits transaction fee	%	
Net annual GHG emission reduction	tCO2	11.4
GHG reduction income		
GHG reduction credit rate	€/tCO2	

Figure 5 – CO_2 emissions from combustion of coal

Case two-the use of diesel

By choosing diesel as a fuel, the software has calculated that for the warming of observed building during the heating season is necessary to provide 3230 liters. Emission of carbon dioxide in this case was 8,7 tons. The average price of diesel in Europe amounted to 1,107 €/l, which implies that the heating in this case it is necessary to allocate 3575,61 €.

Case three-the use of electricity

On the other hand, when electricity is selected for the heating of the building seasonal amount of energy needed to heat this building

would reach value of 33 MWh, with CO_2 emissions of 6,4 tons. The price of electricity per kWh in Serbia, in the blue zone of single-tariff measurement is 7,386 RSD. So, in this case, for the heating, annually is necessary to allocate 243 738 RSD, or 1973,27 €.

Case four-the use of propane

If the heating of observed object is achieved using propane, it would take 4779 liters of fuel. Since the price of propane per liter is 0,705 € for heating the building it is necessary to allocate 3370 €. Using this type of fuel, during the heating season, 8 tons of CO_2 are broadcasted in the atmosphere.

Case five-the use of natural gas

When the heating of observed house, is achieved with the use of natural gas, it would take 3450 m^3 of gas and emissions of carbon dioxide about 6,4 tons. Since the price of natural gas per m^3 is 32,28 RSD, for this type of heating it is annually necessary to allocate 902 €.

Case six-the use of oil

For heating the observed house with oil, it is necessary to allocate 3030 liters, whereby a broadcast 9,2 tons of CO_2. Price per liter of this fuel is 145,4 RSD, and for seasonal heating of object 3567 € should be set aside.

Case seven-the use biomass

If the facility for heating uses biomass as a fuel, it is necessary to provide 6 tones of that fuel. Price of briquetted biomass, obtained from the wheat straw, in Serbia can be found at the value of 15 000 RSD/ton, and for the heating season should be set aside 728,7 €. During the combustion of biomass leads to broadcasting 0,2 tons of CO_2, but it is believed that the plant during its life cycle consumes the same amount of this gas in the process of photosynthesis.

Comparative review of carbon dioxide emission during a heating season is shown in Figure 6.

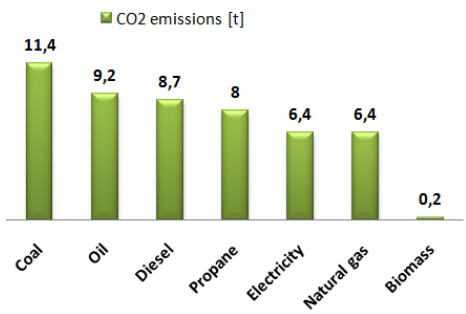

Figure 6 – Comparative review of carbon dioxide emission

In the world there is a policy for reducing of carbon dioxide emission, and other greenhouse gases, and therefore taxes for payment per ton of emitted gas are introduced. Regulation on the types of pollution, criteria for calculation of compensation for environmental pollution and payers, amount and manner of calculation and payment of taxes [8], which are become valid in 2012, it was found that compensation for emissions from individual sources on the territory of Republic of Serbia, pay in the case of emission of sulfur dioxide, nitrogen dioxide and a powder material and waste. Since in our country has not yet started levying taxes for the broadcast of carbon dioxide from the residential buildings, which are major polluters, the authors of this paper are presenting hypothetical, "English" scenario, which is based on the creation of prices taxes modeled on English carbon price floor. In fact, in England is, as well as in Europe, introduced payment of taxes for carbon dioxide emissions for producers that use fossil fuels. The price of this tax in England is 18 £ per ton of CO_2 (21 €/ton of CO_2), with predictions that it will keep this price until 2020 with a tendency to increase it to 2030 [9]. The price of this tax in the territory of the European Union is relatively low and it is 5 €/ton of CO_2 [10]. The French government is considering the possibility of raising the price of this tax to the amount that is represented in the United Kingdom, but in January this year decided not to raise the price of tax [11]. When the tax for emissions of carbon dioxide, would be applied on the observed object, with a price that is valid in England, its owner would be required to pay 239,4 € for the current state of heating with the coal. Height of tax payment for remaining types

of fuel, in the heating season, is presented in Table 1.

Table 1 – Height of tax payment by using the hypothetical "English" scenario

Type of fuel	Fuel price, per year[€]	CO_2 emissions [t]	The Price of Carbon Tax, per year [€]
Coal	550	11,4	239,4
Oil	3567	9,2	193,2
Diesel	3576	8,7	182,7
Propane	3370	8	168
Electricity	1974	6,4	134,4
Natural gas	902	6,4	134,4
Biomass	728,7	0,2	4,2

If on the sum of money, that needs to be set aside for seasonal heating the building, adds the payment price for emissions of carbon dioxide, the current low price of coal would have be increased significantly, as can be seen in Figure 7. On the same figure the price of remaining fuels is presented, as well as fuel prices with the costs for the payment of taxes.

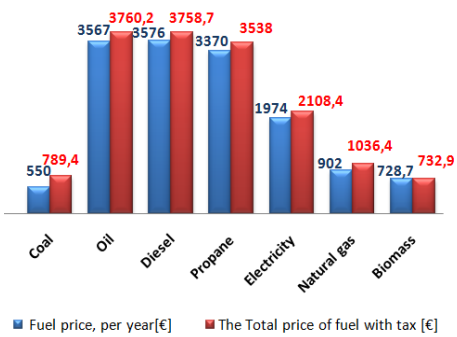

Figure 7 – The annual price of fuel without payment of taxes for emissions of carbon dioxide and price with tax

It is assumed that the implementation of tax payment, for the pollution of carbon dioxide for households, will lead to a mass transition to the use of biomass as main energy source. This would significantly reduce CO_2 emissions, which would directly affect the preservation of environmental quality, but also would promote the concept of sustainable development. Considering that, in the analyzed case, the existing boiler for coal combustion can be used for biomass combustion as well, therefore additional investments when switching to this type of heating are not required. With current prices, switching to biomass heating savings of 56.5 € are achieved during the heating season and the reduction of carbon dioxide emissions of 11,2 tons.

4. CONCLUSION

Heating of housing is one of the largest energy demands in Serbia and in that part hides the possibility of reducing energy use, and emissions of greenhouse gases and other pollutants, which can contribute to sustainable development.

Replacement of conventional fuels with biomass, for heating, is leading to a significant reduction of carbon dioxide in the atmosphere. The paper presents the CO_2 emissions when heating existing home using a variety of energy sources, wherein the observation that the amount of the released carbon dioxide, for the use of coal is 57 times the amount that is released in biomass combustion. In this exact fact lies a great potential, for whose realizations certain degree of stimulation to the manufacture should be introduced to generate using heat energy sources of biomass, as well as measures that would discourage producers in the use of conventional energy sources. For this reason, the authors of this paper proposed the creation of, a hypothetical, "English" scenario, according to which the owners of households had to pay a fee for the show of carbon dioxide per year. By applying these measures, the implementation of energy with high CO_2 emissions needed for heating the observed object, the owner would be in obligation, in addition to the market price of fuel, pay 175 € more, on average, per year. In the observed case biomass would become the most affordable source of energy, and it can be assumed that eventually it will come to its dominance in the energy market. Because the energy source, that is currently used for heating the observed object, is coal, it can be expected that the application of such measures would lead to transition to the biomass fuel, thus the carbon dioxide emission, on the level of the observed housing would decreased by 11,2 tons per year.

Payment of the tax for CO_2 emissions in

the Republic of Serbia, creates the possibility for creating foundation that would allow the development of innovative and efficient technologies for the use of biomass energy, or from which subsidies and loans would be given out for the application, as well as for production of biomass.

It should be mentioned that the further initiatives are necessary to support biomass, as well as a directive related directly to biomass heating.

REFERENCES:

[1] L. N. Ružić, Lj. Kostadinović, N. Počuča, P. Petrović, *Uticaj biomase na smanjenje emisije ugljen dioksida,* Poljoprivredna tehnika, 2012, Vol.3, str. 37-44

[2] *Bioenergy Action Plan Vojvodina,* World Bioenergy Association, 2015

[3] Commission od The European Communities, Communication from the Comission to the European Economic and Social Committee and The Committee of The Regions, 20 20 by 2020 Europe's climate change opportunity, Brussels, 2005.

[4] C.A. Balaras, E.G. Dascalaki, K.G. Droutsa, S. Kontoyiannidis, *Briding the gap of actual and calculated heating energy consumption in bottom-up residental building stock model,* Proceedings, 47th International HVAC&R Congress and exhibition on heating, Refrigeration and air conditioning, Belgrade, Serbia, 30 November-2 December, 2016.

[5] M. Despotović, M. Babić, *Energija biomase,* Mašinski fakultet Kragujevac, 2003

[6] RETScreen, http://www.nrcan.gc.ca/energy/software-tools/7465

[7] BEOISKRA, http://www.prodajauglja.rs

[8] Vlada Republike Srbije, *Uredba o vrstama zagađenja, kriterijumima za obračun naknade za zagađivanje životne sredine i obaveznicama, visini i načinu obračunavanja i plaćanja naknade,* Službeni glasnik Republike Srbije", br. 113/2005, 6/2007, 8/2010, 102/2010, 15/2012 i 91/2012

[9] E. Ares, J Delebarre, *The Carbon Price Floor*, House of Commons Library, breafing paper Number CBP05927, November 2016

[10] Climate Home, http : // www. climatechangenews com/ 2017/04/04/german-coal-plants-burn-eu-carbon-price-stagnates/

[11] Enerdata, https : // www.enerdata. net/publications/daily-energy - news/ france-suspends-carbon-floor- price- planned-1-january-2017.html