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Technical faculty “Mihajlo Pupin”
Zrenjanin, Republic of Serbia

IV International Conference Industrial Engineering and Environmental Protection (IIZS 2014)

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INTRODUCTION

Departments of Mechanical engineering and General Technical Sciences, at Technical Faculty "Mihajlo Pupin", Zrenjanin, organized three international conferences:
1. »PTEP 2011 - Process Technology and Environmental Protection»,
2. «IIZS 2012 - Industrial Engineering and Environmental Protection»,
3. «IIZS 2013 - Industrial Engineering and Environmental Protection»,
4. «IIZS 2014 - Industrial Engineering and Environmental Protection».

Industrial engineering is a field of technique, which includes the processes and procedures, plants, machinery and equipment used in manufacturing final products in different industries. The task of industrial engineers is that on the basis of theoretical and practical knowledge, solve specific problems in engineering practice, and the development of technology in the field of industrial production process.

The theme of scientific conference «IIZS 2014», covers the fields of industrial engineering, which are defined in the program of the conference, such as: Process technology, Engineering, Environmental protection, Health and safety, Manufacturing technology and materials, Machinery maintenance, Design and maintenance of process plants, Oil and gas industry, Basic operations, Machines and processes, Information technology and engineering education, Biotechnology, Reengineering and project management.

The main goals of the conference can be indentified here: innovation and expansion of knowledge engineers in industry and environmental protection; support to researchers in presenting the actual results of research projects, establishing new contacts with leading national and international institutions and universities; popularization of the faculty and its leading role in our society and the immediate environment, in order to attract quality young population for studing at our faculty, cooperation with other organizations, public companies and industry; initiative for collecting ideas in solving specific practical problems; interconnection and business contacts; introducing professional and business organizations with results of scientific and technical research; presentation of scientific knowledge and exchange of experiences in the field of industrial engineering.
We express gratitude to:

- The partners of the conference – University of agriculture, Faculty of agricultural engineering, Krakow, Poland; Technical university-Sofia, Plovdiv branch**,** Faculty of mechanical engineering, Plovdiv, Bulgaria; „Aurel Vlaicu” University of Arad, Faculty of engineering, Arad, Romania; University Politehnica Timisoara, Faculty of engineering, Hunedoara, Romania; University of Niš, Faculty of mechanical engineering, Niš, Serbia; University of East Sarajevo, Faculty of mechanical engineering East Sarajevo, B&H, Republic of Srpska; University «St. Kliment Ohridski«, Technical faculty, Bitola, Macedonia,
- Zrenjanin Town Hall,
- Regional Chamber of Commerce,
- The management of Technical Faculty «Mihajlo Pupin», University of Novi Sad,for supporting the organization of the conference «IIZS 2014». We are also grateful to all the authors who have contributed with their works to the organization of the scientific meeting «IIZS 2014».

We would like our Conference to become a traditional meeting of researchers, every year. We are open and thankful for all useful suggestions which could contribute that the next, International Conference - Industrial Engineering and Environmental Protection, become better in organizational and program sense.

President of the Organizing Committee
Prof. Ph.D Dragiša Tolmač

Zrenjanin, 15th October 2014.

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BUILDINGS ENERGY CONSUMPTION AND RELATED CO_2 EMISSIONS

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Abstract: Energy is one of the greatest challenges of modern society and fundamental condition for progress in a number of areas and technologies. Energy Management System seeks continuous implementation of energy efficiency measures and sustainable management of resources whose end result is to reduce energy consumption, reduce greenhouse gas emissions and reduce energy financial cost. Paper reviews the impact of energy consumption on the amount of carbon dioxide emitted into the atmosphere as a result of measures taken within the Energy Management System in buildings .
Key words: CO_2 emission, Energy Management System.

INTRODUCTION

Today environmental protection is imperative for every local community and is an integral part of socially responsible behavior. Experience shows that in developed countries buyers leading priority in choosing the products, goods and services is the attitude that manufacturers and suppliers have toward environment pollution protection. Energy consumption is closely related to environmental pollution. The fossil fuels consumption (oil, gas, coal) release in the atmosphere many pollutants, especially CO_2, which is considered as main cause of global climate change. Therefore, any irrational use of energy basically means polluting the environment.
Besides creating the so-called "green" image, i.e. the image that declares a commitment to preserving the environment, the rational consumption of energy will also reduce future costs associated with non-compliance with environmental protection regulations, so called environment pollution taxe rates.

ENERGY MANAGEMENT SYSTEM AND CO_2 EMISSIONS ESTIMATION

Energy Management System (EnMS) is directly related to environmental protection. Useful forms of energy, such are electricity or thermal energy, are usually obtained from burning fossil fuels (coal, oil and natural gas). Therefore, by reducing the consumption of electricity or thermal energy through the Energy Management System implementation, the reduction of burned fossil fuels, and respectively pollutants emissions can be done.
As a result of fuels burning flue gases are emitted in the atmosphere, including carbon dioxide, CO_2, sulfur dioxide SO_2 and nitrogen oxides. Carbon dioxide (CO_2), which occurs as a result of fossil fuels burning, has the greatest impact on global warming. Therefore, the impact of reduced energy consumption on global warming is observed primarily by reducing the emission of CO_2. Fuels contain a certain amount of carbon which in one part is turned into carbon dioxide.
CO_2 emissions associated with the fossil fuels burning can be calculated as follows [1,2]:

$$EM = EF_C \cdot H_l \cdot O_C \cdot \frac{44}{12} \cdot B \tag{1}$$

where:
EM - CO_2 emissions [kg],
EF_C - factors which connect the fossil fuels consumption with appropriate carbon emission rate, [kgC/GJ]
H_l - Net or low heating value of fuel ([MJ/kg] or [MJ/m^3]),
O_C - carbon part which is released during the combustion process
44/12 - stoichiometric ratio CO_2 and C, and
B - amount of fuel used ([t] or [10^3 m^3]).

Table 1. Parameters values needed to calculate CO_2 emissions gained from fossil fuels burning using IPCC methodology

Fuel	EF_C	H_l	O_C	$EF_C \cdot O_C \cdot \frac{44}{12}$
	[kg C/GJ]	[MJ/kg] or [MJ/m^3]	-	[kg CO_2/GJ fuel]
Extra light fuel oil - EL1	20,2	42,71	0,990	73,33
Heavy fuel oil - M1	21,1	40,19	0,990	76,59
Liquefied petroleum gas (LPG)	17,2	46,89	0,990	62,44
Anthracite	25,8	24,30	0,980	92,71
Brown coal	26,2	18,20	0,980	94,15
Lignite	27,6	12,15	0,980	99,18
Natural gas	15,3	34,00	0,995	55,82

Table 1 presents the list of values described above which are necessary to estimate CO_2 emissions created by the fossil fuels burning using IPCC methodology (IPCC stands for Intergovernmental Panel on Climate Change) [1,2].
CO_2 emissions also occur in the biomass or bio fuels burning, but according to the IPCC recommendations it should not be calculated considering that it is CO_2 which plants absorb from the atmosphere during their growth period.

COMMONLY USED CO_2 EMISSION FACTORS

Several different organizations and institutions have proposed various CO_2 emission factors values that should be used for different types of energy and fuels [1-4].

Table 2. Energy value of a certain type of energy and fuel

Type of energy / fuel	[kJ]		[kgoe]		[kWh]	
1 [kg] Coke	28 500		0,676		7,917	
1 [kg] Anthracite	17 200	30 700	0,411	0,733	4,778	8,528
1 [kg] Lignite briquettes	20 000		0,478		5,556	
1 [kg] Brown coal	10 500	21 000	0,251	0,502	2,917	5,833
1 [kg] Lignite	5 600	10 500	0,134	0,251	1,556	2,917
1 [kg] Oil shale	8 000	9 000	0,191	0,215	2,222	2,500
1 [kg] Peat	7 800	13 800	0,186	0,330	2,167	3,833
1 [kg] Peat briquettes	16 000	16 800	0,382	0,401	4,444	4,667
1 [kg] Heavy fuel oil - M1	40 000		0,955		11,111	
1 [kg] Extra light fuel oil - EL1	42 300		1,010		11,750	
1 [kg] Gasoline	44 000		1,051		12,222	
1 [kg] Paraffin	40 000		0,955		11,111	
1 [kg] Liquefied petroleum gas	46 000		1,099		12,778	
1 [kg] Natural gas(1)	47 200		1,126		13,10	
1 [kg] Liquefied natural gas	45 190		1,079		12,553	
1 [kg] Wood (25% moisture)(2)	13 800		0,330		3,833	
1 [kg] Pellets/wood briquettes	16 800		0,401		4,667	
1 [kg] Waste	7 400	10 700	0,177	0,256	2,056	2,972
1 [MJ] Produced heat	1 000		0,024		0,278	
1 [kWh] Electricity	3 600		0,086		1(3)	

Source: Eurostat.
(1) 93% Methane.
(2) EU Member States can apply other values depending on the type of wood mostly used in the respective Member State.
(3) To the saved electricity [kWh], Member States may apply automatically coefficient of 2.5, which reflects the estimate of 40% of the average efficiency of energy produced in European Union standardized values during the period considered. Member States may apply a different coefficient if they can justify it.

These values for the same type of energy or fuel can differ depending on the source, primarily because of the different values of the fuel net (lower) heating value and carbon emission factor contained in the fuel which are input parameters in the calculation of carbon dioxide emission factor per heat energy unit contained in the respective fuel or by fuel unit.

If one can obtain the data on the fuel heating value used in the object which have been analyzed, the emissions estimation should be done using these values. Otherwise, data from Table 2 can be used instead [1].

Table 3 provides values for the CO_2 emission factors per unit of fuel, per unit of heat energy contained in the fuel and per unit of useful heat obtained [2]. When estimating the emission factor per unit of useful heat obtained, average efficiency values for stationary energy devices burning individual fuels are applied. In this way the uncertainty of the estimation is increased, so the recommendation is to use the emission factor per unit of fuel, [$kgCO_2/kg$(or m^3)], or per unit of heat energy contained in the fuel ([$kgCO_2/GJ$] or [$kgCO_2/kWh$]).

Table 3. Certain fuels CO_2 emission factors

Type of fuel	CO_2 emission factors		
	per unit of fuel	per unit of heat energy contained in the fuel	per unit of useful heat obtained
	[kg CO_2/kg (or m^3)]	[kg CO_2/kWh]	[kg CO_2/kWh]
Extra light fuel oil - EL1	3,13	0,264	0,318
Heavy fuel oil - M1	3,08	0,276	0,332
Liquefied petroleum gas (LPG)	2,93	0,225	0,264
Anthracite	2,31	0,334	0,439
Brown coal	1,79	0,339	0,446
Lignite	1,16	0,357	0,470
Natural gas	1,90	0,201	0,236

Table 4 provides the additional values for CO_2 emission factors for different types of energy and fuels, per unit of heat energy contained in the fuel [1].

Table 4. CO_2 emission factors for different types of energy and fuels

Type of energy / fuel	CO_2 emission factors
	[t CO_2/MWh]
Extra light fuel oil - EL1	0,267
Natural gas	0,202
Anthracite	0,394
Lignite	0,433
Heavy fuel oil - M1	0,279
Firewood	0
Motor gasoline	0,249
Diesel fuels	0,267
Liquefied petroleum gas (LPG)	0,227
Thermal energy (central heating)	0,259
Electricity from hydropower plants	0,007
Electricity from nuclear power plants	0,016
Electricity from coal fired thermal power plants	1,340
Electricity (CHP)	0,617

These factors are used to estimate the CO_2 amount which is reduced in total emission quantity of this pollutant, based on reduced energy consumption, energy or fuel type substitution, or by the implementation of some measures which can improve energy efficiency.

LOWER CO_2 EMISSION RATES AS A RESULT OF IMPLEMENTED MEASURES WITHIN THE ENERGY MANAGEMENT SYSTEM

Pollutant CO_2 emissions reduction can be estimate as a difference of emissions before and after the application of measures for improving energy efficiency, on annual level, according to the following equation:

$$EM_{RED} = EM_{BEFORE} - EM_{AFTER} \tag{2}$$

where:
EM_{RED} - CO_2 emissions reduction [kg],
EM_{BEFORE} - CO_2 emission, [kg], before the implementation of the measures, calculated by reference declared energy consumption;
EM_{AFTER} - CO_2 emission, [kg], after the measures application.

Thus, the total net savings of final energy per year is multiplied by the appropriate CO_2 emission factor, depending on the type of saved energy (electricity, liquid fuel, fuels used in heating systems etc.).
Total CO_2 emission also depends on the heating system efficiency, because, according to its value, a quantity of fuel consumed is changed. Comparison of CO_2 emissions for different heating systems is given in Figure 1 [2].

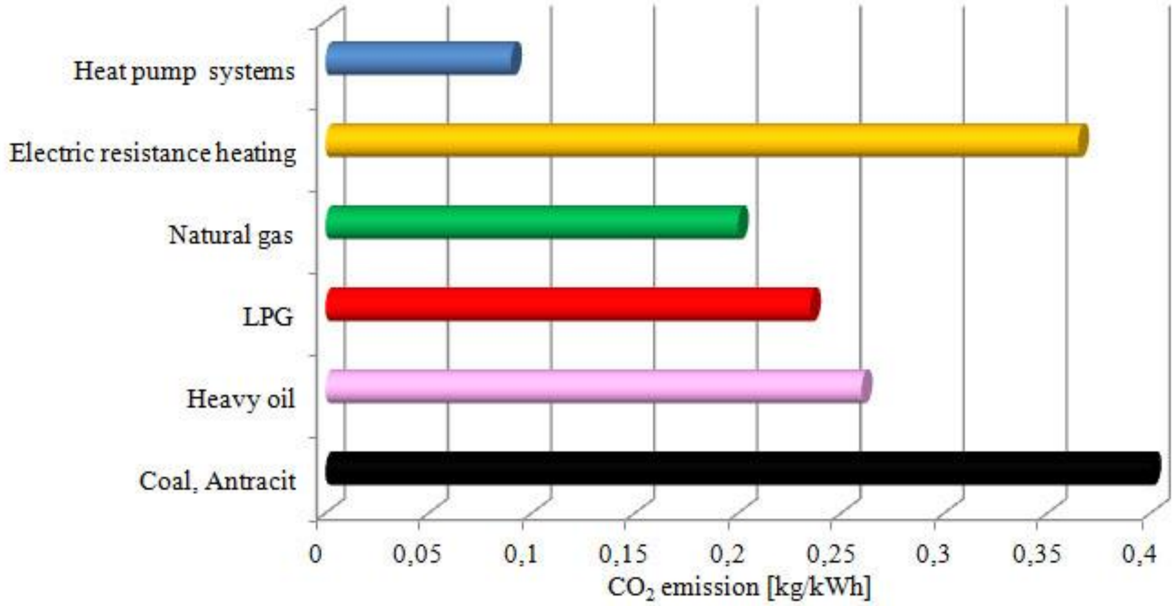

Figure 1. Guidelines on CO_2 emissions for various fuels and heating systems

The Energy Management System can incorporate many various measures which can contribute in improving energy efficiency, decreasing energy consumption, and thus reducing pollutants emission rates, including CO_2 emissions.
One of the possible measures that can be implemented in order to reduce CO_2 emissions into the atmosphere can be the substitution of the classical lamps with energy saving lamps. So, if only one 100 [W] classic lamp which is used 6 hours per day is replaced with energy saving lamp with power of 23 [W], which on other hand has the same light spectrum and intensity as the previous one, in one year the emissions of CO_2 can reduced by about 50 [kg].
Also, energy source/fuel substitution can be one important step that Energy Management System can include in order to reduce financial cost and pollutants emissions form one unit or building.
One such example is shown below.

EXAMPLE OF AN ENERGY SOURCES SUBSTITUTION AND INFLUENCE ON CO_2 EMISSIONS RATE

The building where Faculty of Technical Sciences - Bitola is placed has total heated area of 6000 [m^2], and for energy production for heating and obtaining domestic hot water extra light fuel oil is used.
The analysis considers an option that may be available in the future, replacing extra light fuel oil with natural gas.

Current Status

- To produce thermal energy for heating and preparation of domestic hot water extra light fuel oil is used.
- Annual consumption of extra light fuel oil for heating and preparation of domestic hot water is 60 [tons per year], with an extra light fuel oil energy value of 42.300 [kJ/kg] and density 860 [kg/m^3].
- Pipeline and the heating elements are in good condition, reconstructed two years ago and they have thermostatic radiator valves.
- The development of the infrastructure in the object location made natural gas available for use.
- The existing boiler room according to the characteristics doesn't meet the requirements of the Regulation on technical standards for the design, construction, operation and maintenance of natural gas boiler rooms (SFRY Official Gazette 10/1990 and 52/1990).

A description of the measures taken

- Substitution of extra light fuel oil and instead using natural gas for heat production.

Necessary Investments

Based on the bids submitted by potential contractors a certain amount of necessary investments is equal to a total of 13.530.000 MKD (220.000 Euro).
This amount includes investments in the following items:
- Station for measurements and natural gas pressure reduction (MRS).
- Electrical and mechanical equipment in boiler room (boiler, burner, circulating pumps, mixing valves, gas connection, stack elements etc.), together with the costs of dismantling the old and installation of new mechanical equipment.
- External gas network.
- Internal gas network.
- Construction and reconstruction works.
- Projects for: Station for measurements and natural gas pressure reduction (MRS), gas pipeline and connections, gas boiler room.

Estimation assumptions

- The natural gas energy value is 33.400 [kJ/m^3], and its density 0,69 [kg/m^3].
- Heat energy consumption doesn't depends from fuel type used, and thermal energy which should be provided by natural gas is equal to the thermal energy provided by extra light fuel oil, $E_{e.l.oil} = E_{n.g.}$, i.e.,

$$E_{e.l.oil} = 60.000 \text{ x } 42.300 = 2.538.000.000 \text{ [kJ per year]} \tag{3}$$

$$E_{e.l.oil} = 705.000 \text{ [kWh per year]} = 705 \text{ [MWh per year]} \tag{4}$$

- An assumption that long-term price of natural gas will be maintained at the current level of 28,8 [MKD/m^3] (0,49 [Euro/m^3]), VAT included, that is 3,10 [MKD/kWh] (0,05 [Euro/kWh]), is taken into account.
- The price of extra light fuel oil is 54,5 [MKD/liter] (0,89 [Euro/liter]), VAT included, that is 5,4 [MKD/kWh] (0,09 [Euro/kWh]).

Savings

- *Savings in heating energy (SHE):*

SHE = 0 (Heat energy consumption doesn't depends from fuel type used) (5)

- *Financial savings (FS):*

FS = Costs for extra light fuel oil ($C_{e.l.oil}$) - Costs for natural gas ($C_{n.g.}$) (6)

FS = $E_{e.l.oil}$ × 5,4 [MKD/kWh] - $E_{n.g.}$ × 3,1 [MKD/kWh] (7)

FS = 1.621.500 [MKD/year]= 26.366 [Euro/year] (8)

Investment return period (IRP):

IRP = Total investments / Financial savings per year (9)

IRP = 220.000 / 26.366 = **8,3 years** (10)

Used methodology: CO_2 emissions per unit of fuel [kg CO_2/kg (or m^3)]

As the relevant ratios of CO_2 emissions are taken following:
- 3,13 [kg CO_2/kg] for extra light fuel oil and
- 1,90 [kg CO_2/m^3)] for natural gas

Extra light fuel oil consumption: 60 [tons per year]

CO_2 emission as a result from extra light fuel oil combustion:

60.000 [kg] x 3,13 [kg CO_2/kg] = 187.800 [kg CO_2] (11)

Natural gas consumption:

2.538.000.000 [kJ/year] / 33.400 [kJ/m^3] = 75.988 [m^3/year] (12)

CO_2 emission as a result from natural gas combustion:

75988 [m^3/year] x 1,90 [kg CO_2/m^3] = 144.377 [kg CO_2] (13)

- CO_2 emission reduction (ERED) :

ERED = CO_2 emissions using extra light fuel oil - CO_2 emissions using natural gas (14)

ERED = 187.800 - 144.377 = 43.423 kg CO_2 per year = 43,4 [t CO_2 per year] (15)

Assessment gives the result that we should expect. Substitution of extra light fuel oil with natural gas besides financial savings, has benefit on the environment protection resulting on the reduction of greenhouse gases, primarily CO_2.

CONCLUSION

Energy consumption in buildings and its effects, primary on carbon dioxide emission rates, are analyzed in this paper.

Carbon dioxide emission rates caused by the raised energy consumption can be greatly reduced with the application of energy management system and its measures, particularly energy source/fuel substitution.

This measure can also have an effect on building reduced financial cost for energy.

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