Energy Efficiency and Renewable Energy Sources in The Slavonia Region

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***Abstract*— The paper points out the legal basis for the implementation of energy efficiency in Croatia considering the results of the analysis of energy efficiency in the Osijek-Baranja County by the basic sectors of energy consumption. It also points out an insufficient use of local and regional potential of renewable energy sources. The conclusion emphasizes the need to introduce the regional concept in the energy policy, particularly in the use of renewable energy sources.**

***Keywords*— energy efficiency, renewable energy sources**

I. INTRODUCTION

The EU has taken an energetic development strategy in order to increase the quality and security of energy supply, increase the economic competitiveness and decrease the impacts on the climate changes. In order to provide new local energy sources and reduce greenhouse gases emissions, the EU decided to use more of renewable energy sources (RES) and to improve energy efficiency, especially in the buildings sector. The main objectives of the energy policy of the EU by the year 2020 are as follows: reduce greenhouse gas emission by 20%, produce 20 % of energy from renewable energy sources, save 20% of energy and to consume 10% of total motor fuels consumption on bio-fuels. [21]

Croatia has accepted the goals of the EU and its energy policy is focused on compliance with EU directives and on the creation of the energy market in Croatia, as a preparation for integration into the EU energy market. Therefore, in recent years Croatia has developed an Energy Development Strategy, lots of laws and regulations about energy, two National Energy Efficiency Programs (2009_12 and 2013_16) and has established the Energy Efficiency Fund. [21]

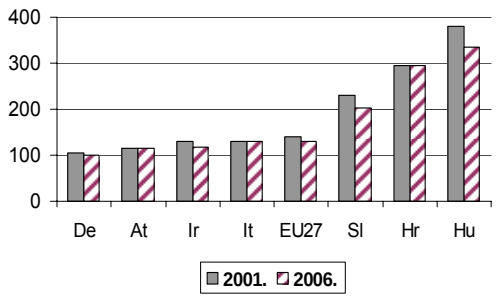

Figure 1 Energy intensity in selected EU countries and Croatia in 2001 and 2006 (kgoe/1000 € GDP) Source: [5]

Croatia consumes 128% more primary energy per unit of GDP than the average EU-27 (Fig. 1). It is also very important to accentuate that Croatia imports more than 40% of energy (oil, gas, electricity). Therefore, the country should pay special attention to the energy efficiency and the use of renewable energy sources. [13] [14] [18].

II. ENERGY CONSUMPTION AND ENERGY EFFICIENCY IN THE OSIJEK-BARANJA COUNTY

A. *Selecting a Template (Heading 2)*

Faculty of Electrical Engineering in Osijek (FEEOS) in early 2011 has started the energy efficiency research project in the Osijek-Baranja County (OBC). Based on these researches the research team FEEOS has later made a study „The program of efficient use of energy in the final energy consumption in OBC for the period from 2012 to 2014 - with reference to the year 2016" [18] On this occasion, there are shown only the basic results of the analysis of energy consumption and energy efficiency in the OBC by the basic sectors of energy consumption.

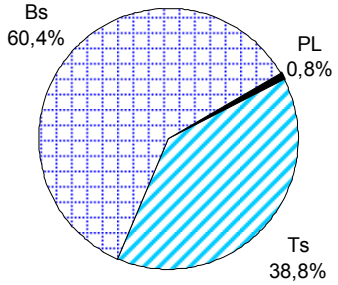

Figure 2 Structure of final energy consumption in OBC (2010) - by sectors (%) Source: [19]

Highest energy consumption for the year 2010 in the OBC had the buildings sector (Bs) 60.7%, the second was the transport sector (Tr) 38.5%, and the public lighting (PL) had 0.8% (a negligible amount of energy in the total energy consumption). (Fig. 2) [18] These facts are respected when defining objectives and measures for energy efficiency realization. The main sources of energy in the final energy consumption in the OBC are: natural gas (26.3%), diesel fuel (24.6%), electricity (21.2%), motor gasoline (12.6%) and heat from the centralized heating system (7%). In the period from 2007 to 2010 there was an increase in total energy consumption from 11.123 PJ to 11.532 PJ at an average annual rate of

growth (ARG) of 1.2%. Total consumption of energy in the OBC in the period from 2007 to 2010, by sector, is shown in the Tab. 1 and Fig. 3.

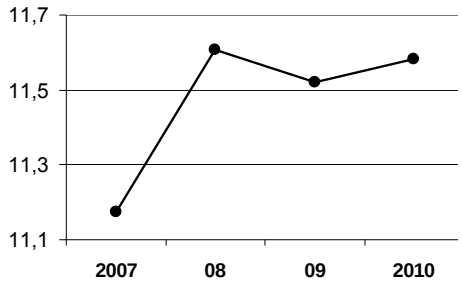

Figure 3 Total final energy consumption in OBC (GWh)
Source: [19]

Table 1 Final energy consumption in the OBC from 2007 to 2010 (GWh)

N°	Sector	2007	2008	2009	2010	ARG (%)
1	Public lighting	22,4	23,9	24,9	25,2	3.9
2	Transport	1,259	1,299	1,277	1,244	- 0.4
3	Buildings	1,808	1,887	1,885	1,934	2.3
4	Total	3,089	3,210	3,187	3,203	1.2

Source: [19]

In the energy consumption of the buildings sector in the OBC the biggest representatives are natural gas (NG) - 43%, electricity (El) - 34% and the heat from the (CHS) - 12% are used the most they are followed by: firewood (Fw), heating oil (HO), liquefied petroleum gas (LPG), field cobs energy (FC), geothermal energy (Geo) and coal (C) [18] [19] [20]; Fig. 4

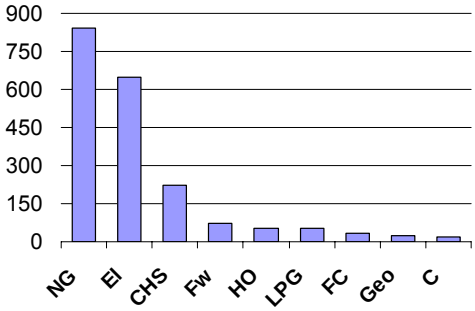

Figure 4 Structure of final energy consumption in OBC buildings' sector (2010) - by energy kinds (MWh)
Source: [19]

From the education subsector in OBC there are 87 kindergartens, 184 primary schools, 59 secondary schools, 18 faculties and university departments from education subsector in the OBC included in final energy consumption (dates of 2007). The main energy sources used in this subsector are: natural gas (30%), heat from CHS (29%), electricity (22%) and heating oil (19%); Fig. 5

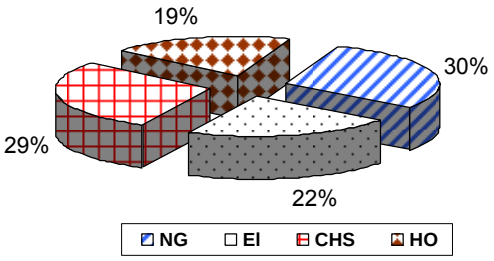

Figure 5 Structure of energy consumption in OBC buildings - subsector education (2010) - by energy kinds (MWh)
Source: [19]

Household sector in the OBC is the biggest consumer in the total final energy consumption in buildings sector (74%), the largest consumer of natural gas (88%), electricity (63%) heat from CHS (50%), heating oil (41%), LPG (54%), firewood (92%), field cobs (100%) and coal (100%). In the structure of energy consumption in the household sector: natural gas (52%), electricity (31%) and heat from the CHS (8.2%) are used the most. Most of the households in the cities (79%) are connected to the gas or CHS. Most of the households in villages (71%) have autonomous home heating installations (AHHI); Fig. 6

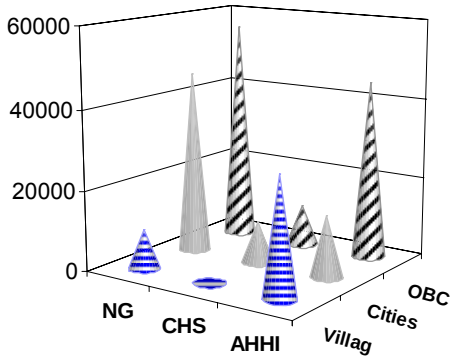

Figure 6 Structure of energy consumption in OBC household sector (2010) - by energy kinds (MWh)
Source: [19]

On Fig. 7 can be seen structure of energy consumption in AHHII of households sector in OBC in 2010 by energy kinds (%). This structure of meeting the needs for the heat in cities has many advantages, but there are also disadvantages. Critical moments occur in a situation of power reduction, when a large part of households in urban settlements are in a very unfavorable position. In crisis situations, people use electricity as an alternative form of the residential buildings warming which threatens stability of power system and reduces energy efficiency. Analysis of electricity consumption in buildings sector shows a great increase of consumption in households; reason is the increase in household equipment, modern appliances and devices. [19]

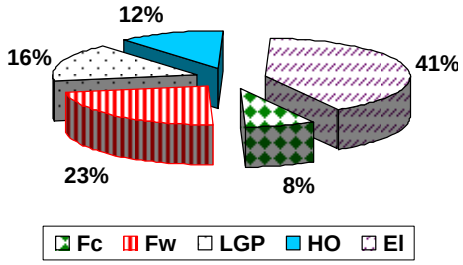

Figure 7 Structure of energy consumption in AHHII of OBC households (2010) - by energy kinds (%)
Source: [19]

Global conditional efficiency of energy use in the final consumption in the OBC (measured by ratio of generated gross domestic product and energy consumed in buildings sector, traffic and public lighting) has a trend growth. In 2005 there was spent 1.52 kWh of energy per 100 € of GDP. In 2007 this ratio improved: there was spent 1.22 kWh of energy per 100 € of GDP – Fig. 8.

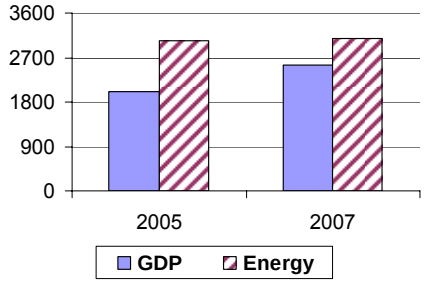

Figure 8 GDP and final energy consumption - buildings sector, transport and public lighting – in OBC (mil. €; GWh)
Source: [19]

Analysis of energy efficiency in the OBC showed that only a few public properties and facilities for housing have an energy certificate that means there are not many objects that meet the requirements of energy efficiency. Energy prices and billing system for energy from CHS consumption have not been incentive for the rational use of energy in buildings sector - the largest sector of energy consumption with an unfavorable structure in which natural gas and petroleum products dominate. In the coming period it is expected energy prices to increase even more, which will raise the cost of public spending, such as the decrease in standard of living. This point to the urgent need for the implementation of energy efficiency measures and the use of domestic renewable energy sources available.

III. RENEWABLE ENERGY SOURCES IN CROATIA

Croatia has a very good potential of renewable energy sources (biomass, geothermal, solar and wind resources) and with the Strategy [14] country opted for the use of renewable energy sources (RES) in accordance with the principles of sustainable development. The share of RES in gross final energy consumption in 2020 will be 20% and that will be achieved by completing the following sector goals for the year 2020: [14]

- 35% of total electricity consumption should be get from renewable energy sources (including large hydropower's);
- 10% of energy used in all forms of transport (energy from gasoline, diesel fuel) should be get from RES (bio fuel);
- 20% of gross final energy consumption for heating and cooling should be get from RES.

Particularly significant is a potential of biomass in Croatia is biomass from wood, agricultural biomass and potential waste of biological origin for the energy production. Strategy has set the goal: the use of about 26 PJ of energy from biomass in year 2020 (in 2010. used about 15 PJ). Part of this biomass will be used in a number of biomass power plants with a total power of approximately 85 MW in 2020 year. In order to increase energy efficiency, advantage will have plants with production of electricity and heat in the combined process.

Table 2
Power plants per renewable energy sources in Croatia

N°	Plant category	In function (2012.)		Planned (2020.)	
		Plants (N°)	Electrical capacity [MW]	Plants (N°)	Electrical capacity [MW]
1	Solar	20	0.4	377	87.7
2	Hydro	2	0.3	62	127.7
3	Wind	9	152.7	103	4,543.0
4	Biomass	2	5.7	91	228.5
5	Biogas	3	4.1	54	80.9
6	Cogeneration	3	10.5	6	36.1
7	Geothermal	-	-	1	4.7
8	Landfill gas	-	-	2	1.6
9	Total	39	173.7	696	5,110.0

Source:[22]

Planning and investment in the construction of biomass power plants is not within the jurisdiction of government institutions and public companies, it is left to the private investors who can use the benefits of privileged electricity producer with privileged rates for electricity delivered. Privileged price for delivered kWh of energy from RES was attractive to investors, but in the mid of 2012., tariff system has been modified and preferential price of kWh for photovoltaic power plants is reduced by additional restrictions (or encouragements) in order to strengthen the energy efficiency and in order to support a domestic industry, which will be reflected on the so-called "accidental" solar power plant investors. However, that's why the purchase prices of electricity from biomass have increased (for the power plants from 1.2 kn to 1.3 kn for delivered kWh, and for the large plants from 0.83 kn to 0.9 kn) - that will increase the interest in biomass power plant investment. [23] [24]

Today, in 2012, in Croatia there are 39 RES power plants with the total electric power of 173.7 MW. The plan is (there

is interest registered) to construct 696 projects with a total of 5110 MW of electric power and additional heat power of 88 MW (Tab. 2).

When it comes to biomass, volume and the structure of registered solid biomass production (bio fuels) should be stressed (Table 3). In 2010 in Croatia there are pellets produced in nine plants with a capacity of 205,000 t a year, that is just a quarter of use. Over 95% of production is sold to foreign markets. Briquette production is estimated at about 60 000 t per year depending of the raw material available (waste from wood processing). Briquettes are also, in large part, sold to foreign markets. Charcoal is produced industrially only in Belišće (Slavonia), which is more than half of the annual production. The rest is produced by dozens of small and medium producers of charcoal. [4]

Table 3 Solid bio fuel production in Croatia in 2010.

N°	Type of bio fuel	UM	Amount
1	Wood pellets	t	62 372
2	Wood briquettes	t	10 227
3	Charcoal*	t	4 319
4	Wood chops	t	76 410
5	Firewood	m^3	1 761 000

Source: [4]

a) Regional potential of renewable energy sources

In Slavonia and Baranja there are functioning 7 plants per renewable energy sources with the total power of 12.9 MW. The plan is to build 138 projects with a total electrical power of 117.73 MW and additionally 88 MW of thermal power; Tab.4

Table 4 Power plants per renewable energy sources in Slavonia and Baranja

N°	Plant category	In function (2012.)		Planned (2020.)	
		Plants (N°)	Electrical capacity [MW]	Plants (N°)	Electrical capacity [MW]
1	Solar	2	0.02	62	1.73
2	Hydro	0	0	7	0.96
3	Wind	0	0	2	104. 00
4	Biomass	1	2.4	29	86.10
5	Biogas	2	2.1	35	50.50
6	Cogener	2	8.4	3	12. 00
7	Geotherm	0	0	0	0
8	Landfill gas	0	0	0	0
9	Total	7	12.92	138	255.29

Source: [22]

b) The remains of crops and fruit production in Slavonia and Baranja

As can be seen from the previous tables there are no balance or any concrete data about energy evaluation of crop and fruit growing residues in Croatia [4] [14] . There are also no such information in a series of studies: "The potential of renewable energy sources in all 20 counties in Croatia"- which EIHP Zagreb has made. [8] [9] [10] [11] [12]

Slavonia and Baranja has extremely favourable biomass potential in forestry [6] [7] and in this category of renewable energy sources. [15] [16] [17]

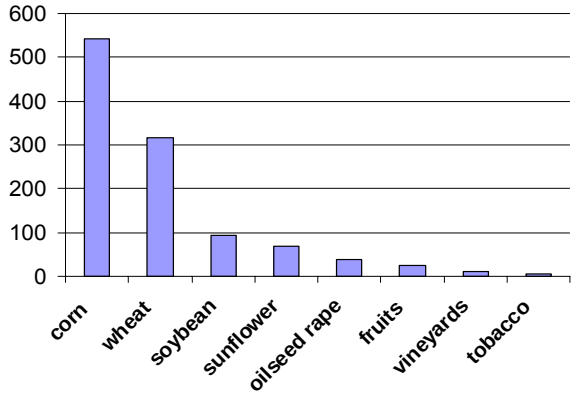

Figure 9 Solid biomass from crop and fruit growing residues and vineyards cutting in Slavonia and Baranja (10^3 toe)

In this research, there is made an evaluation of the energy potential of solid biomass from crop and fruit growing residues in Slavonia and Baranja including the straw of: wheat, barley, rye, oats and soybeans, as also the corn cobs, stalks of sunflower, oilseed rape, tobacco and residues from fruit and vineyards cutting (Tab.4 and Fig. 9). The lower calorific value of certain types of biomass, area harvested and yield per individual cultures (based on the average of the last five years), the standard ratio of yield (seed) and crop (farming) residue (stalks and corn cobs), are all taken into account. [1]

Table 5a Energy potential of crop residues and fruit production in Slavonia and Baranja

Culture	Lower cal.val.	Area harvested	Average yield	Mass of seed
	[MJ/kg]	ha	t/ha	t
Wheat	14	138,962	5.1	703,678
Barley	14.2	38,022	4.2	158,804
Rye	14	563	2.7	1,493
Oats	14.5	16,383	2.5	41,688
Corn	13.5	199,421	6.6	1324,604
Corn cob	14.7	(")	6.6	1324,604
Soybeans	15.7	47,078	2.5	118,805
Sunflower	14.5	28,482	2.8	79,690
Sunfl.head	17.55	(")	2.8	79,690
Oilseed rape	17.4	16,591	2.7	44,786
Tobacco	13.85	5,561	2.1	11,561
Fruit	14.15	19,955	3.4	67,826
Vineyards	14	9,021	3.0	27,243
	Total	520,038		

Table 5b Energy potential of crop residues and fruit production in Slavonia and Baranja

Culture	Seed/ res	Total of biomass	Energy value	Eq. heat. oil
		t	GJ	t
Wheat	1	703,678	9851,498	245,123
Barley	1	158,804	2255,019	56,109
Rye	1.2	1,792	25,084	624
Oats	1	41,688	604,475	15,040
Corn	1	1324,604	17882,160	444,941
Corn cob	0.2	264,921	3894,337	96,898
Soybeans	2	237,610	3730,475	92,821
Sunflower	2	159,379	2310,998	57,502
Sunfl.head	0.3	23,907	419,566	10,440
Oilseed rape	2	89,572	1558,554	38,780
Tobacco	0.35	4,046	56,040	1,394
Fruit	0.325	67,826	959,733	23,880
Vineyards	0.457	27,243	381,399	9,490
Total		3105,070	43929,340	1093.042

Source: counted from [1] [2] [3]

The energy potential of crop residues and fruit production in Slavonia and Baranja is 1 093 042 toe which is more than important for a country that is dependent on energy imports of about 40% of final energy consumption. Here it should be pointed out that around 25% of cobs are plowed again in the land for planting and that about 15% of straw and corn is used in livestock rising. If we take into account that 10% of the biomass is used for some other purposes, it remains about 500 000 toe.

IV. CONCLUSION

Energy policy in Croatia

Croatia has accepted the goals of the EU and its energy policy is focused on compliance with EU directives and on the creation of the energy market in Croatia, as a preparation for integration into the EU energy market. Going toward set goal, in recent years Croatia has developed an Energy Development Strategy, lots of laws and regulations about energy, two National Energy Efficiency Programs (2009_12 and 2013_16) and has established the Energy Efficiency Fund.

Since Croatia has significant energy potential of renewable energy sources (biomass, geothermal, solar and wind resources) there are a series of measures at national level in order to strengthen energy efficiency and to use renewable energy sources. Planning and investment in the construction of renewable energy sources power plants is left to the market – to the private investors (equity) that can use benefits of the status of privileged electricity producer.

Energy consumption and energy efficiency in OBC

Final energy consumption in the OBC is excessive in relation to the GDP. Structure of energy sources consumption is unfavorable; there is a significant dependence on imported fossil fuels and electricity.

The greatest opportunities to increase energy efficiency are in the buildings sector - where is possible to use local potential of renewable energy sources.

Potential and use of renewable energy sources

Croatia has a significant energy potential of renewable energy sources (biomass, geothermal, solar and wind resources), and the Slavonia and Baranja region has a potential in many types of biomass and geothermal energy.

RES capacities (power plants) that are constructed so far (their number and electric power) in Croatia (including Slavonia and Baranja region) have used only a small part of energy potential.

Because of the economic crisis in the country and modification of the tariff system (2012) on the privileged renewable sources energy producers can be counted with a reduced interest to build planned power plants in the next period.

A pure market approach to energy development can not be effective - especially in transition countries such as the Croatia.

In economy and energy terms it is unreasonable for the country not to use its own renewable energy resources and at the same time to import fossil fuels and electricity for the final consumption.

Slavonia and Baranja region has significant potential of renewable energy sources in biomass and geothermal energy that are not used and there are no indications of increased use.

With this research the potential of biomass residues from farming and fruit production in Slavonia and Baranja has been determined. On this basis, region has at least 500 000 toe.

In order to start using this energy potential, there is an establishment of regional energy policies required- energy policies that will evaluate the potential of renewable energy sources and bring them to use far more efficient and faster than the current national model that is based solely on market laws. After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

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