

## CONSUMPTION OF WOOD FUELS IN HOUSEHOLDS IN SERBIA – PRESENT STATE AND POSSIBLE CONTRIBUTION TO THE CLIMATE CHANGE MITIGATION

by

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*The paper presents results of the research in wood fuels consumption for household needs in Serbia. Research was performed during the period from October 2010 until April 2011, i. e. in the period of heating season in order to get the actual situation regarding the presence of certain fuel types in the consumption of households with special highlight on types and amounts of wood fuels. For this purpose, an adequate methodological concept was defined with the aim to primarily get relevant and reliable data on wood fuels consumption and afterwards, by using FAO WISDOM methodology and adequate GIS software packages to perform their analysis, mapping, and graphic representation. One of the most significant elements of the adopted methodological concept was field research-questionnaire of households which was conducted on the sample of 36.946 households out of which 20.725 urban and 16.221 rural in 22 municipalities in Serbia, which was 1.46% of the total number of households in Serbia. Results of the survey showed that 23.2% of the total number of households in Serbia used district heating system (based on conventional fossil fuels as dominant), 25.3% used electricity, and 10.6% used gas for heating purposes. Most households (40.9%) used solid fuels such as fuelwood, coal, briquettes, pellets, agricultural residues and combinations of solid and other fuels.*

Key words: wood fuels, fuelwood, briquettes, pellets, consumption, households

### Introduction

In fulfilling its needs, Serbia largely depends on fossil fuels import, the costs of which are rapidly increasing due to the increase of oil and gas prices. Large amounts of imported fossil fuels are used for heating (in 2008 the import dependence was 44%) [1]. In recent years, natural gas has increasingly started to replace wood through the construction of gasification network, where potentials of wood as one of the clean and renewable energy sources, carbon neutral and available in certain amounts are ignored. It is a fact that wood-based fuels cannot fully satisfy the needs for energy in Serbia, however, through increased usage and conversion from fossil fuels they can contribute to significant decrease of import of these fuels and thus the reduction of CO<sub>2</sub> emissions.

To that effect, in the previous ten years, a number of studies were done, and several projects were implemented, supported by the Ministry for Science and Technological Development of the Republic of Serbia as well as certain international organizations (UNDP,

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USAID). Numerous papers were published on the topic of available amounts of woody biomass, especially wood residue from forestry and wood processing. However, in all those studies, projects and papers there were no significant research regarding the actual consumption of wood fuels in Serbia, especially in the segment of households, which represent the area in which wood fuels are consumed to the largest extent. This statement represented one of the reasons for undertaking the research within the project titled “Wood Based Energy for Sustainable Rural Development in Serbia” supported by the Food and Agriculture Organization (FAO) of the United Nations and the Ministry of Agriculture, Trade, Forestry and Water Management of the Republic of Serbia.

Beside households, the research of wood fuels consumption was also done in district heating systems, bakeries, meat roasters, restaurants, meat shops and car services in the selected strata. Special segment of the research was devoted to the consumption of wood fuels for heating school facilities in the system of primary and secondary education in Serbia, as well as in health care centers, dispensaries and religious facilities of the Serbian Orthodox Church. Apart from the above-mentioned, the research also included wood consumption for the production of charcoal and lime in 2010. In that way, the research included the largest and most significant consumers of wood fuels in Serbia for heating purposes.

Nevertheless, having in mind that fuelwood consumption in households makes 88.9% of total fuelwood consumption in Serbia [2], that was the main reason to present results of fuelwood consumption for households in this paper. Fuelwood consumption in other segments will be subject of another paper.

The most significant results of the stated project as well as the research conducted for the purpose of this paper are presented hereafter.

### **Scope of work and objective**

Scope of the research in this paper is wood fuels consumption for the purpose of energy in households in Serbia. The main objective of the paper is to observe the actual situation and presence of wood fuels in households in Serbia regarding structure, amounts, energy value and consumption characteristics. Apart from the above-mentioned, special objective of the paper is to observe the position and role of wood fuels in total energy balance of Serbia, especially in the segment of households within final energy consumption.

The stated research and obtained results with their representativeness through the selection of appropriate methodology and comprehensiveness, should contribute to clear observation of the role and significance of wood fuels in energy system and thus the removal of numerous dilemmas and assessments which currently exist among various stakeholders in Serbia.

### **Method of work**

Considering the fact that Serbia does not have reliable statistical data on the production and consumption of wood fuels and that numerous studies and papers with the topic of woody biomass were based on the assessment of experts based on official statistical and other data published by certain institutions and organizations (for example “The state of biomass energy in Serbia”) [3], the need to conduct a comprehensive research emerged with the purpose to observe actual consumption and thus participation of wood based energy in the total balance of final energy consumption.

The paper used WISDOM methodology defined by the FAO organization [4]. WISDOM is the abbreviation of woodfuel integrated supply/demand overview mapping. Since the stated methodology is based on the analysis and mapping of data on production and consumption of wood fuels, it implies that the data imported in adequate databases within GIS system are reliable and relevant enough for conducting the stated analyses. However, as there are no such data for Serbia, it was necessary to primarily define and adopt adequate methodological procedure in order to reach reliable and relevant data and afterwards by using WISDOM methodology to analyze, map, and display them in adequate table and graphic presentation.

Therefore, this research adopted “new methodological concept” representing an improvement of FAO/WISDOM methodology. Its implementation in Serbia for the first time, surely adds to this research’s significance. As such it can be applied to other countries which do not have sufficiently reliable and relevant data on production and consumption of wood fuels.

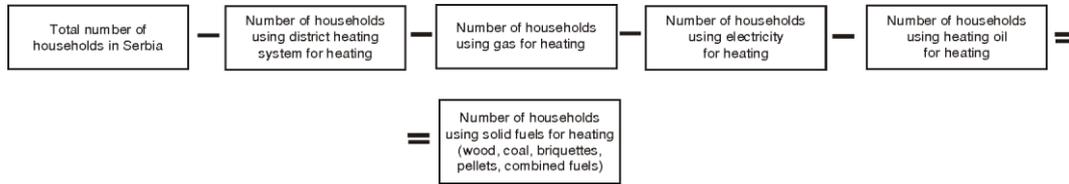
Research started on October 25, 2010, and field research ended on April 1, 2011. The selected time period is the period of heating season (2010/2011), thus it was possible to have insight into actual situation in the field, which provided relevance and high reliability of the collected data.

In the selected methodological approach, total number of households registered in Serbia in the last census published in 2002 was used as the starting point. Selection of such an approach resulted from the fact that it was the only reliable source of data on the number of households in urban and rural areas by settlements, towns, and counties. The stated number of households included the number of household members as well as their age structure. The second important element of the selected methodological approach referred to the need to conduct the stated research on county level because of differences among counties in Serbia mostly regarding climate characteristics, household size, tradition in using certain fuels for heating, availability and convenience of using certain fuels (wood, coal, agricultural biomass, and others) and socioeconomic factors (income level, level of equipping with various combustion devices, *etc.*).

Pursuant to the census conducted in 2002, total number of residents in Serbia was 7,498,001 and the number of households was 2,521,190. Most households are situated in towns, 1,481,304 or 58.6% while rural households comprise 41.4% or 1,039,886 [5].

Out of the stated number of households, those households using either district heating systems (based on conventional fossil fuels as dominant), electricity, gas or fuel oil for heating were deducted in order to obtain the number of households that use solid fuels such as wood, coal, briquettes, pellets, or combined fuels (fig. 1). Number of households which used the stated fuels was obtained from the Association of Serbian Heating Plants [6], Electric Power Industry of Serbia [7], gas distributors [8] and Petroleum Industry of Serbia [5] representing the number of active households which used the stated fuel forms in the period in which the research was conducted.

The calculated number of households using solid fuels in Serbia represented the basis for conducting further research in order to observe not only the number of households using specific forms of solid fuels but also the volume of their consumption individually and on average per household expressed in cubic meters or tonnes. To that effect, data from all coal mines in Serbia were collected with the purpose to obtain amounts of coal placed on the market for the so called mass consumption, *i. e.* for the needs of households, schools, hospitals, commercial facilities, and other users.



**Figure 1. Methodology for determining the number of households which use solid fuels for heating purposes in Serbia**

At the same time, data on export and import of certain coal types in 2010 were collected. However, obtained data were not sufficiently reliable to identify the number of households which used coal out of the number of households using solid fuels as well as the volume of its consumption, and the reasons were:

- data obtained from coal mines and official statistics of Serbian foreign trade represented only total amounts distributed on the market without the possibility to monitor amounts consumed in households and for the needs of other users (schools, hospitals, commercial, religious facilities, *etc.*), and
- certain number of households using solid fuels use the combination wood/coal, coal/briquette, coal/pellet, *etc.*

Because of everything above-mentioned, it was necessary to conduct field research by using questionnaires to households in order to get the actual situation regarding the consumption of certain fuel types and their amounts in the part of households which use solid fuels.

For the purpose of this, sample size was defined in the amount of 5% of the number of households which use solid fuels for heating in Serbia, which was 36,946 households out of which 20,725 urban or 56.1%, and 16,221 rural or 43.9%. Size of the selected sample was representative enough to observe the actual situation regarding the consumption of solid fuel types and amounts for the purpose of heating households in Serbia. Compared to the total number of households in Serbia, which was 2,521,190 according to the most recent census [9], the selected number of households in the sample for household questionnaire was 1.46%.

After defining sample size, certain strata were defined regarding geographic position and number of households (in urban and rural areas) in which the survey was to be conducted. Size of individual stratum is defined in the amount of 5% of the number of urban households and 5% of the number of rural households which use solid fuels for heating. Number of households which use solid fuels for heating is obtained in accordance with the methodology presented in fig. 1. Regarding that, and taking into consideration above-mentioned characteristics (climate differences, tradition, *etc.*) as well as available resources, 16 strata with 22 municipalities were selected the spatial distribution and size of which are given on fig. 2. The stated strata represented administrative centers of certain counties and as such they were at the same time areas (urban and rural) in which most residents lived. Within each individual stratum, urban and rural areas were defined with the number of questioned households therein.

In certain strata, due to their size, it was necessary to select two additional municipalities in order to obtain as relevant picture as possible of the situation in the field in those strata. For example, in Zlatibor stratum, Nova Varoš, and Prijepolje were selected as

well apart from Užice, as two mountainous municipalities in which climate factors are somewhat different than the ones present in Užice. Also, in Raška stratum, apart from Kraljevo, Novi Pazar was selected as well because of the differences in climate as well as cultural characteristics. Approach was similar for other strata as well.

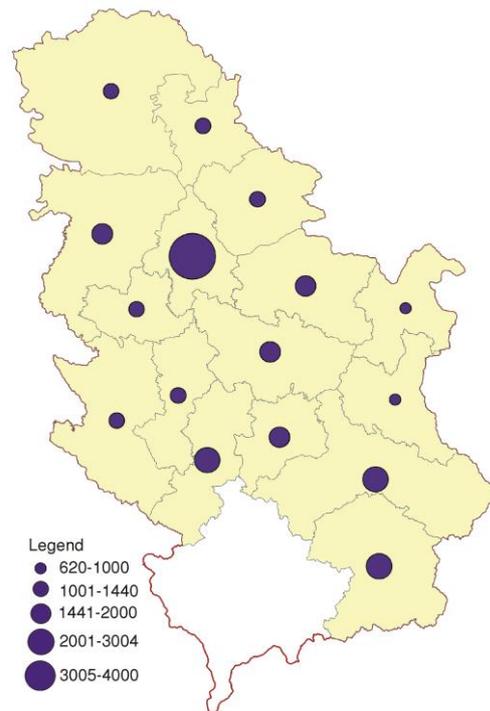
After defining strata and the number of households, an appropriate questionnaire was created and 24 interviewers were trained who performed household questionnaires within a stratum in the period of January 1 to March 20, 2011. Questionnaire contained basic data on the household, type and amount of fuel the household used for heating and food preparation, size of area heated, number of household members, purchase price of energy-generating products, and fuel purchasing system. Survey was conducted in such a manner that interviewers visited households and applied the method of direct interviews (face-to-face).

Validation, processing and statistical analysis of obtained data was done in the period April-June 2011. In data processing and analysis, adequate statistical methods were used in program packages ArcGIS Version 9, Statistika V.50. and MS Office Excel 2007.

For the purpose of calculating values of tones of oil equivalent (toe) of wood fuels used for heating households as well as their participation in final energy consumption in the energy balance of Serbia, the following assumptions were adopted based on the results of the survey:

- volume of specific wood species in total consumption of fuelwood for heating purposes was calculated for the above-mentioned users, and afterwards, amounts of fuelwood per certain wood species were calculated,
- moisture content of fuelwood in the amount of 35%, and
- lower heating value per cubic meter of solid wood at moisture content of 35% for the following wood species which participated in fuelwood consumption in the season 2010/2011, and mixed non-coniferous hardwood and softwood species 2.311 kWh/m<sup>3</sup>, non-coniferous solid hardwood sawmill residue 2.309 kWh/m<sup>3</sup>, non-coniferous solid softwood sawmill residue 2.007 kWh/m<sup>3</sup>, coniferous solid sawmill residue 1.904 kWh/m<sup>3</sup>, non-coniferous solid mixed sawmill residue 2.027 kWh/m<sup>3</sup>, sawdust (mixed coniferous and non-coniferous) 3.144 kWh/ton (moisture = 35%), wood briquettes 4.550 kWh/t (moisture = 10%), and wood pellets 4.680 kWh/ton (moisture = 8%) [10].

The most significant results of the conducted researches are presented in the continuation along with appropriate analyses and discussion.



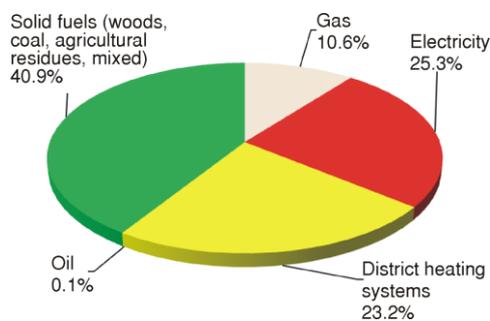
**Figure 2. Spatial distribution and size of strata for questioning households in the heating season 2010/2011 in Serbia**

## Research results and discussion

Current situation on wood fuels market in Serbia is characterized by the fact that the following types of wood fuels are used for the purpose of heating households in Serbia: fuelwood, wood briquettes, and wood pellets. In district heating systems, wood briquettes and wood pellets are used, and charcoal is used in restaurants and butcher's stores (which offer the service of meat roasting apart from selling it). Beside the above-mentioned, charcoal is used in forging iron. Currently all wood chips volumes are used for the production of wood based panels (particleboard and hardboard) and for wood pellets production, so at the moment wood chips are not used for heating purposes.

### *Consumption of wood fuels in households*

The stated statistical indicators of the number and structure of households are significant for the analysis of fuel consumption for own purposes (heating, food preparation, *etc.*). Consumption of wood fuels in households depends on numerous factors among which the following are highlighted in particular: average monthly temperatures in certain regions during winter months, altitude, quality of constructed residential facilities (insulated or not), possession of central heating system, lifestyle, tradition, *etc.* Due to a large number of factors that impact the size of fuel consumption in households as well as their applicability for the purpose of observing wood fuels consumption in Serbia, the survey was conducted pursuant to the methodology explained in the chapter *Method of work*.



**Figure 3. Participation of certain fuel types for heating households in the heating season 2010/2011 in Serbia**

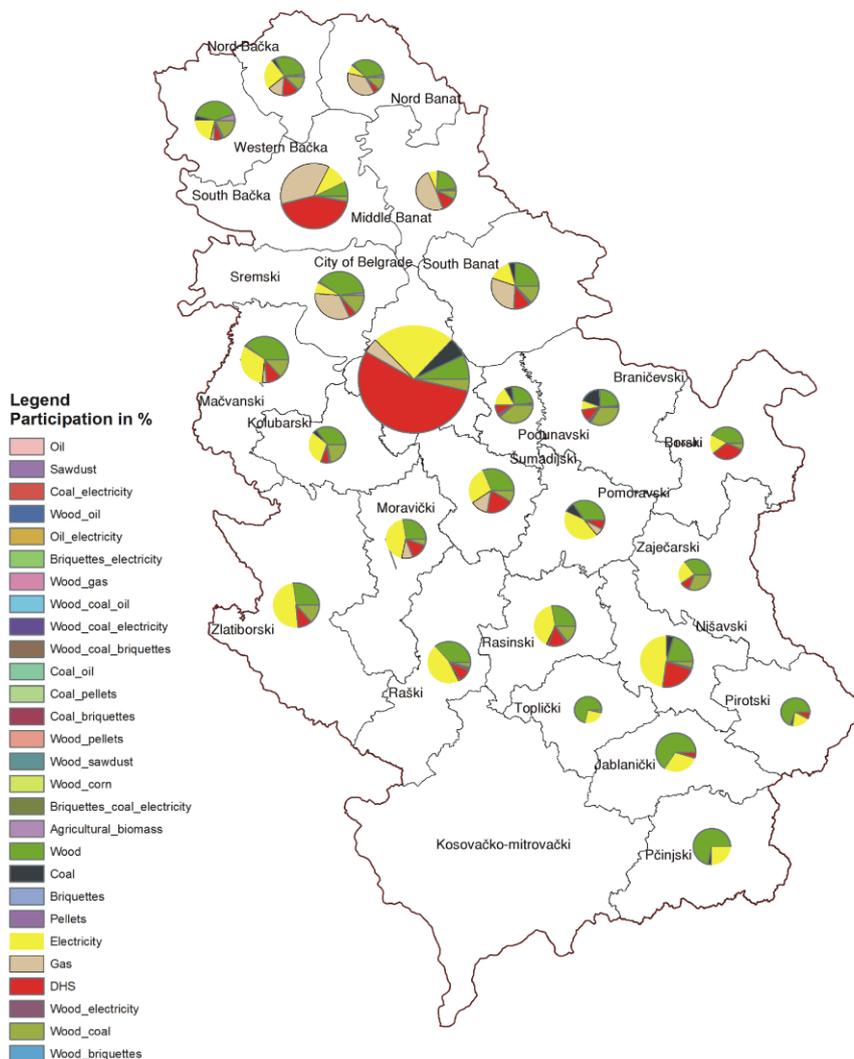
Results of the survey showed that 23.2% of the total number of households in Serbia used district heating system, 25.3% used electricity, and 10.6% used gas for heating purposes. The largest number of households (40.9%) used solid fuels such as wood, coal, briquettes, pellets, agricultural residues, and combinations of solid and other fuels (fig. 3).

Relatively high participation of the number of households which use electricity for heating results from its relatively low price. Thus, the costs of 1 kWh of electricity used for heating households in the system of storage heaters which are charged only during the night when the so called cheap electricity tariff is in force, in the heating season 2010/2011, were 3.6 € cents (c€). For the same heater, if it is charged during the night and occasionally charged during the day, the costs were 5.2 c€ [11].

Regarding district heating systems, they are present in 56 towns in Serbia. The majority of power plants within these systems use coal, followed by oil and gas. In the heating season 2010/2011 the consumption of 2.150 tons of wood pellets was planned for one power plant and one boiler station in Belgrade district heating. Heat produced in district heating systems is used for heating 36.9 million m<sup>2</sup> of residential surfaces [6].

Presence of certain fuel types for the purpose of heating households varies in different regions in Serbia. Graphic representation of the results of the conducted

questionnaire regarding the participation of certain fuel types for heating households is given in fig. 4. In south and south-east parts of Serbia, dominant fuel for heating households is wood fuels. Thus, for example, in Jablanica county wood fuels are present in 65.6% of households, in Pčinj county in 70.8%, and in Pirot county in 69.3%. Together with electricity, wood fuels are dominant source of energy for heating households in central, south-west, and west Serbia. Thus, for example, in Zlatibor county (south-west Serbia), participation of electricity for heating households is 47.9% and wood fuels participate with 26.8%. In 13.7% of households in this region, combination wood/coal is present. In Belgrade, two forms of heating households with the highest participation are district heating systems (54.1%) and electricity (23.7%) and wood fuels take the third place (8.2%). Fuel combination wood/coal

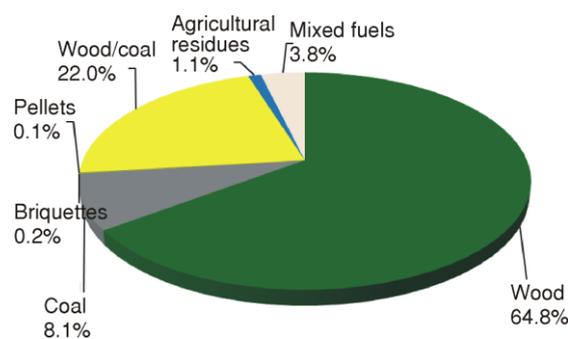


**Figure 4. Presence of certain fuel types for heating households in the heating season 2010/2011 in Serbia [12] (color image see on our web site)**

participates with 3.6%. In the region of Vojvodina, gas and district heating systems have high presence, and in certain counties such as north and west Bačka, wood along with gas is fuel with the highest participation. Participation of wood fuels in west Bačka is 39.9% and in combination with coal it is 17.2%.

The second important characteristic of fuel consumption for heating households is the fact that a lot of fuel combinations are present in the consumption. Results of the questionnaires [12] showed that in the heating season 2010/2011, 28 different fuel combinations were present (fig. 4). Here, it should be mentioned that the combination wood/coal had the highest participation, while other fuel combinations were present to a smaller degree. However, even beside relatively low presence, they have to be taken into consideration when determining the amounts of certain fuels used for the purpose of heating households.

Since most households (40.9%) in Serbia use solid fuels (only or combinations with other fuels) for heating purposes, from the point of calculating total amounts of wood fuels consumed in Serbia in the heating season 2010/2011, analysis of the data from the questionnaires was done regarding the participation of certain types of solid fuels by counties and on the level of Serbia. Results of the research are presented in fig. 5.



**Figure 5. Participation of certain types of solid fuels for heating households in the heating season 2010/2011 in Serbia [12]**

Data from fig. 5 show that almost 2/3 of households, which used solid fuels for heating, use wood, while the combination wood/coal is present in 22.0% of households. Compared to the total number of households in Serbia, the number of households which used only wood, combination wood/coal and combination wood/other fuels was 934,237 or 37.1%. Results of the survey on the presence and amounts of fuel consumed in households in Serbia showed that total consumption of wood (urban and rural households collectively) was 6,416,693 m<sup>3</sup> of solid wood.

Regarding relatively high number of options in which wood fuels are used (alone, mutually combined or combined with other fuels – electricity, coal, heating oil), for each of the options the amount of wood fuels was taken as was present in county level questionnaires. That amount was multiplied by the number of households which used the particular fuel combination and thus total amount was obtained for each type of wood fuels.

Questionnaire results also showed that in Serbia in the heating season 2010/2011 wood pellets were used for heating households for the first time. According to [2] total consumption of wood pellets in households in the heating season 2010/2011 was 7,722 tonnes while the consumption of wood briquettes in the same time period was 13.189 tonnes.

Amounts of wood fuels by counties consumed for household needs are given in tab. 1 and graphic representation of the presence of households which use wood and wood fuels in the total number of households by counties is given in fig. 6.

**Table 1. Number of residents, households, and consumption of wood fuels by counties in Serbia**

County/City	Population	Number of households	Average area of the households [m <sup>2</sup> ]	Wood fuels consumption in heating season 2010/2011 (results of survey)		
				Fuelwood* [m <sup>3</sup> ]	Wood briquettes [tonnes]	Wood pellets [tonnes]
Bačka North	200,140	74,402	70.4	196,263	319	118
Bačka South	593,666	207,679	69.0	127,736	602	233
Bor	146,551	50,743	63.8	283,396	122	28
Braničevo	200,503	63,072	75.1	215,753	1,160	144
Central Banat	208,456	73,865	74.2	140,143	336	148
City of Belgrade	1,576,124	566,028	57.9	406,209	4,265	944
Jablanica	240,923	73,604	60.2	401,399	60	106
Kolubara	192,204	62,818	61.9	330,975	266	392
Mačva	329,625	104,159	60.5	403,316	160	126
Morava	224,772	74,556	56.7	204,104	254	198
Nišava	381,757	130,441	58.1	221,163	156	822
North Banat	165,881	61,080	74.1	185,161	448	64
Pčinje	227,690	64,668	60.8	344,976	137	86
Pirot	105,654	38,481	59.2	197,553	46	42
Podunavlje	210,290	66,874	65.6	242,326	1,272	182
Pomoravlje	227,435	75,006	68.5	184,845	112	208
Rasina	259,441	81,270	65.8	268,937	738	312
Raška	291,230	87,894	63.0	290,575	741	446
South Banat	313,937	106,234	70.8	246,591	98	357
Srem	335,901	110,528	66.8	276,404	257	128
Šumadija	298,778	101,093	60.1	290,778	656	198
Toplica	102,075	35,073	59.9	180,677	76	25
West Bačka	214,011	74,475	71.2	239,585	458	628
Zaječar	137,561	46,946	64.0	257,527	126	915
Zlatibor	313,396	97,305	55.5	280,301	324	872
Serbia (total)	7,498,001	2,528,294	63.4	6,416,693	13,189	7,722

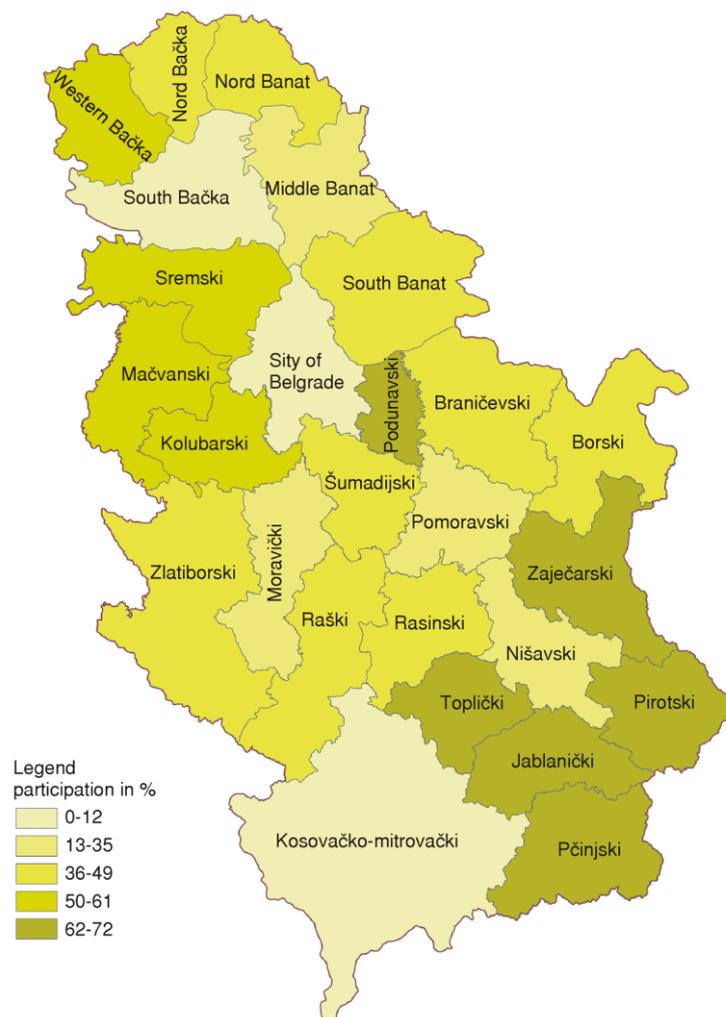
\* Fuelwood and solid residues together from industry

Sources: [9, 12-14]

Results of field research and the questionnaire have shown that there are certain differences in using wood fuels in urban and rural households both regarding the amounts and regarding the type of wood fuels.

In the consumption of urban households, consumption of all three wood fuels is present (fuelwood, wood briquettes, and wood pellets) while in rural households only fuelwood is present. One of the reasons of such a situation is the fact that in rural households

wood briquettes and wood pellets are extremely slowly accepted as fuel. This is the situation even in those rural areas in which briquettes are produced and where the local population works in factories for its production, which are located in rural, forested areas. Results of the conducted field research among workers in the factories in which wood pellets and briquettes are produced show that there is strong belief that nothing valuable and good can be produced from wood residues, although local population participates in their production. Also there is a high degree of ignorance among rural population regarding the effect of certain types of wood fuels, which along with low standard of living and limitations for purchasing modern and efficient combustion stoves impacts the slow acceptance of new types of wood fuels in rural areas in Serbia.



**Figure 6. Presence of households which used wood and wood fuels for heating in the heating season 2010/2011 in total number of households by counties in Serbia [12]**

Beside the above-mentioned, an important characteristic of wood fuels consumption in rural areas is consumption continuity. Namely, in most rural households in Serbia fuelwood is used all year round. In winter months it is used for heating and food preparation, and during other months for food preparation, distilling brandy, meat drying, hot water and other purposes. Also, it is necessary to highlight the fact that in many rural households there is a need to keep living spaces warm all year round, even during summer months in evening hours, especially in mountainous regions. Usage of electricity in rural households for food preparation is symbolic because of extremely poor budget of most rural households.

In urban households, wood fuels consumption is largely only during the heating season, while electricity is used for food preparation and other purposes.

Concerning urban households, research showed that “new” wood fuels, primarily wood pellets, are accepted faster in households with relatively high incomes and among members with high education. Owing to comfort and efficiency as well as financial savings compared to fuel oil, the number of urban households which use wood pellets is increasing. Action Plan for Biomass of the Government of the Republic of Serbia has not foreseen yet any incentives and subsidies for households regarding the transition from fossil fuels to fuels from renewable sources, which partly slows down the process of their mass usage.

In the total wood consumption of 6.42 million m<sup>3</sup>, there was a certain amount of wood which households bought from sawmill processing companies, as well as from companies for wood packaging production in the region of Vojvodina and Belgrade. Survey results showed that in the heating season 2010/2011, total consumption of solid wood residue from sawmills and packaging production for heating households was 55,905 m<sup>3</sup>, which means that the remaining of 6,360,788 m<sup>3</sup> was fuelwood.

On the other hand, Serbia is a very small importer and exporter of fuelwood, which leads to conclusion that the highest quantities of produced fuelwood are used in consumption on the local market [2].

#### *Energy value of wood fuels consumed for heating households and their significance in total final energy consumption in Serbia*

Energy value of consumed wood fuels in Serbian households in the heating season 2010/2011 was calculated based on the results of the questionnaire on the presence of certain types of wood fuels for each county individually. For calculating energy value of consumed fuelwood, lower heating value of wood was adopted in the amount of 2,311 kWh/m<sup>3</sup> solid wood. This heating value refers to value of non-coniferous wood at moisture content of 35% and includes heating value of hard and soft non-coniferous wood in balanced amount regarding their presence in total amounts of fuelwood consumed in Serbia in the heating season 2010/2011. Since the presence of coniferous fuelwood for energy purposes in households is symbolic (about 1% compared to the total amount of fuelwood consumed in households), the adopted lower heating value is representative for calculating total energy value of fuelwood. Adopted moisture content is average moisture content of fuelwood which is mostly present in practice.

For calculating energy value of solid wood residues from sawmill wood processing and packaging production (soft non-coniferous wood), adequate lower heating value was adopted depending on wood species, and amounts by certain wood species are obtained based on the questionnaire described in the chapter *Method of work*.

For other wood fuel types (briquettes, pellets, sawdust) total energy value was calculated pursuant to the same principle as for fuelwood by multiplying the consumed amounts with their minimal calorific value expressed in kWh/tonne (chapter *Method of work*).

Collective overview of energy value of consumed wood fuels in the heating season 2010/2011 in Serbia is given in tab. 2.

**Table 2. Collective overview of energy value of consumed wood fuels in the heating season 2010/2011 in Serbia**

Wood fuel type	Measurement unit	Consumed amount	Inferior calorific value in kWh/mes.unit	Total energy value in kWh	Total energy value in toe
Fuelwood	m <sup>3</sup> solid wood	6,360,788	2,311	14,699,781,068	1,263,954
Solid residues of hard non-coniferous wood	m <sup>3</sup> solid wood	34,661	2,609	90,430,549	7,776
Solid residues of soft non-coniferous wood	m <sup>3</sup> solid wood	11,553	2,007	23,186,871	1,994
Solid residues of coniferous wood	m <sup>3</sup> solid wood	7,382	1,904	14,055,328	1,209
Solid residues (mixed coniferous and non-coniferous wood)	m <sup>3</sup> solid wood	2,309	2,027	4,680,343	402
Sum of fuel wood and solid residues	m <sup>3</sup> solid wood	6,416,693		14,832,134,159	1,275,335
Wood briquettes	tonnes	13,189	4,550	60,009,950	5,160
Wood pellets	tonnes	7,722	4,680	36,138,960	3,107
Sawdust (mixed coniferous and non-coniferous)	tonnes	4,172	3,144	13,116,769	1,129
TOTAL				14,941,399,838	1,284,731

Source: [10, 12]

Based on questionnaire results and performed calculations it can be concluded that total amount of consumed energy from wood fuels in households in the heating season 2010/2011 was 1.28 million tonnes of oil equivalent (Mtoe). This amount is 4.6 times higher than the value of energy from fuelwood which is contained in the energy balance of the Republic of Serbia for 2009 (0.28 Mtoe<sup>\*</sup>) [15]. The main reason for such a large difference between the values contained in energy balance and actual value of consumed energy from wood fuels in Serbia results from the lack of data on overall consumption of wood fuels. Namely, official statistics calculates energy value of fuelwood only from officially registered amounts, mostly from state forests. However, the largest part of fuelwood amounts produced

\* This value include households, tertiary sector (schools, hospitals), industry, and others

in private forests as well as fuelwood amounts outside forests are not recorded, thus they could not be included in the earlier official Serbian energy balance.

According to Serbian energy balance for 2009 gross final energy consumption in households in Serbia was 2.291 Mtoe with the contribution of energy from wood fuels in the amount of 0.225 Mtoe [15].

As the calculated values of energy from wood fuels in this research (1.28 Mtoe) refer to the heating season 2010/2011, they cannot be compared to the value from energy balance for 2009. However, taking into consideration above-mentioned statements and facts, it can be concluded that the participation of energy from wood fuels in Serbia in gross final energy consumption in households is very high, and much higher than previously estimated.

On the other hand, if the stated amounts of energy from fuelwood (1.263 Mtoe) (without solid residues, briquettes, pellets and sawdust) are calculated per single household (879,734 households were included in the calculation which used fuelwood and solid wood residue or their combination with coal) average consumption in the amount of 1.44 toe is obtained. Relatively high average consumption of wood energy mostly results from the following factors:

- wood as fuel is used in most rural households all year round for various purposes (heating, food preparation, brandy distilling, *etc.*), as well as in a number of urban households for food preparation. Since there are 1.04 million rural households in Serbia and they mostly use wood fuels, it is understandable that consumption of wood energy per household compared to other heating systems (*e. g.* district heating systems which operate 6 months in a year maximum) has to be higher,
- efficiency of combustion devices used in households which use wood and wood fuels is extremely low, thus heat losses are very high. Detailed research on the presence and efficiency of certain combustion devices in Serbian households were not done for the purpose of this paper, but the given statement represents personal observation of the author based on field research of wood fuels consumption in Serbia when many households were visited in various Serbian regions,
- energy efficiency of residential facilities in individual households is significantly lower than of residential facilities heated from district heating system, which also contributes to the increased consumption of wood energy, and
- other factors should be added to the stated factors as well so that all together they could represent a good basis for the continuation of the research in the area of energy efficiency in Serbia.

However, in order to check the obtained values of average energy consumption from fuelwood per household in the amount of 1.44 toe, it was transformed into cubic meters of stacked fuelwood by using the adopted inferior calorific value of wood in the amount of 2,311 kWh/m<sup>3</sup>. In that sense, average consumption of wood per household was 7.3 m<sup>3</sup> solid wood or 10.4 stacked m<sup>3</sup>, which fully corresponds to the situation present in practice in Serbian households. As additional check of the stated amount, its comparative analysis with average consumption of fuelwood per household in Slovenia was performed. Pursuant to [4], average consumption of wood energy for heating per household was 1.28 toe, which indicates that the consumption of wood energy per household in Serbia is bigger by 12.5%. Having in mind above stated factors for Serbia as well as the level of average income per household in Serbia and Slovenia, higher consumption of wood energy per household in Serbia is quite expected. At the same time, it is a signal to the Government and other stakeholders to initiate more efficient measures in the shortest possible period in order to increase energy efficiency in all

spheres, including households. Action Plan for Biomass [16] in force until the end of 2012 does not foresee any stimulating measures for households regarding the increase of energy efficiency and transition from fossil fuels to biofuels, which should be corrected as soon as possible.

### **Consumption of wood fuels in households in Serbia and possible contribution to the climate change mitigation**

Wood is a neutral material from the standpoint of emission of carbon-dioxide and its impact to creation of greenhouse which represents the main cause of global warming. High contribution to environment can be provided by using wood instead of other types of fuels due to much lower quantity of CO<sub>2</sub> emitted in course of their combustion. That is not the case with other types of fuel and especially not with fuel oil and coal.

Consumed quantity of fuelwood in 2010 in Serbia of 6,416.693 m<sup>3</sup> provides 14.8 billion kWh of energy. By combustion of wood, around 444.652 tonnes CO<sub>2</sub> (0.03 kg/kWh) is emitted into atmosphere for that energy quantity. If, instead of fuelwood, coal would be used for the same energy quantity, the quantity of emitted CO<sub>2</sub> into atmosphere would be 4,298,303 tonnes (0.29 kg/kWh) or almost 9.7 times more in regard to fuelwood.

Stated effects clearly show all advantages of wood fuels in regard to their preservation of environment and climate change mitigation.

### **Conclusions**

Based on the results of the conducted research, it can be concluded that wood and wood fuels individually or combined with other fuels represent dominant source of energy for heating households in Serbia. In the heating season 2010/2011, 934,237 households or 37.1% of the total number of households in Serbia used wood fuels, combination wood/coal and combination wood fuels/other fuels. In the structure of wood fuels consumption, fuelwood had dominant participation with 6,360,788 m<sup>3</sup>. Besides fuelwood, in the stated heating season, 55,905 m<sup>3</sup> of large wood residues from wood processing were also consumed, as well as 13,189 tonnes of wood briquettes and 7,722 tonnes of wood pellets. Total energy value of consumed amounts of wood fuels was 1.28 million tonnes of oil equivalent, which gives special significance to wood fuels as well as high participation in gross final energy consumption in households in Serbia. Average consumption of energy from fuelwood calculated for individual household was 1.44 toe, which is equal to the amount of 7.3 m<sup>3</sup> solid wood or 10.4 stacked m<sup>3</sup>. The stated amounts fully respond to the situation which is present in practice in households. However, compared to average consumption of energy from fuelwood in Slovenia (1.28 toe), average consumption in Serbia is 12.5% higher, which is a clear signal to the Government and other stakeholders to undertake measures regarding the increase of energy efficiency and energy savings in as short period as possible.

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