

CONSUMPTION OF WOODY BIOMASS IN INDUSTRY, COMMERCIAL, AND PUBLIC FACILITIES IN SERBIA Present State and Possible Contribution to the Share of Renewable Sources in Final Energy Consumption

by

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This paper is the continuation of the presentation of results obtained in comprehensive researches of woody biomass consumption in Serbia conducted as a part of the TCP/FAO project "Wood energy for sustainable rural development". The previous paper (No. 3, 2011) showed results of wood fuels consumption for households heating and this paper shows their consumption for the needs of industry, commercial and public facilities.

Research results show that total consumption of woody biomass in Serbia in 2010 was 7.41 million m³, out of which 7.03 million m³ was in the form of roundwood and 0.38 million m³ was in the form of wood residue from industry. The biggest consumers of woody biomass (roundwood, chips, residues) are households with the participation of 86.54%, followed by the production of wood-based panels with 4.47% and energy production for own purposes of wood processing companies with 2.96%.

Compared to the officially registered consumption in energy balance in the amount of 0.281 Mtoe, actual consumption of wood energy in Serbia in 2010 was 1.37 Mtoe or 4.9 times higher. Participation of wood energy in final energy consumption in Serbia was 57,300 TJ or 13.6% in 2010.

Current use of wood energy substitutes imports of light heating oil in the value of 1.3 billion € or 650 million € in the case of natural gas substituting. Use of wood fuel prevented emissions of about 7 million tonnes of CO₂ from fossil fuels.

Key words: woody biomass, consumption, energy, balance

Introduction

Woody biomass in Serbia has a wide range of users starting from the traditional manner of usage for heating in households and numerous commercial facilities (restaurants, meat roasters, bakeries, car repair services), public facilities (schools, ambulances, health-care centers) to industrial companies which produce wood biofuels (pellets, briquettes, wood chips) and wood-based panels. Such a wide specter of users is a result of, the one hand long

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tradition and relatively easy availability of woody biomass that Serbia has and new trends in the production of energy from renewable sources, as well as of sudden expansion of wood consumption as a natural material for the production of numerous products on the other. Here, the term woody biomass most often implies wood for energy production. However, consumption of woody biomass for non-energy purposes such as the production of wood-based panels, wood biofuels, lime, and other products is also present practice in Serbia. For that reason, why analyzing production, consumption and development of woody biomass market, both components (energy and non-energy) have to be taken into consideration because woody biomass appears in the same starting form in numerous segments of its consumption. Thus, for example, small-diameter roundwood is used for energy purposes (heating, lime production*, pellets production) as well as for industrial production of wood-based panels. The second reason why the stated analyses have to observe both segments together is the fact, that development of production and consumption in one segment has direct impact on the offer, demand and prices of woody biomass in the other segment and *vice versa*. This implies the fact that woody biomass market in Serbia has become unified, regardless of the segments in which it is used.

Scope of work and objective

Scope of research in this paper is woody biomass consumption in Serbia. The main objective of this paper is the determination of total woody biomass consumption in quantitative and energy values and the related participation in total final energy consumption in Serbia. Special objective of the paper is the research, analysis and characteristics of the certain consumer categories participation in total consumption and the related determination of total woody biomass consumption for energy and non-energy purposes in Serbia.

Such structured special objective of the paper according to its form and contents has not been the subject of research in Serbia so far. That adds a great significance to the endeavors to get an answer to the question how big is actual woody biomass consumption in Serbia, which will be based on scientifically relevant and practically grounded indicators.

Method of work

In accordance with the scope of the work and objectives, adequate methodological concept is defined with the aim to get primarily relevant and reliable data on practical woody biomass consumption and then, by using of WISDOM methodology and adequate GIS software packages, to perform their analysis, mapping, table, and graphic representation. One of the most significant elements of the adopted methodological concept was field research which was conducted in industrial wood processing companies, wood-based panel production companies, lime production companies and wood fuels production companies (charcoal, wood chips, wood briquettes and wood pellets) by using questionnaire method (with appropriate questionnaires). Apart from the above-mentioned, field research was also conducted in numerous commercial facilities (restaurants, bakeries, meat roasters, car repair services, tourist facilities) and public facilities (schools, health-care centers, ambulances and Serbian Orthodox Church facilities). Number and structure of woody biomass consumers

* Limestone (calcium carbonate) is heated with wood to produce calcium oxide

among which field research was conducted was as follows: 4892 school facilities, 112 health-care centers, 168 bakeries, 111 meat roasters, 153 car repair services, 193 restaurants, 81 lime-burning factories, more than 1000 facilities of the Serbian Orthodox Church, 3 factories of wood-based panels, 378 companies for sawn timber production, 42 producers of wood packaging, 34 producers of wood pallets, 41 producers of wood briquettes, 11 producers of wood pellets, 5 producers of wood chips, and 173 producers of charcoal. This way, the research involved all most significant groups of woody biomass consumers in all Serbian regions with the purpose to obtain the overall image of its total consumption and participation of certain consumer categories.

Research of woody biomass consumption by the stated consumer categories involved time period from September 15, 2010, until the end of June 2011. A part of the research was done within the questioning of households regarding to the consumption of wood fuels for heating purposes and the largest part was implemented through direct visits to the stated consumer categories. To that effect, users (consumers) of woody biomass on 225 locations (places) were visited in their regions in Serbia and for that purpose 17,648 kilometers were travelled.

For the purpose of calculating values of tonnes 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 for the consumption in health care centers, schools, car services, restaurants, religious objects, bakeries, grills and energy for internal purposes of industry, 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 abovementioned 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: mixed non-coniferous (hardwood and softwood) species 2,311 kWh/m³, non-coniferous solid hardwood sawmill residue 2,641 kWh/m³, non-coniferous solid softwood sawmill residue 2,007 kWh/m³, coniferous solid sawmill residue 1,904 kWh/m³, solid mixed sawmill residue (non-coniferous and coniferous) 2,027 kWh/m³, sawdust (mixed coniferous and non-coniferous) 3,144 kWh/tonne (moisture = 35%), wood briquettes 4,550 kWh/tonne (moisture = 10%), wood pellets 4,680 kWh/tonne (moisture = 8%) [1].

By using of such defined methodology, obtained results with adequate analyses and discussion are presented hereafter.

Research results and discussion

Current state on the market of wood fuels in Serbia is characterized by the fact that for purpose of heating in households in Serbia the following types of wood fuels are used: fuelwood, wood briquettes and wood pellets. In the district heating systems the wood briquettes, and wood pellets are used, and in the restaurants and butcheries (which offer the grill service) charcoal is used. Furthermore, charcoal is also used in blacksmith's workshop. Beside the above-mentioned, firewood is largely used for the purpose of heating schools and religious facilities as well as facilities within Serbian health care system (health care centers, ambulances, hospitals) [2].

Needs of numerous bakeries, meat roasters, and for lime production represent a special segment of firewood usage. Wood chips is the only type of wood fuels which is not used for heating purposes yet, however it is used for the production of wood based panels and wood pellets. However, ongoing activities primarily on local self-governments level in certain towns (Majdanpek, Nova Varoš) indicate that changes can be expected soon in this segment, especially regarding to its utilization for the needs of district heating systems.

Woody biomass consumption for heating in households

For consumption of woody biomass (wood fuels) for household purposes was given detailed elaboration in the paper by Glavonjić [2]. According to the results from the stated paper, total consumption of woody biomass for heating purposes in households in Serbia in the heating season 2010/2011 was 6,416,693 m³, out of which 6,360,788 m³ was firewood and 55,905 m³ was solid wood residue from sawmills and packaging production [2].

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.

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). Average energy consumption from fuelwood per household was 1.44 toe [2]. Pursuant to [3] average consumption of wood energy for heating per household in Slovenia was 1.28 toe, which indicates that the consumption of wood energy per household in Serbia is larger by 12.5%. The situation is also similar with wood energy consumption in households in Slovakia [4].

Woody biomass consumption in combined heat and power plants (CHP)

In Serbia there are no constructed CHP plants for co-generation of electricity and heat from woody biomass so it is not being used for that purpose in the moment. The situation is such even beside the fact that the Government of the Republic of Serbia has adopted feed-in tariffs for electricity generation from biomass as an incentive.

Reasons of non-using of this governmental suitability are numerous. The most significant are a large number, complexity, and long time consuming procedures for obtaining permits and approvals for plants construction. At the moment, it is taking 1.5-2 years only to conduct the procedures for obtaining all prescribed approvals and permits [5].

Beside the stated feed-in tariffs for electricity generation [6], drafting of the new Action plan for renewable energy sources (APRES) for the period 2012-2020 is ongoing, where the list of stimulating measures is expected to be wider as well as the definition of new proposal for reducing and simplification of procedures for obtaining required permits for constructing of plants for energy generation both from biomass and other renewable energy sources, which should have a positive impact on future investments in this area.

At the moment of APRES drafting, there is an initiative within the Public Enterprise "Beogradske elektrane" (district heating plants) on the need to construct a CHP plant using biomass on the territory of Belgrade. Having in mind the usual slowness, resulting from complicated decision making procedures for producing the required studies and projects concerning public enterprises, it is not certain when will this initiative get elements of practical implementation.

Woody biomass consumption for biofuels production

The largest amounts of woody biomass in 2010 were used for firewood production. 382.3 thousand m³ were used for the production of other wood fuels (charcoal, wood pellets, briquettes and wood chips) (fig. 1).

After firewood, charcoal is the second most important wood fuel, because 63% of woody biomass consumed for the production of biofuels is used for its production. The largest part of woody biomass used for this purpose originates from forests, however in south west and west Serbia wood from orchards, village enclosures and large wood residue from sawmill industry are used a lot.

Wood pellets take the second position according to the use of woody biomass for other fuels. The main source of wood biomass for pellets production is roundwood (63%) followed by wood chips and wood residues from industry. High participation of small-diameter roundwood in the production of wood pellets results from the consumption of the largest factory for wood pellets production which meets about 80% of its raw material needs. Several other factories for wood pellets production use firewood in smaller amounts, while others use only sawdust or the combination sawdust/wood chips.

Year 2010

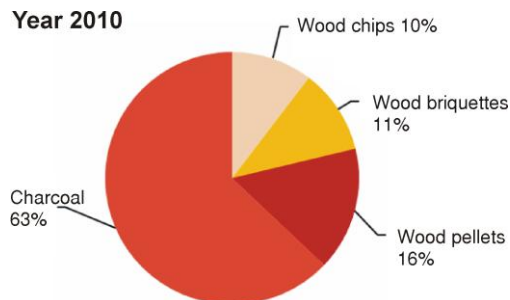


Figure 1. Percentages of non-firewood/other wood fuels in total consumption of woody biomass for their production [7]

Woody biomass consumption for industry, commercial, and public buildings purposes

The most significant segments in which woody biomass is used are: production of wood based panels, energy generation for internal needs of wood processing industry, lime production, bakeries, meat roasters, schools, facilities of Serbian Orthodox Church, restaurants, facilities in health care system and car repair services. Total consumption of woody biomass in stated segments in 2010 was 615.9 thousand m³, out of which 25.9 thousand m³ in the form of wood chips and the rest in the form of firewood, long-length roundwood and large-sized residues from sawmills [8]. These data refer only to mentioned users from sample (see the chapter *Method of work*).

The biggest part of woody biomass amounts is used for the production of wood based panels, followed by energy generation for internal needs of industry, schools, and lime production (fig. 2).

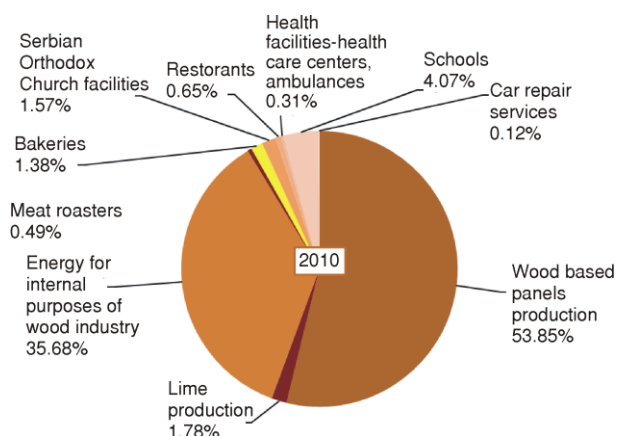


Figure 2. Participation of certain consumers in total woody biomass consumption for other purposes in 2010 [7]



Picture 1. Woody biomass for the needs of particleboard production (photo by B. Glavonjić, 2011)

wood, long-length roundwood, wood chips and sawdust (picture 2). Depending on the installed technology, long-length roundwood is dominantly present in one and small-diameter roundwood in the other particleboard factory, while the hardboard factory dominantly uses small-diameter roundwood of 1 m length.

Particleboards are produced in two large factories with capacity of about 0.5 Mm^3 per year, and hardboard is produced in one factory with capacity of $40,000 \text{ m}^3$ per year. Since all three factories are in the phase of achieving of full capacity after general overhaul or construction, it is realistic to expect the increase of their consumption of woody biomass (picture 1) in the following years above the level they had in 2010.

The most significant forms of woody biomass for the consumption in the industry of wood based panels are small-diameter round-



Picture 2. Woody biomass in the form of firewood for hardboard production (photo by B. Glavonjić, 2011)



Picture 3. Brick-built lime-burning factory in the village Veliki Šenj (photo by B. Glavonjić, 2011)

In energy generation for internal needs of wood processing industry, woody biomass in the form of sawdust and large wood residue is used. Such produced energy is mostly used for the purpose of production plants heating, wood drying, and steaming. Boilers which burn woody biomass are used for heat generation. Installed capacity of boilers in sawn timber production, wood packaging and pallets production (companies from sample) is 149.6 MW, where most boilers are very old and used with very low degree of efficiency [7].

The third most significant form of woody biomass consumption in this segment is lime production. It is done in a traditional manner by using of wood for burning of stone (picture 3). Total consumption of woody biomass for lime production in Serbia in 2010 was $11,000 \text{ m}^3$ [7]. Form in which is woody biomass used for this purpose with the highest participation is the so called wood waste from forests (branches, buttresses, tops), while firewood is used in a smaller scale. Beside the above-mentioned, there are several lime-burning factories where the combination of sawdust and the so called wood waste from

forests is used. The main reason why firewood is not used in significant quantities for these purposes is the fact that lime producers are at the same time sellers of firewood for market requirements because it is more profitable for them to sell it, as to use it for lime kilning [9].

In Serbia there are 81 lime-burning factories and they are all active in lime production. The only difference is that in some of them production is done all year round, while in others the production is occasional depending on demand. Results of conducted surveys showed that the greatest number of lime producers is in Šumadija county in Central Serbia, followed by Zlatibor, Morava, Kolubara and Toplica counties (fig. 3).

Common characteristic of all lime producers is that the lime-burning factories were erected in villages in the proximity of quarries from which raw material for baking of lime is delivered. Lime-burning factories vary in sizes and capacities, as well as in needs for wood in one cycle. The most dominant lime-burning factories in Serbia have the capacity of 2, 5, and 15 tonnes of lime in one cycle which lasts from 1-13 days.

Depending on the capacity of lime-burning factories, various quantities of wood are required for one cycle. They range from 5-40 stacked m³ per one cycle.

For the needs of bakeries and meat roasters in Serbia in 2010, 11,500 m³ of woody biomass was spent, mostly in the form of firewood and in smaller amounts in the form of large wood residue from sawmill industry (primarily for big meat roasters) [7].

Two big meat roasters are situated in Leskovac and in the village of Gornja Sabanta near Kragujevac. Amounts of meat roasted in these meat roasters range from 14-15 tonnes per meat roaster on annual level.

Beside woody biomass in the form of wood, wood briquettes are also used for the needs of bakeries. Therefore, bakeries represent an important segment of consumers for many producers of wood briquettes in Serbia.

The survey conducted in Kragujevac included 18 bakeries which use wood, wood briquettes, gas, and electric energy for their requirements. Analysis of profitability of selected fuels was conducted for the quantity of 1,000 loafs of bread weighting 600 grams. The results of the analysis are presented in tab. 1.

The results of the analysis show the multiple advantages of wood fuels, primarily fuelwood and wood briquettes compared to gas and electricity. Thus, the production costs of 1,000 loafs of bread using fuelwood are lower by 55.6% compared to gas, and 54.7% compared to electricity. That fact why a large number of bakeries in Serbia use wood and wood briquettes for their requirements should not be surprising, because the costs of

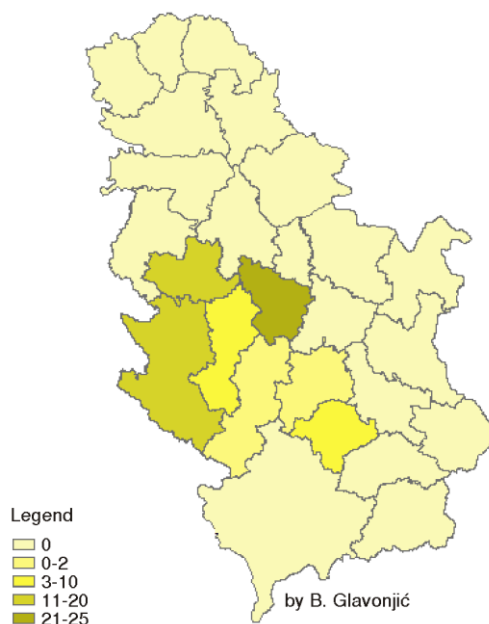


Figure 3. Geographic distribution of the presence of lime-burning factories in Serbia [7]

production are significantly lower compared to bakeries on gas or electricity, which makes their profitability and competitiveness significantly higher.

Table 1. Costs of production of 1,000 loafs of bread weighting 600 grams by using various types of fuel in bakeries in Kragujevac

Type of energy product	Measurement unit	Required quantity of energy product per measurement unit	Price of energy product (EUR per measurement unit)	Costs of production of 1,000 loafs of bread in EUR
Wood (beech moisture = 30%)	Stacked m ³	1	30	30
Wood briquettes	Tonnes	0.4	80	32
Gas	Normal m ³	193	0.35	67.55
Electricity	kWh	1840	0.036	66.24

Sources: Entrepreneurs for sales of fuelwood in Kragujevac; Elektrošumadija AD, Kragujevac; Srbijagas AD Novi Sad; Selected bakeries in Kragujevac

The survey conducted in Belgrade included the sample of 11 grills as the inherent part of which offer “free” service of roasting meat (barbecue) bought in butcheries. All 11 grills used charcoal as the main energy product. Daily consumption of charcoal on the selected sample ranged from 75-90 kg depending on scope of work, *i. e.* quantity of meat roasted during the day. Usual quantity of meat roasted daily in these grills ranged from 450-500 kg, which means that for 6 kg of meat 1 kg of charcoal is used. The price of 1 kg of charcoal was 0.32 € which means that the share of charcoal as energy product in costs of roasting of 1kg of meat was 0.053 € *i. e.* 5.3 c€. This amount of costs is really negligibly low and does not represent more significant costs for butchery owners. When other costs are added to costs of charcoal (labor force and equipment) which are on a very low level in Serbia, it is not surprising that almost every bigger butchery in Belgrade offers services of meat roasting.

Based on conducted analyses we can conclude that wood fuels are very competitive compared to other types of energy products for purposes of bakeries and grills in Serbia which enables their owners to realize high level of profitability.

For the purpose of this paper the survey was conducted about the consumption of fuel in all school buildings in Serbia, as well as the consumption of fuel in health care buildings (health centers).

The surveying of 4,892 school buildings in 24 districts in Serbia was conducted. Out of that number, 2,324 school buildings are

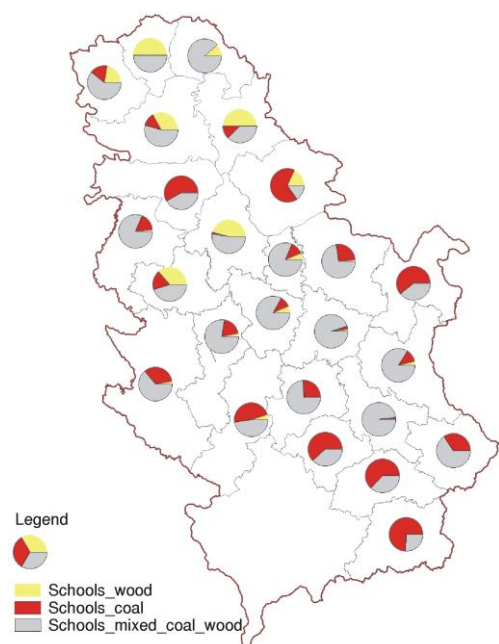


Figure 4. Geographical distribution of school facilities in Serbia which use wood, coal, and wood/coal combination for heating in 2010/2011 [7]

using coal or combination coal/wood for purpose of heating (fig. 4). Total quantity of coal consumed in these buildings in the heating season 2010/2011 was 37,837 tonnes as well as 25,067 m³ of firewood.

Following trends in Western European countries, especially in Italy, numerous pizzerias in towns of Serbia especially emphasize in their offer that pizza is baked using beech-wood [10]. Reasons are the same as for the grills. That is why the market of split beech-wood of 0.5 m and 1.0 m in length is slowly being established in the towns with the request to be dried to the level of transport dry wood (approximately 25%). A Higher humidity level causes problems in obtaining of optimal temperature for baking pizzas, which also reflects on their quality.

Total consumption of woody biomass in Serbia

The calculations showed that total consumption of woody biomass in Serbia (without industrial roundwood) in 2010 was 7.41 Mm³, out of which 94.94% (7.03 Mm³) was woody biomass in the form of wood (firewood, long-length roundwood, branches, buttresses, tops). Participation of the second two types is significantly lower, especially of sawdust which participates with 0.75% in the total consumption of woody biomass, while the participation of large residue from industry was 4.31% or 319,300 m³. Participation of certain users in total consumption of firewood and large wood residue from industry and forestry is presented on fig. 5.

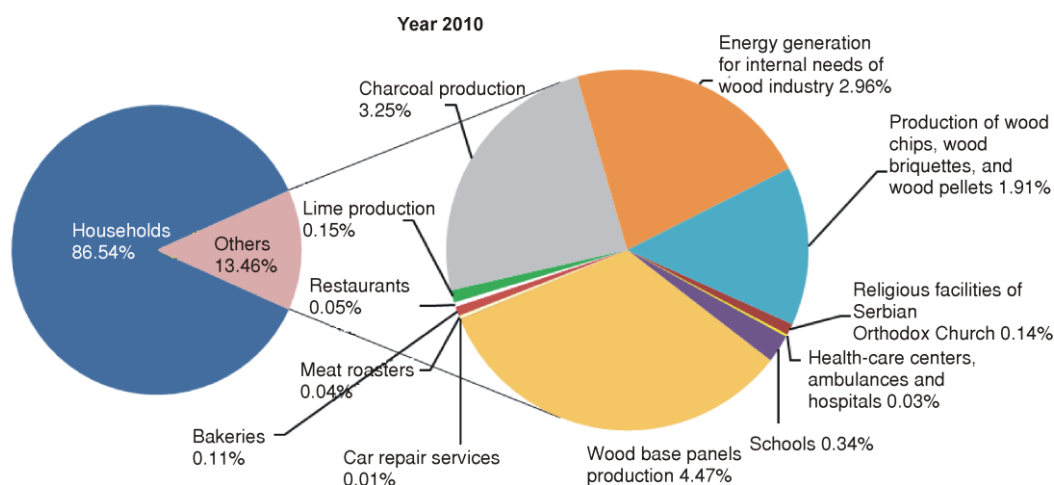


Figure 5. Participation of households and other users in total consumption of firewood and large wood residue from industry and forestry in Serbia [7]

In the category of other consumers, the largest consumption of small-diameter roundwood is realized in the segment of wood-based panels (particleboard and hardboard) and charcoal production, followed by energy generation for internal needs of wood industry companies, production of wood chips, wood briquettes and wood pellets, and heating of school facilities (fig. 5).

Woody biomass and its participation in total final energy consumption in Serbia

Energy value of consumed woody biomass (wood fuels) in households and other consumers in the heating season 2010/2011 was calculated based on the consumption of certain types of wood fuels for each county individually. For calculating energy value of consumed fuelwood, lower calorific value of wood was adopted in the amount of 2,311 kWh/m³ solid wood. This calorific value refers to calorific value of non-coniferous wood at moisture content of 35% and includes calorific value of high- and low-density 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 insignificant (about 1% compared to the total amount of fuelwood consumed in households and other consumers without wood based panels production), the adopted inferior calorific value is representative for calculating total energy value of fuelwood. Adopted moisture content of 35% is average moisture content of fuelwood which is mostly present in practice.

For calculating energy value of large wood residues from sawmill wood processing and packaging production (low-density non-coniferous wood), adequate inferior calorific value was adopted depending on wood species, and amounts by certain wood species are obtained based on results of the survey.

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.

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 for energy purposes (all consumers)

Wood fuel type	Measurement unit	Consumed amount	Total energy value in kWh	Total energy value in toe
Fuelwood	m ³ solid wood	6,414,303	14,823,454,233	1,274,587
Residues from wood industry and forestry	m ³ solid wood	281,129	700,902,010	60,267
Wood briquettes	tonnes	29,087	132,645,850	11,405
Wood pellets	tonnes	9,872	46,200,960	3,973
Charcoal	tonnes	27,603	224,676,216	19,319
TOTAL			15,927,879,269	1,369,551

Sources: Questionnaire results; Author's calculations

Graphic representation of certain types of wood fuels in total consumption of wood energy in 2010 is given in fig. 6.

Basing on this study's results and performed calculations it can be concluded that total amount of consumed energy from wood fuels in households and other consumers in the heating season 2010/2011 was 1.37 Mtoe. This amount is 4.9 times higher than the value of energy from fuelwood which is contained in the energy balance of the Republic of Serbia for 2010 (0.281 Mtoe) [11]. 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 is a result of the lack of data on overall consumption of wood fuels. Namely, official statistics calculates energy value of fuelwood only from officially registered amounts out of which mostly in state forests. However, the largest part of fuelwood amounts produced in private forests as well as fuelwood amounts outside forests are not recorded, thus they could not be included in Serbian energy balance.

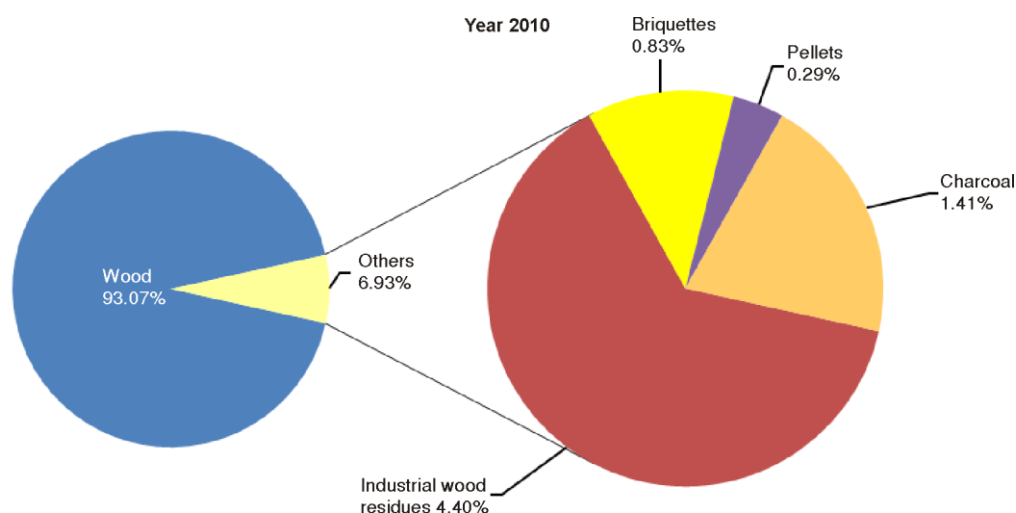


Figure 6. Participation of certain types of wood fuels in total consumption of wood energy in Serbia in 2010

Basing on this study's results and calculations it can be concluded that final consumption of energy for energy purposes in Serbia in 2010 was 421,978 TJ or 10.08 Mtoe with the participation of wood energy in the amount of 57,300 TJ or 13.6% (assuming that the values of other fuels are as presented in the official energy balance) (fig. 7). When obtained values of wood energy consumption from tab. 2 are added to the values of gross final energy consumption (GFEC) from the Serbian energy balance for 2010 (411,440 TJ or 9.83 Mtoe) (deducing the values of wood energy included in the official balance), the result of GFEC in the amount of 456,982 TJ (10.92 Mtoe) in 2010 is reached. Participation of wood energy in GFEC was 57,300 TJ or 12.5%.*

This means that wood energy has a significant position and role in satisfying of energy needs in Serbia. Due to the lack of reliable data this role is extremely underestimated.

On the other hand, taking into consideration the amount of woody biomass used for energy purposes in Serbia (7.08 million m³) in the form of firewood, long-length roundwood and solid residues from industry and forestry, as well as its consumption for non-energy purposes (production of wood-based panels) (0.33 Mm³), it can be concluded that the consumption of firewood and long-length roundwood has reached its peak.

* It should be take into consideration that there are differences between Gros Final Energy Consumption and Final Energy Consumption (please see Energy balance of the Republic of Serbia 2010 [11])

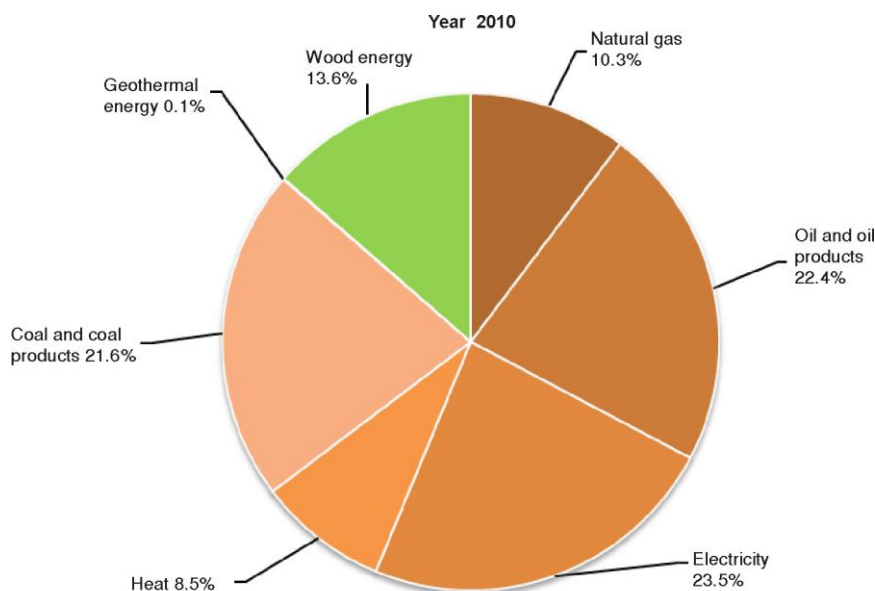


Figure 7. Participation of certain fuel types in total final energy consumption for energy purposes in Serbia (according to the TCP/FAO project)

Such a conclusion is result of the fact that annual increment in Serbian forest fund is 9.08 Mm^3 , annual allowable cut is even smaller and that wood consumption should not exceed level of annual allowable cut, in order not to jeopardize the principle of sustainability. About 1.4 Mm^3 of woody biomass can be used out of forest, from areas covered with trees. Taking into consideration woody biomass consumption level as well as annual allowable cut in forests and 1.4 Mm^3 of woody biomass out of forest annually, it can be concluded that the principle of sustainability in forestry has not been yet jeopardized [12]. If this trend of woody biomass consumption in Serbia continues, it could be expected, that in the near future missing woody biomass quantities will be imported.

Current use of wood energy substitutes imports of light heating oil in the value of 1.3 billion € or 650 million € in the case of substituting of natural gas (done calculations are based on the prices of light heating oil of 0.9 EUR per liter and 0.47 EUR per m^3 for gas) [7].

Usage of wood fuels prevented emissions of about 7 million tonnes of CO_2 from fossil fuels. The theoretical value of these carbon emission currently is 55 million € (8 € per tonne, November 2011) [7].

Conclusions

Wood energy consumption is much higher than anticipated in energy and forestry statistics. Survey results indicate that the total amount of wood used for energy purposes was 1.37 million tonnes of oil equivalent (Mtoe) in the heating season 2010/2011. This amount is 4.9 times higher than the value reported in the official energy balance of the Republic of Serbia for 2010 (0.281 Mtoe). According to results, wood energy accounts for about 13% of Serbia's total final energy consumption. Future energy scenarios require revision, based on these new data.

Current use of wood energy substitutes imports of light heating oil in the value of 1.3 billion € or 650 million € in the case of substituting natural gas. Usage of wood fuels prevented emissions of about 7 million tonnes of CO₂ from fossil fuels. The theoretical value of these carbon emission currently is 55 million € (8 € per tonne).

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