

## WOODY BIOMASS CONSUMPTION IN MONTENEGRO AND ITS CONTRIBUTION TO THE REALIZATION OF THE NATIONAL 2020 RENEWABLE ENERGY TARGET

by

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*This paper is the continuation of the presentation of results obtained in comprehensive research of woody biomass consumption in Montenegro conducted as a part of the FODEMO/MONSTAT project Wood Fuels Consumption in Montenegro. The previous paper (Thermal Science, No. 2, 2013) showed results of wood fuels consumption for households heating and this paper shows their consumption for the other energy purposes as well as its participation in total final energy consumption in Montenegro.*

*Total consumption of woody biomass for energy and non-energy purposes in Montenegro in 2011 was 1.06 million m<sup>3</sup>, out of which 732.9 thousand m<sup>3</sup> or 69.1% was in the form of firewood and 326.6 thousand m<sup>3</sup> or 30.8% was in the form of industrial roundwood. Additionally, 251 m<sup>3</sup> of woody biomass in the form of wood residue were used for the needs of charcoal producers and households. Apart from this, 423 tonnes of wood briquettes, 948 tonnes of wood pellets, 1039 tonnes of charcoal, 86,193 m<sup>3</sup> of wood residue from industry and 5,254 m<sup>3</sup> of wood waste from construction industry were also used for energy purposes.*

*Total final consumption of wood energy, which includes the consumption of all wood fuel categories, was 7,275.04 TJ or 173,761 toe (tonne of oil equivalent) in Montenegro in 2011, which is equal to the value of 2,020,844,444 kWh. The size of energy values and significance of wood energy is best shown by the fact that wood is the third most important energy-generating product in final energy consumption in Montenegro, just behind petroleum products and electricity. Compared to final consumption of electricity of 12,290 TJ, value of wood energy in the amount of 7,275.04 TJ is 59.2% of electricity consumption.*

Key words: woody biomass, energy, consumption, renewable energy target, Montenegro

### Introduction

The term woody biomass is mostly associated with biomass used for energy. In Montenegro, it has a long tradition of being used for energy purposes mostly in households as well as in numerous public facilities (schools), commercial facilities (restaurants, pubs, bakeries, meat roasters), and industry. However, apart from energy purposes, woody biomass in Montenegro is also used for non-energy purposes, primarily in wood processing companies and for production of other wood fuels (charcoal, wood pellets). Thus, research of total woody biomass consumption should include both mentioned segments. Regarding this, quantification of

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woody biomass consumption is mostly done in terms of physical measurement units in which certain wood fuels are produced, distributed and used as well as in energy measurement units (mostly in TJ, toe or kWh) because of the need to observe the participation of wood energy in energy balances and final energy consumption. The latter approach is particularly intensive in South East European countries as of 2012 when these countries adopted the national target for the participation of energy from renewable sources in total final energy consumption by 2020. The situation is the same in Montenegro too. Therefore, this research has multifold significance from the aspect of the users of results, primarily policy makers in forestry, energy and environmental sectors. It should be mentioned that the results presented in this paper, together with the results presented in the preceding paper Wood Fuels Consumption in Households in Montenegro [1], represent a unity and as such they give a full image of the current situation in the segment of woody biomass consumption in Montenegro.

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

The main scope of research in this paper is woody biomass consumption for energy and non-energy purposes as well as the participation of wood energy in total final energy consumption in Montenegro. To that effect, the goal of the paper is the quantification of the stated consumption in physical and energy measurement units as well as the participation of certain consumer categories in this consumption, their characteristics and significance. Objective of the paper is the research of the contribution of wood energy to the reduction of import dependence of Montenegro in terms of energy as well as its contribution to the mitigation of climate changes through the process of fossil fuels substitution, which are still widely used in public sector in Montenegro. Beside this positive aspects of woody biomass use also other relevant socio-economic and environmental aspects [2] such as job creation should be analyzed in the future to enhance the importance of this sector for rural development.

Foreseen research will include all most significant categories of woody biomass consumers in all municipalities, thus becoming the most comprehensive researches conducted so far in Montenegro. This is of special importance from the aspect of reliability of the obtained results and getting relevant answers to all open issues in the field of woody biomass that exist in Montenegro at the moment.

### **Used methodology**

Adequate methodological concept was used for researching woody biomass consumption and participation of wood energy in total final energy consumption in Montenegro consisting of the following: field research method, method of statistical data processing, statistical evaluation of performed research, and analysis and synthesis method. Adequate GIS software packages and program package STATISTIKA V.5.0 were used for the purpose of mapping and graphic presentation.

The most significant element of the adopted methodological concept is field research, which was conducted in households, public facilities (kindergartens and schools), commercial facilities (bakeries, meat roasters, restaurants, and car repair services), industrial companies and wood fuel producers (producers of charcoal, briquettes, *etc.*) by using questionnaire method with adequate questionnaires and interviewing method.

Used methodological concept is fully compatible with UNECE/FAO and EUROSTAT methodology for collecting, processing and publishing data on woody biomass and wood energy consumption. It is also used in similar researches conducted in the surrounding countries, the last of which was in Serbia in 2011 [3].

In the segment of wood fuels consumption in households, the research was conducted by questionnaire method on the representative sample of 5% of the total number of households which stated to use solid fuels for heating purposes in 2011 census [4]. Total number of the selected households for questionnaires was 6,520, 3,590 of which were urban households and 2,930 were rural households. Questionnaire method included 652 interviewing circles in 21 municipalities in Montenegro. This segment also included collective households\*\*.

In the segment of wood fuels consumption in public facilities, the research was conducted in all schools and kindergartens in Montenegro. Report method was used and the total of 272 schools took part in the research.

In the segment of wood fuels consumption in commercial facilities, the research was conducted by questionnaire method in bakeries, meat roasters, restaurants, and car repair services in all municipalities in Montenegro pursuant to the address book of the Statistical Business Register and actual situation in the field. Total number of processed commercial facilities was 331.

In the segment of woody biomass consumption for industrial own purposes, the research was conducted in 125 companies dealing with primary wood processing in all municipalities in Montenegro by using questionnaire method. Apart from this, the research also involved companies and entrepreneurs dealing with wood fuels production and trade. In 2011, 3 companies were engaged in wood briquettes production and also there were 20 charcoal producers a few of which were registered as entrepreneurs while most of them were registered as agricultural households. In both cases, report method was used which was conducted by filling in adequate questionnaire forms [5].

In order to observe woody biomass market and its competitive position, the method of interviewing wood fuel traders was used as well as the data on wood fuels foreign trade and the data of the biggest distributors of other fuel types (primarily fuel oil, heating oil, and gas fuels) in Montenegro.

Above described manner of data collection provided high incorporation of all segments of wood fuels production and consumption in Montenegro. This way, the largest and most significant wood fuels consumers were included in the research, which made this research representative and the obtained data were made reliable for the needs of various types of analyses.

This statement is confirmed by the evaluation of statistical research in the segment of households, the results of which are given in tab. 1.

Coefficient of variation (CV) on the level of Montenegro, as a parameter of homogeneity of the observed phenomenon (firewood consumption in this case), is 0.0077, which implies that the homogeneity of the observed phenomenon is very high and consequently the accuracy of the obtained results is also high.

The higher the coefficient of variation (closer to one), the lower the homogeneity of the feature (phenomenon) and *vice versa*. In statistical researches, phenomenon is considered homogenous until the coefficient of variation exceeds the limit of 0.3 [7].

## Research results and discussion

Pursuant to the scope, objective and adopted methodology, the most significant results of the conducted research of woody biomass consumption are presented hereafter both by certain consumer categories and collectively on the level of Montenegro.

\* Interviewing circle comprises the list of all households, which are presented on some territory within some municipality as the smallest administrative unit. One municipality contains several interviewing circles.

\*\* Collective households comprise gerontology centres, hostels for single persons and other households, in which live persons that are permanently cared for.

**Table 1. Statistical evaluation of firewood consumption in households in Montenegro in 2011**

Municipality	Total consumption [m <sup>3</sup> ]	Average consumption at the level on sample [m <sup>3</sup> ]	Standard error of the mean [m <sup>3</sup> ]	Standard deviation [m <sup>3</sup> ]	95% confidence interval [m <sup>3</sup> ]		CV
Andrijevica	10837	120.4166	5.845214	526.069279	9806.229	11868.77	0.048542
Bar	26323	73.12036	3.379957	1216.784442	23938.03	28708.63	0.046225
Berane	64712	137.6857	3.773791	1773.681914	61235.3	68189.3	0.027409
Bijelo Polje	83009	133.8857	3.182531	1973.16912	79141.08	86877.21	0.023771
Budva	5259.97	75.14238	5.148227	360.375897	4553.511	5966.422	0.068513
Cetinje	24529	106.6479	3.865491	889.062828	22786.16	26271.87	0.036245
Danilovgrad	23897	95.58877	3.085932	771.483017	22384.83	25409.55	0.032283
Herceg-Novi	13981	69.90385	3.487299	697.459894	12613.52	15348.02	0.049887
Kolašin	20675	147.6792	6.581236	921.373024	18868.89	22481.29	0.044564
Kotor	9144.09	57.15056	2.983168	477.30685	8208.41	10079.77	0.052198
Mojkovac	17129	122.3495	5.335989	747.038509	15664.48	18593.37	0.043613
Nikšić	97926	105.2965	2.135664	1986.167859	94032.19	101819.3	0.020282
Plav	27390	161.1202	7.532059	1280.450035	24880.34	29900.55	0.046748
Pljevlja	48790	97.57933	2.469328	1234.664168	46369.31	51210.01	0.025306
Plužine	7828.55	156.571	8.847616	442.380816	6961.336	8695.761	0.056509
Podgorica	142686	96.40916	1.598929	2366.415599	138046.6	147324.5	0.016585
Rožaje	40248	154.8012	5.993343	1558.269097	37193.58	43303.02	0.038716
Tivat	6137.90	68.19892	3.518768	316.689153	5517.087	6758.718	0.051596
Ulcinj	17426	82.98333	4.239617	890.319656	15681.18	19171.82	0.05109
Šavnik	4781.13	119.5282	4.460274	178.410964	4431.383	5130.872	0.037316
Žabljak	10860	180.9979	11.714892	702.893545	9481.968	12237.78	0.064724
MONTENEGRO	703571	107.9097	0.828574	5402.30519	692980.7	714161.3	0.007678

Source: [6]

### *Wood fuels consumption in households in Montenegro*

Results of the conducted researches on the presence and amounts of fuels consumed in households in Montenegro showed that total firewood consumption in the heating season 2011/2012 (both urban and rural households) was 703,571 m<sup>3</sup>. Average wood consumption in households in the coastal zone municipalities is 3.79 m<sup>3</sup>, in the central zone it is 5.02 m<sup>3</sup> and on the north of Montenegro it is 6.74 m<sup>3</sup> per household. Observed on the level of Montenegro, average firewood consumption per household was 5.49 m<sup>3</sup> and as such it best represents relatively low consumption level in the coastal zone and high consumption level on the north of Montenegro [1].

### *Public facilities*

Schools are the most important category of public facilities regarding wood fuels consumption. Research conducted in the project showed that wood fuels were not present in the heating system for facilities in the health care system in Montenegro or in 125 preschool facilities (kindergartens) [8].

Out of the total of 479 school facilities in Montenegro (including central schools and their regional school departments) 327 facilities or 68% used wood fuels in 2011 (fig.1). Among other fuels, heating oil, LPG, and coal were used for heating purposes.

Regarding wood fuels consumption, firewood is in 2011 was consumed the most in the amount of 5,357 m<sup>3</sup> while other wood fuels are used to a smaller extent. In 2011, wood briquettes were used for the heating purposes of two school facilities, while wood pellets were not present in the system for heating school facilities in 2011 [8]. However, activities conducted during 2012 by the Ministry of Education and Sports of the Republic of Montenegro and certain international organizations will have an impact on the introduction of wood pellets in the heating system of school facilities in Montenegro in the upcoming years.

Although firewood is used for heating 68% of school facilities in Montenegro, its participation in total costs of heating all school facilities in 2011 was only 5.89%. Namely, total heating costs of all school facilities in Montenegro in 2011 were EUR 4.18 million, out of which EUR 3.52 million or 84.2% were costs for heating oil [9]. This means that every year Montenegro allocates large sums of money for importing oil derivatives for the needs of heating school facilities although it has own woody biomass resources which are locally available and several times more competitive in terms of prices and environment protection compared to heating oil and light oil. Environmentally, substitution of heating oil with woody biomass would reduce CO<sub>2</sub> emission in this case by about 9 times [2].

Results of the conducted researches showed that the situation was highly unfavorable regarding the presence of thermal insulation on school facilities. Namely, out of 370 schools in total for which data are obtained, only 56 facilities or 15.1% has thermal insulation while the remaining 314 facilities do not have any form of thermal insulation [8]. Participation of school facilities with and without thermal insulation in total number of school facilities by municipalities is given in fig. 2.

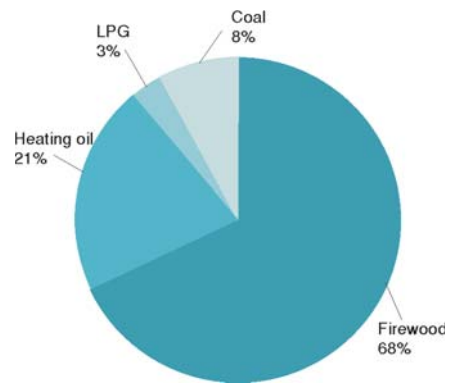


Figure 1. Participation of different fuels used for heating school facilities in Montenegro in 2011 [8]

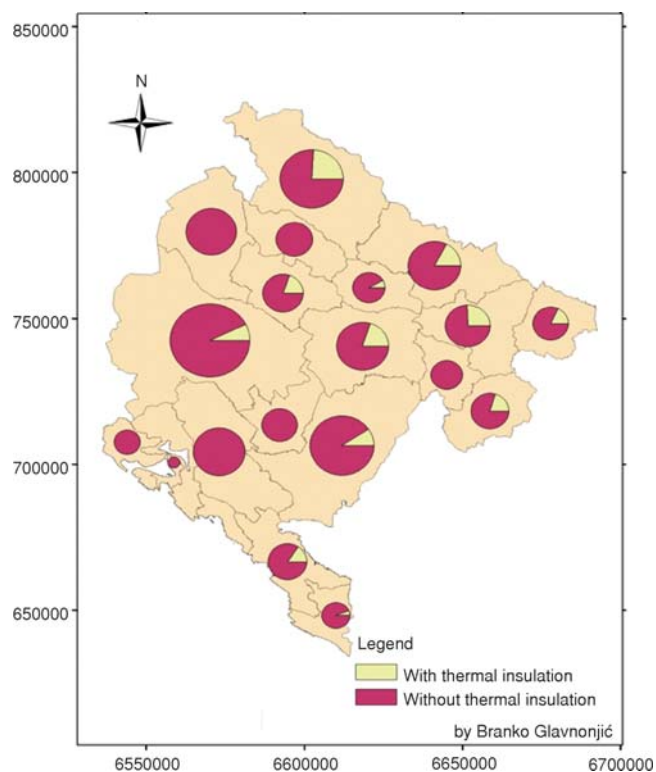
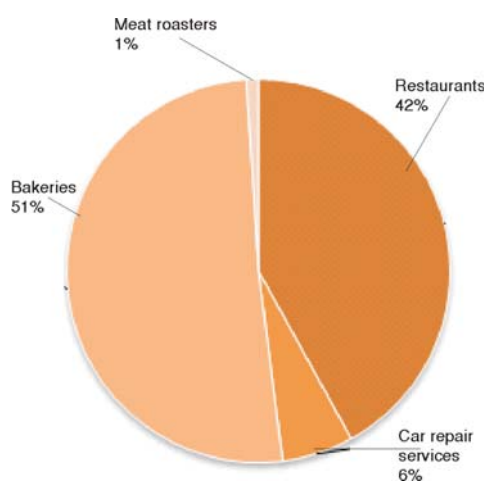


Figure 2. Participation of school facilities with and without thermal insulation in total number of school facilities by municipalities in Montenegro

The situation is also similar with school facilities that have double-glazed windows. Namely, only 59 facilities have insulating glass while other facilities do not have them.

### Commercial facilities

Consumption of wood fuels in facilities with commercial character included restaurants, bakeries, meat roasters and car repair services. Selection of these categories of commercial facilities results from a long tradition of wood fuels use (primarily firewood) in these facilities on one hand and new trends in using certain wood fuel types in these facilities (wood pellets) on the other. Inclusion of commercial facilities in the research made it entirely complete in the sense that all most significant categories of wood fuel consumers in Montenegro are comprised. Thus a full image and overview of the total consumption of wood fuels are obtained, which is certainly an important element of comprehensiveness and representativeness of the research.



**Figure 3. Participation of different consumer categories in total firewood consumption in commercial facilities in Montenegro in 2011 [8]**

The largest consumption of wood fuels in the category of commercial facilities is realized in bakeries and restaurants. In the total of 21.219 m<sup>3</sup> of firewood used for the needs of commercial facilities, bakeries participated with 51% and restaurants with 42.4% (fig. 3).

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Regarding the consumption of slabs as woody biomass form, their consumption was 231 m<sup>3</sup>, 155 m<sup>3</sup> of which were used in car repair services and the remaining 76 m<sup>3</sup> were used in restaurants and pubs. Hotels and restaurants were the most important consumers of wood briquettes and wood pellets in 2011 in the category of commercial facilities, while restaurants and meat roasters were the most significant consumers of charcoal [8]. Firewood is used for baking bread and heating space in bakeries, for heating and meat roasting in restaurants and meat roasters and for heating in car repair services.

Research results showed that fuelwood traders were the main sources for supplying bakeries, meat roasters, car repair services and restaurants with firewood. Traders also represented the main source for supplying meat roasters and restaurants with charcoal.

### Production of wood fuels

The most significant types of wood fuels currently produced in Montenegro are firewood, wood briquettes, and charcoal. Apart from these wood fuels, wood chips are also produced the entire amount of which is exported, while there are currently two lines for wood pellets production (one in Pljevlja and the other in Andrijevica). The line in Pljevlja was not operational yet in early 2013, while the production in the plant in Andrijevica was in the phase of trial production at the beginning of 2013 [10].

The largest amounts of woody biomass in Montenegro are used for firewood production, while 24.353 m<sup>3</sup> were used for the production of other wood fuels in 2011. 85% of this amount was used for wood chips production the entire amount of which was exported and only 3.779 m<sup>3</sup> were used for the production of charcoal and wood briquettes (fig. 4) [10].

The largest amounts of woody biomass used for wood chips production originate from saw-mill wood processing and in smaller scale from forests.

Out of the total of 3,779 m<sup>3</sup> which were consumed for the production of charcoal and wood briquettes, 763 m<sup>3</sup> in the form of small wood residue (sawdust) from industrial wood processing was used for wood briquettes production and 3,016 m<sup>3</sup> was used for charcoal production, out of which 2,765 m<sup>3</sup> were in the form of firewood and 251 m<sup>3</sup> were in the form of large wood residue from forests, orchards and other sources. Practically, only 15% of the total woody biomass consumption for the production of wood chips, briquettes and charcoal remained in Montenegro in 2011 and 85% of it was exported [10].

Charcoal is produced in 23 charcoal kilns, 20 of which are brick-built and 3 are light steel (portable). Most charcoal kilns and the largest amounts of charcoal are produced in Kolašin municipality, followed by Pljevlja and Nikšić [10].

Concerning wood briquettes production, it was realized in three companies in 2011 (Nikšić, Kolašin, and Bijelo Polje) with equipment of modest capacity [10].

#### Woody biomass consumption in industry

Results of the conducted questionnaire among 125 active wood processing companies in Montenegro showed that total amount of industrial roundwood processed in primary wood processing companies in 2011 was 326,649 m<sup>3</sup>, 81% of which or 264,586 m<sup>3</sup> were softwood and the remaining 19% were hardwoods. The largest amounts of processed roundwood originated from state forests (72.4%) while 86,964 m<sup>3</sup> or 27.6% was roundwood from private forests. The amount of industrial roundwood exported in 2011, namely 60,804 m<sup>3</sup> of softwood and 9,879 m<sup>3</sup> of hardwood, should be added to the previously mentioned. This means that total production of industrial roundwood in 2011 was 397,332 m<sup>3</sup>, 325,390 m<sup>3</sup> of which were softwood and 71,942 m<sup>3</sup> were hardwood [10].

In primary wood processing processes in 2011, the total of 119,453 m<sup>3</sup> of wood residue originated, 77,769 m<sup>3</sup> of which were large residue (slabs, edgings) and 41,684 m<sup>3</sup> were small wood residues (sawdust). Out of this amount, only 27,983 m<sup>3</sup> or 23.4% was used for heating purposes of the companies themselves. Certain amounts of large wood residue were placed on the market to local population and other users (30,581 m<sup>3</sup>) and 40,495 m<sup>3</sup> or 33.9% was exported. Poor situation regarding the use of wood residue is additionally aggravated by the fact that 20,394 m<sup>3</sup> were disposed of at waste disposal areas (mostly sawdust) (fig. 5) [10].

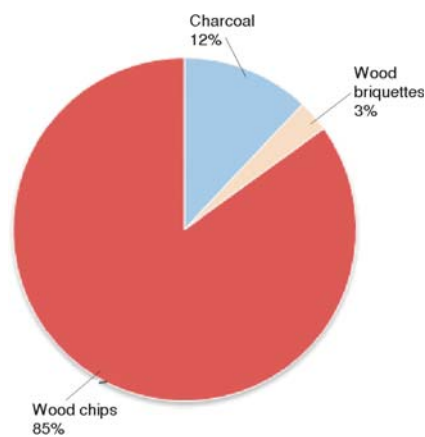


Figure 4. Participation of wood fuel types in biomass consumption for their production in 2011 [8]

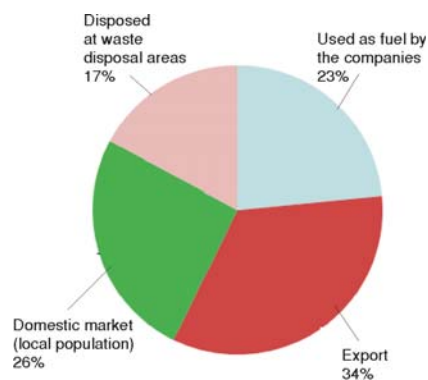


Figure 5. Structure of users of wood residue from industry in Montenegro in 2011 (Sources: [8] and calculations of Prof. Branko Glavonjić)

The stated data show that over 1/2 or to be precise 51% of the total wood residue production in industry was not used at all in Montenegro in 2011. Reasons are numerous, and one of the most significant is the lack of appliances for its combustion as well as poor condition of appliances in the companies that possess them.

Out of the total of 152 companies performing productive activities in 2011, 46 of them did not possess any appliances for woody biomass combustion. Total amount of heat produced for own purposes of the companies was 59.2 million kWh in 2011, the largest amount of which was used for technological purposes (wood steaming and drying) and the rest was used for space heating [10].

The main conclusion that can be made based on the abovementioned analyses is that the condition in the field of using wood residue from industry for own purposes of companies in wood processing industry in Montenegro is unsatisfactory from the aspect of amounts which are used as well as from the aspect of energy inefficiency in the companies where it is used.

#### *Total woody biomass consumption in Montenegro in 2011*

Total woody biomass consumption for energy and non-energy purposes in Montenegro in 2011 was 1.06 million m<sup>3</sup>, out of which 732.9 thousand m<sup>3</sup> or 69.1% was used in the form of firewood and 326.6 thousand m<sup>3</sup> or 30.8% was used in the form of industrial roundwood. Also, 251 m<sup>3</sup> of woody biomass in the form of wood residue was used for the needs of charcoal producers and households (tab. 2).

**Table 2. Total woody biomass consumption for energy and non-energy purposes in Montenegro in 2011**

Woody biomass form	Measurement unit	Amount
Firewood	m <sup>3</sup>	732,911
Industrial roundwood	m <sup>3</sup>	326,649
Wood residue from forests, orchards, <i>etc.</i>	m <sup>3</sup>	251
TOTAL	m <sup>3</sup>	1,059,811

Sources: MONSTAT, Podgorica 2013.; Calculations of Prof. Branko Glavonjić

Amounts of other wood fuels consumed in 2011 on the level of Montenegro are presented in tab. 3.

**Table 3. Total consumption of wood fuels in Montenegro obtained in woody biomass transformation processes in 2011**

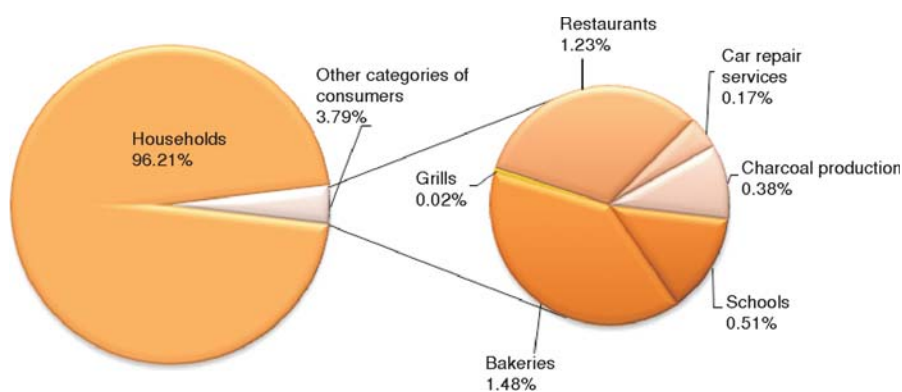
Wood fuel form	Measurement unit	Amount
Wood briquettes	tonnes	423
Wood pellets	tonnes	948
Charcoal	tonnes	1,039
Large wood residue from industry	m <sup>3</sup>	79,498
Small wood residue from industry	m <sup>3</sup>	6,695
Wood waste from construction industry	m <sup>3</sup>	5,254

Sources: MONSTAT, Podgorica 2013.; Calculations of Prof. Branko Glavonjić



Among other wood fuels, the increase of wood pellets consumption is noticeable reaching the level of 948 tonnes in 2011, which is significantly higher than the traditionally present wood briquettes (423 tonnes). If it is taken into consideration that wood pellets are present as fuel in the consumption in Montenegro from 2010, not before, it implies that their increase will be expressed in the upcoming years as well.

Regarding firewood as woody biofuel with the highest participation in woody biomass consumption in Montenegro, results of the researches conducted in the FODEMO/MONSTAT project showed that households represented the most significant consumer category with the participation of 96% in total consumption of this woody biofuel (fig. 6). All other consumer categories share the remaining 4%, where firewood consumption has the highest participation in bakeries (1.48%) and restaurants (1.23%).



**Figure 6. Participation [%] of different consumer categories in total firewood consumption in Montenegro**

(Sources: MONSTAT, Podgorica 2013; Calculations of Prof. Branko Glavonjić)

Households also represent the most significant consumers of wood briquettes and pellets as new forms of woody biofuels although the number of hotels and restaurants switching to these woody biofuels has been significantly increasing for the last two years.

### **Final consumption of wood energy in Montenegro**

#### *Current situation and participation of wood energy in total final energy consumption*

Analysis of the current situation and participation of wood energy in total final energy consumption and its contribution to the achievement of the national target 2020 is done based on the new Wood Fuels Balance for 2011 as well as the Statistical Energy Balance for 2011 for all energy-generating products in Montenegro.

New Wood Fuels Balance for 2011 was made based on the achieved results from the research of consumption, export, import, and production of wood fuels in Montenegro conducted in the FODEMO/MONSTAT project where a new methodology was used, fully compatible with the UNECE/FAO/EUROSTAT methodology.

According to the results of the FODEMO/MONSTAT project, total firewood consumption in Montenegro in 2011 was 732,911 m<sup>3</sup>. Based on the obtained results and conducted

calculations, tab. 4 shows the structure of final consumption of wood energy by certain consumer categories in 2011.

**Table 4. Structure of final consumption of wood energy for energy purposes in Montenegro in 2011**

Consumer categories	TJ	Toe
Industry	209.32	5,000
Civil engineering	–	–
Transport	–	–
Households	6,805.59	162,549
Agriculture	–	–
Other consumers	260.13	6,213
TOTAL	7,275.04	173,761

Source: [11]

Total final consumption of wood energy, which includes the consumption of all wood fuel categories, was 7,275.04 TJ or 173,761 toe in Montenegro in 2011, which is equal to the value of 2,020,844,444 kWh. The size of energy values and significance of wood energy is best shown by the fact that wood is the third most important energy-generating product in final energy consumption in Montenegro, just behind petroleum products and electricity. Compared to final consumption of electricity of 12,290 TJ, value of wood energy in the amount of 7,275.04 TJ is 59.2% of electricity consumption.

Total final energy consumption in Montenegro in 2011 is obtained in the amount of 32,665.04 TJ (tab. 5).

**Table 5. Final consumption of certain fuels for energy purposes in Montenegro in 2011 according to the results of the FODEMO/MONSTAT project and the Statistical Energy Balance**

Consumer categories	Wood fuels	Coal	Electricity	Petroleum products	Total
	TJ				
Industry	209.32	138	7,783	6,175	14,305.32
Transport	–		72	6,446	6,518.00
Households	6,805.59	129	4,435	211	11,580.59
Other consumers	260.13				261.13
TOTAL	7,275.04	268	12,290	12,832	32,665.04

Sources: Results of the FODEMO/MONSTAT project (based on calculations of Prof. Branko Glavonjić); [13]

In that case, participation of wood fuels compared to other energy-generating products in final energy consumption was 22% (fig. 7).

#### *Final energy consumption in Montenegro and the national target 2020*

From the aspect of meeting the national target regarding the achievement of energy participation from renewable sources of 33% in total final energy consumption in 2020, it is sig-

nificant to highlight that the participation of electricity and wood energy in final consumption in 2011 was 60%, 22% of which was wood energy and 38% electricity.

According to the methodology for determining national target for RES 2020 for all south east European countries by the Energy Community, planned gross final energy consumption in Montenegro in 2020 should be 40,256 TJ, where 33% or 13,284.48 TJ should be energy from renewable sources [12].

Total final energy consumption from renewable sources in Montenegro in 2011 corresponded to the consumption of wood energy only in the amount of 7,275.04 TJ, or 54.7% of national target, while 4,334 TJ of electricity produced in hydro-power plants (1204 GWh) was used in transformations (The Statistical Energy Balance, 2012).

Compared to the planned target of 13,248.48 TJ in 2020, “for the missing amount of energy from renewable sources in the amount of 5,973.44 TJ” it is necessary to stimulate production and consumption of energy from other renewable sources (wind, Sun, *etc.*) since the potentials of firewood are already used to a high extent and no significant consumption increases are possible in this segment (the exception is increase of efficiency of wood combustion).

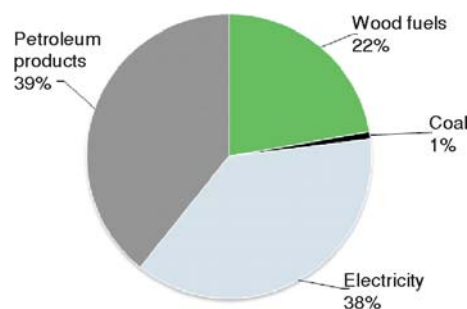
Apart from the significance of wood energy for meeting the national target 2020, it has multiple significance for reducing import dependence of fossil fuels by Montenegro and also contributes the reduction of CO<sub>2</sub> emission. This significance is proved best by the following facts:

- consumption of wood energy in the amount of 173,761 toe is equal to the amount of energy obtained from 203.3 thousand tonnes of heating oil,
- usage of wood energy in the stated amount in 2011 contributed the reduction of import dependence of Montenegro on heating oil by 162,679,462 EUR, calculated with heating oil prices at which it was imported in Montenegro in 2011,
- use of wood energy in the stated amount instead of heating oil directly contributed the saving of CO<sub>2</sub> emission in the amount of 0.5 million tonnes.

Energy obtained from the residues in the process of vine pruning should be added to the stated amounts of wood energy. In 2011, registered consumption of residues from vine pruning for household heating was 1,075 stacked m<sup>3</sup>, which was the energy consumption of 1.9 TJ.

## Conclusions

Results of the conducted research in the stated project clearly show that total consumption of woody biomass for energy purposes in Montenegro is about five times higher than the statistically recorded consumption. Also, wood energy was the third most significant energy-generating product in Montenegro with the participation of 22% in total final energy consumption in 2011. From economic and environmental aspect, wood energy has a significant contribution to the reduction of energy dependence of Montenegro, reduction of fossil fuels import and reduction of CO<sub>2</sub> emission with the substitution of fossil fuels. In the planned 13,248.48 TJ of energy from renewable sources in total final energy consumption in 2020, it is realistic to expect that the partici-



**Figure 7. Participation of certain fuels in total final energy consumption for energy purposes in Montenegro in 2011 according to the results of the FODEMO/MONSTAT project and Statistical Energy Balance**

pation of wood energy will get to almost 60%, which alone points at its extremely high significance for meeting the national target 2020.

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