

Project title: Inventory of wood energy consumption and GHG emissions from wood fuels in  
Vojvodina and East Serbia

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## **Inventory of wood energy consumption and GHG emissions from wood fuels in Vojvodina and East Serbia**

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## **PREFACE**

This report contains the results of the research on wood energy consumption in two selected regions in Serbia: Vojvodina and Eastern Serbia in 2020. The research was implemented between April and June 2021. The project **“Inventory of wood energy consumption and GHG emissions from wood fuels in Vojvodina and East Serbia”** was funded by the FAO organization in accordance with the Project number: TCP/SRB/3801/C1.

The aim of the research on the inventory of wood energy consumption was to collect the data on types, amounts, and values of wood fuels being consumed in the above-mentioned regions in Serbia, as well as GHG emissions from their combustion. In addition, through this research, data on sources of wood fuel supply were collected, as well as the data on appliances used for their combustion.

The research included the most important categories of wood energy consumers: (i) households (urban and rural), (ii) public buildings (schools, health-care centres, ambulances, kinder gardens, local government facilities, etc.), (iii) commercial buildings (restaurants, meat roasters, bakeries, car repair services, shops, business facilities, etc.), (iv) district heating systems, (v) CHP plants, (vi) wood fuels producers (producers of pellets, briquettes, wood chips).

Based on the results of the inventory of wood fuels consumption, the corresponding balance of GHG emissions was developed. The inventory included a calculation of the emissions of carbon dioxide and nitrogen oxides.

This report contains the assessment of the interest of households in planting forests on abandoned agricultural and other bare lands in the selected pilot regions (East Serbia and Vojvodina).

I am grateful to all participants in the project who contributed to the improvement of the existing methodology, and for collecting the data on the consumption of wood energy in the selected regions in Serbia.

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## Abbreviations and symbols

ha	Hectare
Loose m <sup>3</sup> (Bulk m <sup>3</sup> )	Loose m <sup>3</sup> is the unit for the bulk material – typically for wood chips
m <sup>3</sup>	Solid cubic meter. A cubic meter of compact wood is a measurement unit that indicates a volume completely filled with a wood content.
stacked m <sup>3</sup>	Stacked cubic meter. The stacked cubic metre is the unit of measurement used for neatly stacked log woods.
LPG	Liquefied petroleum gas
t	Tonne
kWh	Kilowatt-hour
MJ	Megajoule
TJ	Terajoule
FAO	The Food and Agriculture Organization

## Symbols

Not any = -

Data not available = ...

Data less than 0.5 of the unit given = 0

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## **The Goals of the project**

The main goals of this project were:

- (i) conducting the inventory of wood energy consumption in the selected regions of East Serbia and Vojvodina in accordance with the methodology by using the method of direct surveys of the most important categories of wood energy consumers ((i) households (urban and rural households), (ii) public buildings (schools, health-care centres, ambulances, kinder gardens, local government facilities, etc.), (iii) commercial buildings (restaurants, meat roasters, bakeries, car repair services, shops, business facilities, etc.), (iv) district heating systems, (v) CHP plants, (vi) wood industry,
- (ii) updating the methodology for estimating the current greenhouse gas emissions from firewood combusted in the selected pilot regions of East Serbia and Vojvodina covering all the most important categories of wood fuels, in accordance with the requirements arising from the structure of greenhouse gas balances of biomass.
- (iii) investigating the interest of households for planting the forests on the abandoned agricultural and other bare lands.

## **1 METHODOLOGY APPLIED FOR DETERMINING WOOD ENERGY CONSUMPTION AND GHG EMISSIONS FROM WOOD FUELS IN VOJVODINA AND EASTERN SERBIA**

For realisation and completion of the project goals, the methodology applied comprehended two segments:

1. Conduction of wood energy consumption inventory, and
2. Calculation of the GHG emissions from the wood fuels combustion processes

The methodological concept used within the WISDOM projects in Serbia, Montenegro, Bosnia and Herzegovina, North Macedonia and Albania was adopted in this research as well. Those projects were conducted in the period 2010-2017 by FAO and the corresponding ministries.

The most important elements of the methodology used for the conduction of the wood energy consumption in the inventory in the chosen regions are shown underneath.



Fig. 1. Position of the selected regions on Serbian map

## **1.1 METHODOLOGY APPLIED FOR DETERMINING WOOD ENERGY CONSUMPTION IN VOJVODINA AND EASTERN SERBIA**

The methodological concept implemented to the examination of the wood energy consumption in the selected Serbian regions was developed in a way that it can comprehend all significant consumer categories. It takes into consideration the consumers' size and number. Furthermore, the presence of households in the total (statistical) population was very well reflected in the sample. The data about other consumers' categories were gathered through direct interviewing and covers either all of them, like district heating systems and wood fuels producers), or the vast majority of them (like public, commercial and industrial facilities) in the chosen regions. All of that guarantees a high level of data confidence and relevance for assessing the objective representation of the wood energy consumption in these two regions.

### **1.1.1 Sample and methodology for field survey**

As the basis for determining the sample for interviewing of households were used the results from the census conducted in 2011. This sample could include only those households that use solid fuels for heating.

In the selected methodological approach, the total number of households registered in two selected regions (Vojvodina and Eastern Serbia) in the last census conducted in 2011 was used as the starting point. The selection of such an approach resulted from the fact that it was the only reliable source of data on the households in urban and rural areas by settlements, towns and counties. The second important element of the selected methodological approach referred to the need to conduct the stated research on a county level because of differences among counties in Serbia mostly regarding climate characteristics, household size, the 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.).

Out of the stated number of households, those households using either district heating systems, 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. 2).

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.

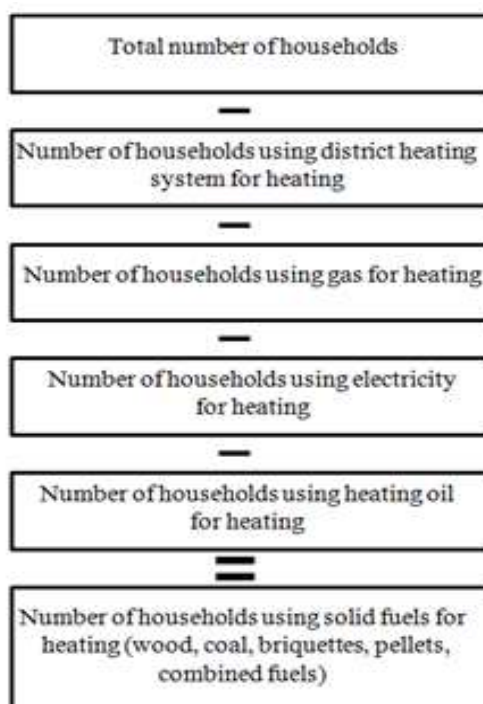


Fig.2. Methodology for determining the number of households that use solid fuels for heating purposes in Vojvodina and Eastern Serbia

For this project, the sample was 1,010 households out of which 701 in Vojvodina, and 309 in Eastern Serbia. The number of the interviewed households per county (divided by urban and other) is given as followed (see table).

	Sample size	Number of urban households	Number of other households
VOJVODINA	701	449	252
West Bačka county	119	66	53
South Bačka county	137	116	21
North Banat county	79	51	28
North Bačka county	115	88	27
Central Banat county	97	61	36
South Banat county	45	19	26
Srem county	109	48	61
EAST SERBIA	309	167	142
Bor county	78	48	30
Braničevo county	70	22	48
Zaječar county	55	29	26
Pirot county	106	68	38
TOTAL (Vojvodina + East Serbia)	Total 1,010	Urban 616	Rural 394

After determining the sample, the following methodological steps were made:

1. To determine the sample size in some counties was used the same percentage as each county had in the total number of households that used solid fuels in both selected regions. The total number of 1,010 households in the sample was multiplied by that percentage and thus was obtained the sample for each county.
2. A sampling of the number of households in particular towns/municipalities within the county was done in the same way. The number of households in the sample in certain towns/municipalities within the county was determined based on a percentage share of the number of households in that town/municipality in the number of households at the level of a county.
3. The division of such sampled households into "urban households" and "other households" was based on a share of those two categories (urban and other) in the total number of households at the level of town/municipality.
4. The selection of households for the sample in each town was random and stems from the database covering over 60,000 households. The software tool used was the programme package "*Statistica V.7.0*". This database contains all information on the consumption of solid fuels for heating, which was necessary to the interviewers for sampling, organisation and conduction of the research. It has been covering this topic for the last twelve years and already used in similar projects conducted in the mentioned period. The households in the database were grouped into urban and other.
5. Each sample of households on the level of a town contained the main and the so-called replacing households. The replacing households were only covered in the cases when some of the main households rejected to participate in the interview. The logic behind the selection of the replacing households was the same as the logic behind the selection of the main households, i.e. random selection was applied for both categories of households.

### **1.1.2 Interviewing of households**

Households were interviewed between April 20<sup>th</sup> and June 15<sup>th</sup> 2021. Interviewing was conducted in urban settlements, and in the two biggest other (rural) settlements in every city/municipality. A total number of 1,010 households were interviewed for the selected regions, as follows:

- Households in urban settlements: 616
- Households in other settlements: 394

The collection of data on wood fuel consumption and characteristics of buildings and appliances for wood fuels combustion was conducted using the appropriate questionnaire.

#### **1.1.3 Interviewing in commercial buildings**

A survey on wood and wood fuel consumption in commercial buildings had the intention to ensure proper geographical distribution in the entire two selected regions. The questionnaire for commercial buildings contains significantly fewer questions than the one for households. 75 commercial buildings were interviewed, mostly from the following categories: bakeries, shops, car repair centres, hair salons, hotels, etc.

#### **1.1.4 Interviewing in public buildings and district heating systems**

For wood fuel consumption research purposes, interviewing included the following:

- District heating systems in 2 local communities;
- 16 administrative buildings;
- 17 health institutions;
- 59 kindergarten and school institutions.

#### **1.1.5 Survey on wood-processing industry and wood fuel producers**

Methodology defined the criteria to interview the largest wood processing companies, i.e. those that produce semi-finished or finished products. This project included 60 industry enterprises. Additionally, 1 CHP plant and 9 wood fuel producers were identified and interviewed (this includes wood chips, wood briquettes and wood pellets).

#### **1.1.6 Data processing**

After interviewing and entering the data into the digital application, the entered data were checked, logical control of consumption in physical measurement units per m<sup>2</sup> of the heating surface was conducted, and then the data were processed, systematized and calculated from the level of a sample to the level of a whole.

### **1.2 CALCULATIVE METHODOLOGY OF GHG EMISSIONS STEMMING FROM THE WOOD FUELS COMBUSTION PROCESS IN THE CHOSEN PILOT REGIONS**

The calculation of the GHG emissions from the wood fuels combustion process in the chosen regions was based on the IPCC 2006 methodology and additions from the corresponding European standards, relevant scientific papers and publications measurements from practice.

The starting equation for calculating the GHG emissions from the stationary wood fuels combustion was the equation from the methodological instructions of IPCC 2006:

$$\text{Emissions}_{\text{GHG, fuel}} = \text{Fuel consumption}_{\text{fuel}} \times \text{Emission Factor}_{\text{GHG, fuel}} \quad (1)$$

where:

Emissions<sub>GHG, fuel</sub> = emissions of a given GHG by type of fuel (kg GHG)

Fuel Consumption<sub>fuel</sub> = amount of fuel combusted (TJ)

Emission Factor<sub>GHG, fuel</sub> = emission factor of a given GHG by type of fuel (kg gas/TJ). For CO<sub>2</sub>, it includes the carbon oxidation factor, assumed to be 1.

Different wood fuels contain different levels of moisture (moisture content- MC). The emission factors are different for different levels of moisture. For the GHG balancing in this project, the emission factor was determined for different wood moisture levels. That was based on the standard EN 16449:2014 and the following parameters:

$$P_{\text{CO}_2} = \frac{44}{12} \times cf \times \frac{\rho_w \times V_w}{1 + \frac{w}{100}}$$

where

$P_{\text{CO}_2}$  is the biogenic carbon oxidized as carbon dioxide emission from the product system into the atmosphere (e.g. energy use at the end-of-life) (kg);

$cf$  is the carbon fraction of woody biomass (oven dry mass), 0,5 as the default value;

$w$  is the moisture content of the product (e.g. 12 (%));

$\rho_w$  is the density of woody biomass of the product at that moisture content (kg/m<sup>3</sup>);

$V_w$  is the volume of the solid wood product at that moisture content (m<sup>3</sup>).

For wood-based products, wood volume content  $V_w = VP \times \text{percentage of wood}$ .

$VP$  is the gross volume of the wood-based product.

The results of the emission factors based on different wood moisture levels are shown in the following table:

Moisture content (%)	Emission factor kgCO <sub>2</sub> per TJ	Moisture content (%)	Emission factor kgCO <sub>2</sub> per TJ
10	104,539	30	118,995
15	106,818	35	125,446
18	108,619	40	133,553
20	109,934	45	143,880
25	113,974	50	157,439

Sources: 1. Author's calculations; 2. EN 16449: Wood and wood-based products - Calculation of the biogenic carbon content of wood and conversion to carbon dioxide; 3. EU Joint Research Centre

For wood pellets and wood briquettes, the emission factor amounts to 98,303 kg/TJ (MC=8%).

The CO<sub>2</sub> emissions from the combustion of wood fuels for certain levels of moisture were calculated by application of the equation (1). For the N<sub>2</sub>O calculations in this project, the IPCC 2006 default emission factor of 4 kg per TJ was taken for all wood fuels and all levels of moisture. The emissions of SO<sub>2</sub> from the combustion of wood fuels are symbolically low. Therefore, they were not separately calculated in this project.



## 2 WOOD ENERGY CONSUMPTION IN VOJVODINA AND EASTERN SERBIA

Overview and characteristics of wood energy consumption in Vojvodina and Eastern Serbia and its counties in 2020. is given based on the conducted interviewing of all major categories of consumers: households, public buildings, commercial buildings, wood fuels producers and wood industry.

### 2.1 Wood fuels consumption in households by region

Within this part of the Report, besides the overview of wood fuels consumption by certain types, there are also presented characteristics of households, their residential buildings and characteristics of their appliances for wood fuels combustion.

#### 2.1.1 Structure and characteristics of households that use solid fuels for heating in Vojvodina and Eastern Serbia

Data on the number of households that use solid fuels for heating in Vojvodina and Eastern Serbia are given in Table 1.

Table 1. Structure of households that use solid fuels for heating in Vojvodina and Eastern Serbia by number of household members

Region	Number of households with the number of household members					
	Total	1	2	3	4	5 and more
<b>Vojvodina</b>	<b>251,492</b>	<b>17,123</b>	<b>53,509</b>	<b>59,217</b>	<b>65,281</b>	<b>56,363</b>
Urban	<b>161,240</b>	9,988	32,819	37,813	44,591	36,029
Other	<b>90,252</b>	7,135	20,690	21,404	20,690	20,333
<b>Eastern Serbia</b>	<b>127,827</b>	<b>7,422</b>	<b>39,585</b>	<b>24,741</b>	<b>22,267</b>	<b>33,812</b>
Urban	<b>68,862</b>	2,474	20,617	14,844	12,370	18,556
other	<b>58,965</b>	4,948	18,968	9,896	9,896	15,257

The most common category of households by the number of members in Vojvodina are households with four members, and in Eastern Serbia with two members. The participation of households with 5 and more members in Vojvodina is 22%, and in Eastern Serbia is 27% (fig.3).

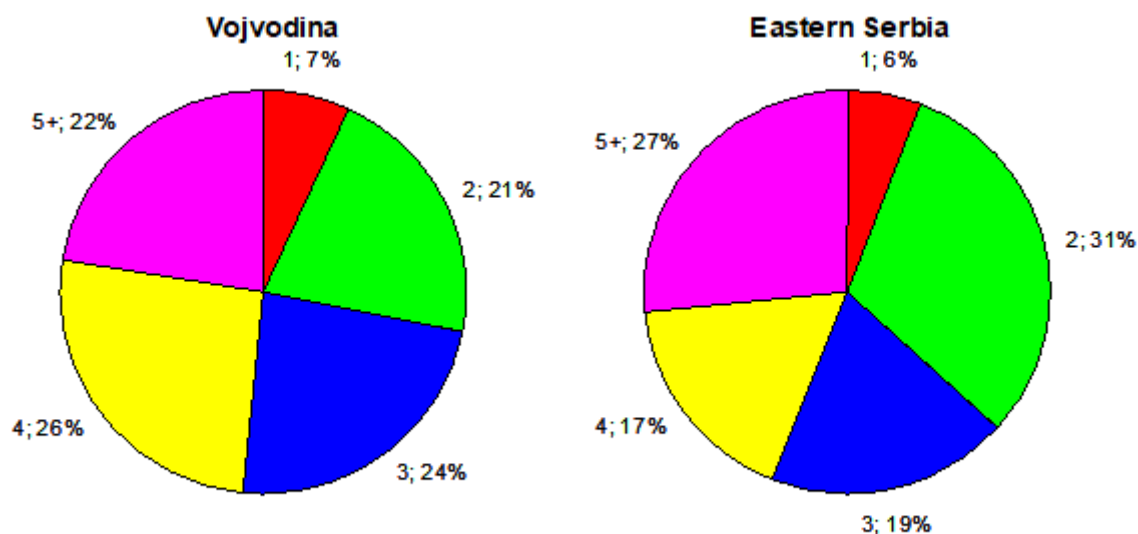


Fig. 3. Share of the households with different number of members in the total number of households in Vojvodina and Eastern Serbia

The dominant share of the households with two and five and more members in Eastern Serbia is an indicator of the depopulation of this region and low standard of living. One of the consequences of this process is a connection of families into multi-member households.

#### 2.1.2 Age and possession of thermo-isolation on residential buildings that use solid fuels for heating

A number of facilities with households that use solid fuels for heating which have thermo-insulation and their age, as well as the number of facilities with no thermo-insulation and their age, at the regional level are given in table 2.

Table 2. Age and existence of thermo-insulation on residential buildings of households that consume solid fuels for heating

Region	Number and age of buildings that have thermal insulation					Number and age of buildings that have not thermal insulation				
	Total	Buildings' age (years)				Total	Buildings' age (years)			
		Up 5	6-10	11-15	Over 20		Up 5	6-10	11-15	Over 20
<b>VOJVODINA</b>	<b>117,006</b>	<b>1,784</b>	<b>5,351</b>	<b>18,193</b>	<b>91,679</b>	<b>134,486</b>	<b>1,784</b>	<b>3,211</b>	<b>7,135</b>	<b>122,357</b>
urban	81,334	1,070	4,281	14,269	61,714	79,907	1,070	1,427	4,994	72,415
other	35,673	713	1,070	3,924	29,965	54,579	713	1,784	2,140	49,942
<b>EASTERN SERBIA</b>	<b>56,491</b>	<b>2,062</b>	<b>2,886</b>	<b>4,123</b>	<b>47,420</b>	<b>71,336</b>	<b>3,711</b>	<b>6,185</b>	<b>6,185</b>	<b>55,254</b>
urban	31,751	1,649	825	1,237	28,039	37,523	2,062	2,886	2,474	30,101
other	24,741	412	2,062	2,886	19,380	33,812	1,649	3,299	3,711	25,153

The first important characteristic of households that consume solid fuels for heating in both regions is a dominant share of those, whose residential buildings do not have thermal insulation: in Vojvodina 53%, and in Eastern Serbia 56% (fig. 4). The second important feature of those residential buildings is their age: the majority is over 20 years old: in Vojvodina 85%, in Eastern Serbia 80.3%. Such state of the residential buildings is unsatisfactory from the aspect of the conditions in which the wood fuels are consumed/combusted.

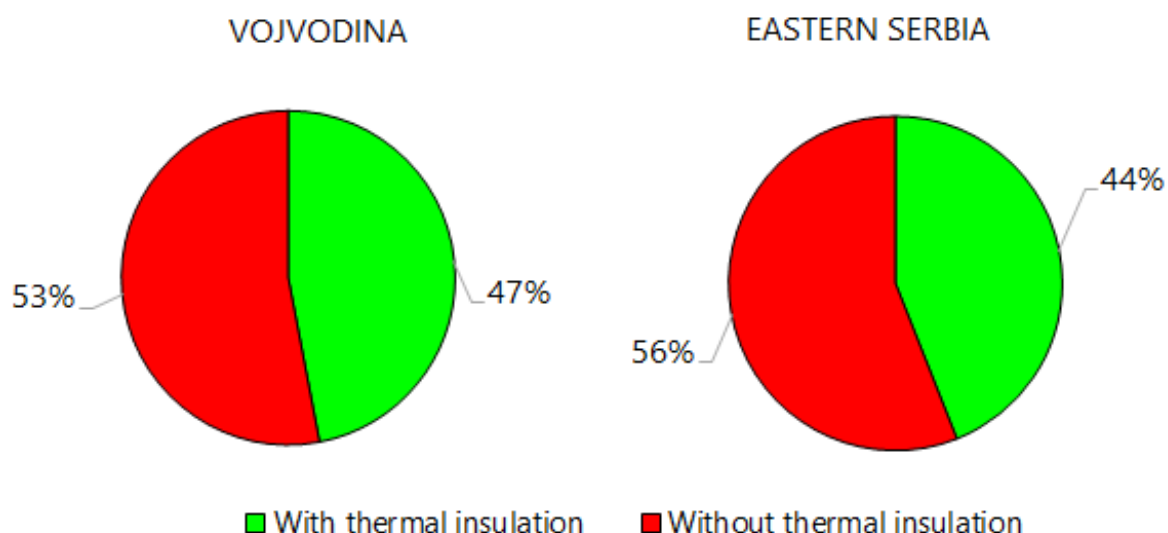


Fig. 4. Distribution of households with and without thermal insulation in Vojvodina and Eastern Serbia

The ratio between urban and rural households with thermal insulation differs between the regions. In Vojvodina, 69.5% of all residential buildings with thermal insulation is located in urban areas, whereas 30.5% in rural areas. In Eastern Serbia, that ratio is more even: 56.2% make the urban residential buildings, whereas 43.8% make the rural residential buildings.

### 2.1.3 Residential facilities by average number and area of rooms in the households that use solid fuels in Vojvodina and Eastern Serbia

Data on the average number of rooms in general and rooms being heated during the heating season as well as their average area in residential facilities of households that use solid fuel in Vojvodina are given in Table 3.

In Vojvodina, the average number of rooms in residential facilities (including kitchen, corridor and WC/toilet) in urban settlements is 7.1, and in other settlements is 7.2. In Eastern Serbia, the average number of rooms is 6.2 in urban and 6.3 in other settlements.

The average number of rooms in residential facilities (including kitchen, corridor and WC/toilet) being heated in urban settlements in Vojvodina is 5.6, while in other settlements it is 5.3. In Eastern Serbia, it is 4.8 in urban and 4.9 in other settlements.

The average area of residential facilities in both regions is between 100.2 m<sup>2</sup> and 108.5 m<sup>2</sup>. The average area of residential facilities in urban settlements in Vojvodina is 103.4 m<sup>2</sup>, and in other

settlements, it is 108.5 m<sup>2</sup>. In Eastern Serbia, it is 100.2 m<sup>2</sup> in urban, and 107.2 m<sup>2</sup> in other settlements.

Table 3: Facilities by the average number of rooms and average area

Region/Households		The average number of rooms in a facility (including kitchen, corridor and WC/toilet)	The average area of a facility [m <sup>2</sup> ]	The average number of rooms in a facility being heated during the heating season (including kitchen, corridor and WC/toilet)	Average area being heated in a facility during the heating season [m <sup>2</sup> ]
VOJVODINA	Urban	7.1	103.4	5.6	81.6
	Other	7.2	108.5	5.3	82.7
EASTERN SERBIA	Urban	6.2	100.2	4.8	79.7
	Other	6.3	107.2	4.9	85.3

The average area being heated in residential facilities during the heating season at the level of Vojvodina is 81.6 m<sup>2</sup> in urban and 82.7 m<sup>2</sup> in other households. In Eastern Serbia, it is 79.7 m<sup>2</sup> in urban and 85.3 m<sup>2</sup> in other settlements.

#### 2.1.4 Residential buildings by the manner of use and age of windows and doors in households that use solid fuels in Vojvodina and Eastern Serbia

An overview of the age of windows and doors in residential facilities for Vojvodina and Eastern Serbia is given in Table 4.

Table 41. Age of windows and doors in the residential facilities in Vojvodina and Eastern Serbia

Region	Number of residential facilities and age of windows and doors			
	Total	Age of windows and doors (in years)		
		0-10	11-20	More than 20
<b>Vojvodina</b>	<b>251,492</b>	<b>80,977</b>	<b>40,310</b>	<b>130,205</b>
urban	161,240	48,158	29,252	83,831
other	90,252	32,819	11,059	46,374
<b>Eastern Serbia</b>	<b>127,827</b>	<b>46,183</b>	<b>8,247</b>	<b>73,397</b>
urban	68,862	26,802	4,536	37,523
other	58,965	19,380	3,711	35,874

In residential facilities in both regions, windows and doors are mostly over 20 years old. In Vojvodina, the share of windows and doors over 20 years old is 52%. In Eastern Serbia, the corresponding share is 57%. The share of new windows and doors (the age of up to 10 years) is around 1/3: in Vojvodina 32%, in Eastern Serbia 36%). This is for sure an unsatisfactory situation when it comes to energy efficiency and intensively impacts wood energy consumption.

#### 2.1.5 Number of residential facilities which have windows with or without thermo-insulating glass

Data on the number of residential facilities which have or do not have windows with thermo-insulating glass, in Vojvodina and Eastern Serbia are given in Table 5.

Table 5. Number of residential facilities with windows that have or do not have thermo-insulating glass in Vojvodina and Eastern Serbia

Region	Type of a settlement	Number of facilities with windows that have an insulating glass	Number of facilities with windows that don't have an insulating glass
	<b>Total</b>	<b>116,649</b>	<b>134,843</b>
VOJVODINA	urban	74,199	87,041
	other	42,450	47,801
	<b>Total</b>	<b>56,904</b>	<b>70,923</b>
EASTERN SERBIA	urban	33,400	35,462
	other	23,504	35,462

In Vojvodina, 46.4% of residential facilities have windows with thermo-insulating glass, while 53.6% have windows without thermo-insulating glass. The situation is similar in Eastern Serbia. Namely, 55.5% of residential facilities in this region have windows without thermo-insulating glass (over 1/2), while 44.5% possess thermo-insulating glass.

#### 2.1.6 Consumption patterns of wood fuels in households in Vojvodina and Eastern Serbia

Total consumption of wood fuels in households in Vojvodina and Eastern Serbia in heating season 2020/2021 is given in Table 6. Data in this Table are structured to show consumption of certain wood fuels in households separately at the level of Vojvodina and Eastern Serbia.

Table 62. Wood fuels consumption in households in Vojvodina and Eastern Serbia in heating season 2020/2021

Region	Type of wood fuel	Unit	Quantity
VOJVODINA	Firewood	m <sup>3</sup>	1,620,254
	Wood pellets	tonnes	51,802
	Wood briquettes	tonnes	5,004
EASTERN SERBIA	Firewood	m <sup>3</sup>	1,014,294
	Wood pellets	tonnes	33,850
	Wood briquettes	tonnes	127

The main characteristic of wood fuel consumption is the domination of firewood. The vast majority of households from both chosen regions consume only firewood. Only some of them consume firewood in combination with coal and other fuels (like agro biomass or electricity). However, the consumption of wood pellets has been growing from year to year thanks to the comfort in their consumption, their affordable prices and stable market supply.

The wood fuels consumption differs significantly between the regions. In Vojvodina, they are often combined with the agro biomass, which is prevalently combined with firewood and wood briquettes. That is reasonable since this is a region with a lot of agricultural soil. Every year residuals of wheat, corn, sunflower, soy and other agricultural cultures are numerous and are used for energy purposes. Furthermore, the combinations of gas (LPG) and wood fuels are also very spread in Vojvodina. Fig. 5 depicts the share of combinations of solid fuels in households per county in Vojvodina.

As it could be seen, In all counties except in Western Bačka, firewood is a dominant fuel consumed by households for heating. Its share is in the range from 40.2% in Middle Banat to 74% in Nord Bačka. In Western Bačka, the households predominantly combine wood and coal (31.1%) and wood and electricity (26.1%) for heating. The share of households that consume only firewood is 18.5%.

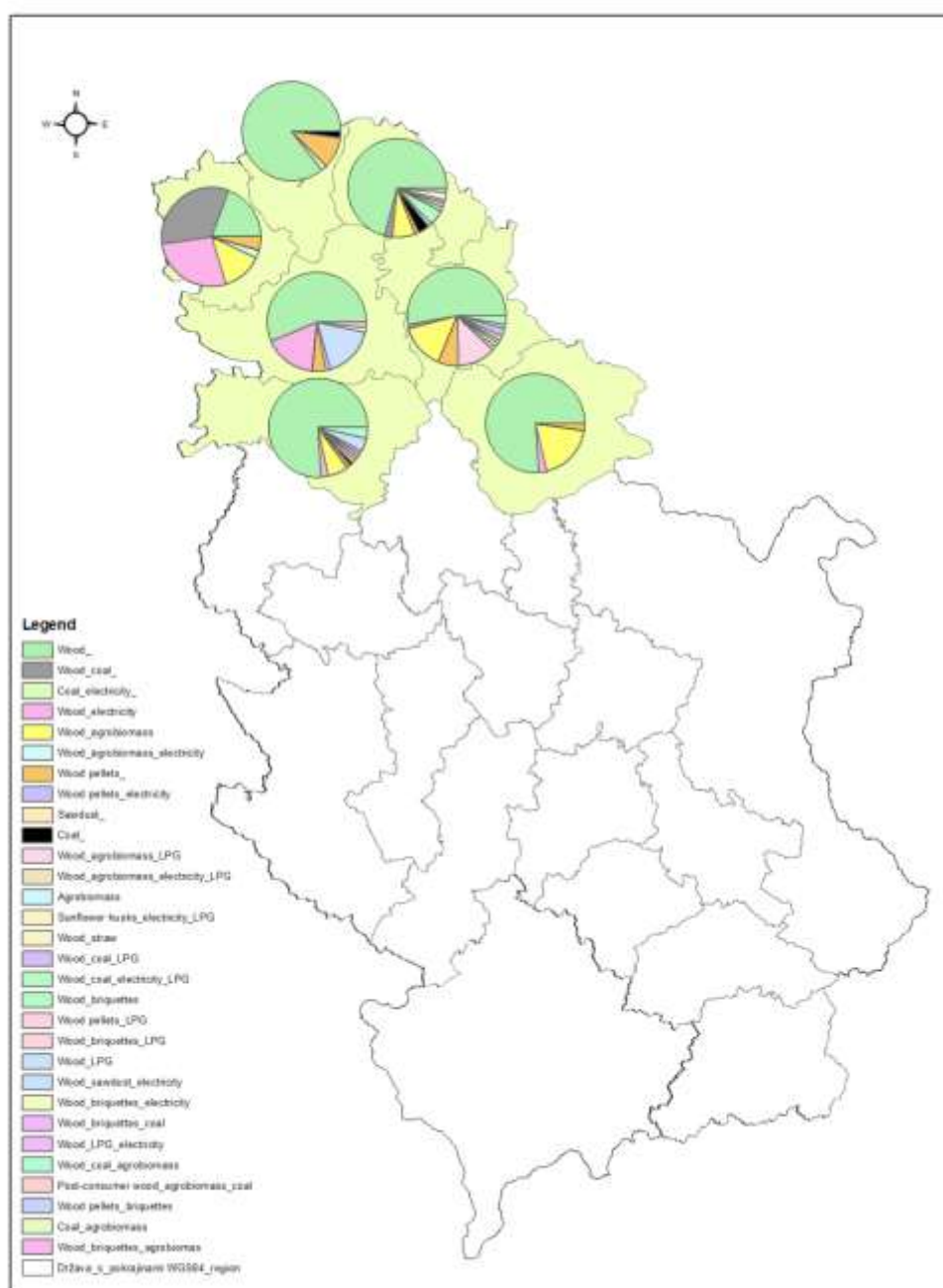


Fig. 5. Presence of certain fuel types for heating households in the heating season 2019/2020 in Vojvodina

The second important characteristic of the fuel consumption in Vojvodina is the variety of the combinations. According to the survey conducted within this project, 30 different combinations of fuels have been registered. The households in this region may use only one or combine up to four different fuels (e.g. wood, coal, electricity and gas/LPG). The combinations of two or more fuels have been registered in the households with the individual heating appliances which simultaneously heat many rooms.



The third characteristic of the fuel consumption in Vojvodina is a high share of the agro biomass in the forms of cobs, straw and sunflower husks, as well as grainy residues. The agro biomass is mostly combined with firewood. The share of households that combine firewood and agro biomass for heating is predominantly spread in South Banat, Middle Banat and Western Bačka.

The fuels consumption in Eastern Serbia is completely different. In this region, firewood is the dominant fuel in all counties. Fig. 6 depicts the presence of all solid fuels types per county in Eastern Serbia.

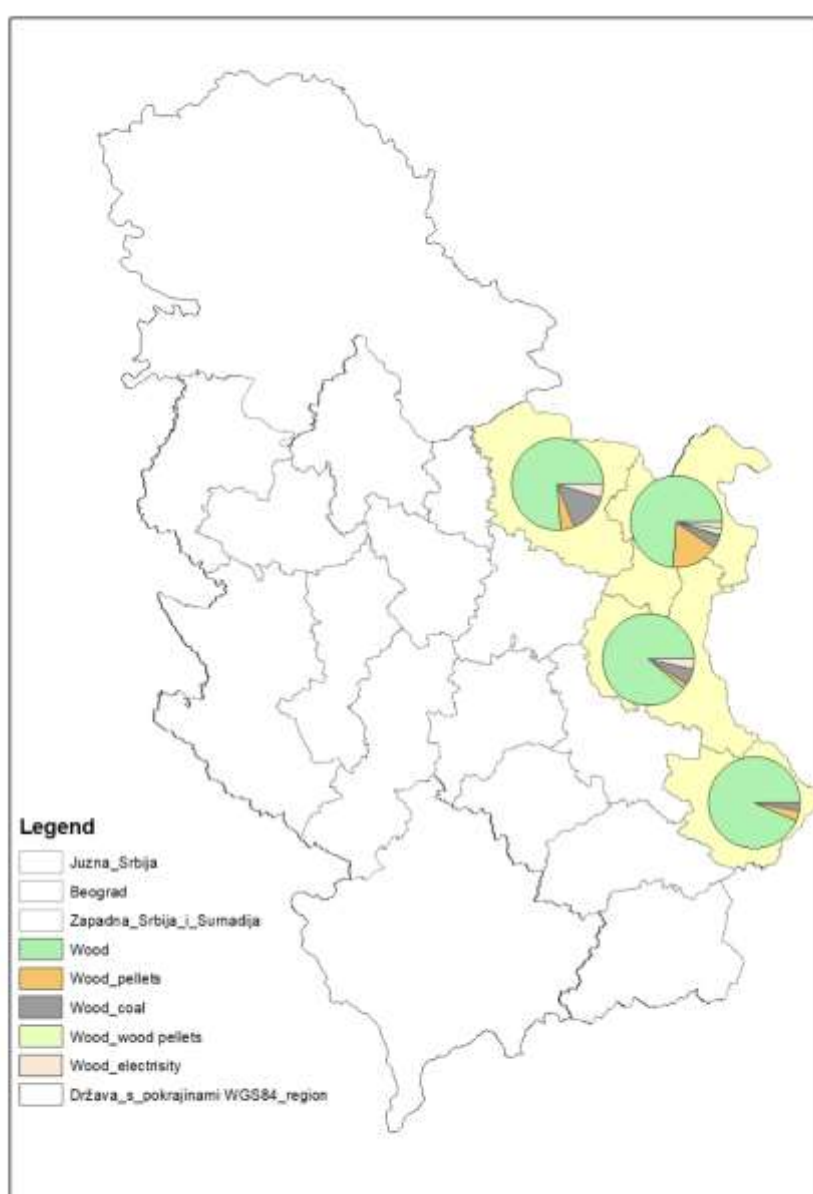


Fig. 6. Presence of certain fuel types consumed for heating households in the heating season 2019/2020 in Eastern Serbia

The share of the households that consume firewood for heating is in a range from 73.8% in the county of Bor up to 93.4% in the county of Pirot. The share of households that consume wood pellets is the highest in the county of Bor (16.6%) and the lowest in the county of Zaječar (1.8%).

The second important characteristic of the fuels consumption in the households from Eastern Serbia is a small number of combinations of different fuels consumed for heating. Additionally, the consumption of agro biomass in households from this region is low.

The comparison of the diversity of solid fuels in households from both regions is presented in fig.7.

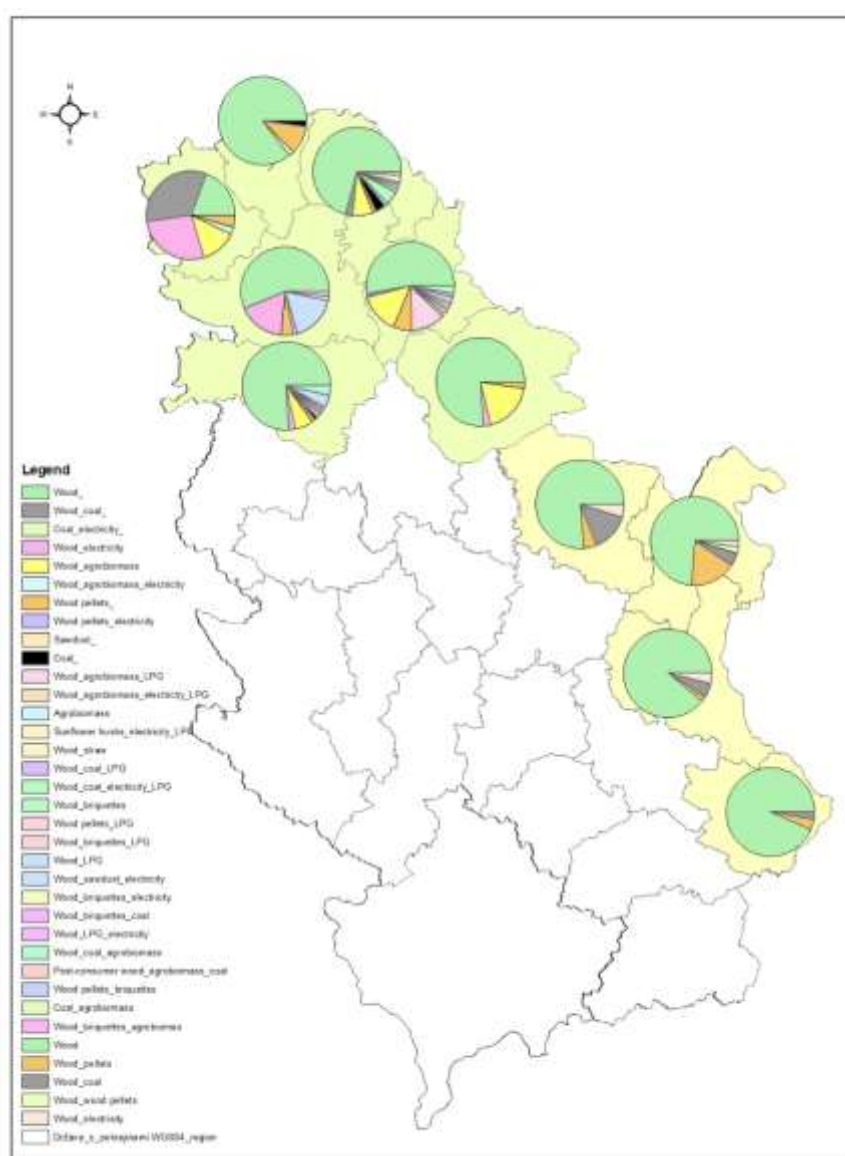


Fig. 7. The comparison of the diversity of solid fuels in households from both regions in the heating season 2019/2020 in Vojvodina and Eastern Serbia

When it comes to the efficiency of the wood fuels consumption, it is assessed by the consumption indicators measured per household or per 1m<sup>2</sup> of the heated area. More details about these indicators in the chosen region could be found in table 7.

Table 7. Indicators of the firewood consumption efficiency in the households from Vojvodina and Eastern Serbia.

Region		Firewood consumption [m <sup>3</sup> /household]	Firewood consumption [m <sup>3</sup> /m <sup>2</sup> heated surface]	Wood energy consumption [kWh/m <sup>2</sup> heated surface]
Vojvodina	Urban	6.3	0.077	199.0
	Other	6.9	0.083	214.5
Eastern Serbia	Urban	7.2	0.090	232.6
	Other	8.0	0.094	242.9

The consumption of wood energy in the households measured in kWh/m<sup>2</sup> of the heated area is not satisfactory in both regions. Its values are beyond the values of the last class of the energy passport for residential buildings [G class > 188 kWh/m<sup>2</sup> (a)].

From the aspect of the wood fuels consumption in the households from the chosen two regions, it would be interesting to compare the development of the consumption between 2020 and 2010, in terms of quantity. The last big inventory of the wood fuels consumption in Serbia was done in 2010. In table 8, one may find the consumption from that year and the consumption from 2020.

Table 8. Consumption of wood fuels in Vojvodina and Eastern Serbia in 2010 and 2020.

Region	Type of wood fuel	Unit	Quantity		Change 2010 to 2020
			2010.	2020.	
VOJVODINA	Firewood	m <sup>3</sup>	1,411,883	1,620,254	14.7%
	Wood pellets	tonnes	531	51,802	97.5 times
	Wood briquettes	tonnes	2,299	5,004	117.6%
EASTERN SERBIA	Firewood	m <sup>3</sup>	954,229	1,014,294	6.3%
	Wood pellets	tonnes	1,059	33,850	32 times
	Wood briquettes	tonnes	1,186	127	-89.3%

Sources: 1. WISDOM Serbia, FAO, 2015; 2. Households survey 2021.

The consumption of all types of wood fuels in both regions increased between 2010 and 2020. The only exception is the consumption of wood briquettes. It fell in Eastern Serbia during this period. The consumption of firewood in Vojvodina grew by 14.7%, in Eastern Serbia by 6.3%. In Vojvodina, there are two reasons for that consumption growth. First, the number of households that consume firewood increased by 1% during the last decade. Second, wood fuels are more competitive in terms of prices compared to heating oil and gas, which is a very spread fuel for the households' consumption in this region.

In Eastern Serbia, the consumption of firewood grew although the number of households that consumed firewood decreased by 6.2%. The main reason was an increase in the heated areas and the number of the households' members since many households merged. In this region, the process of the population's migration from urban to rural areas, or from smaller urban areas to bigger urban areas is very prominent. Those people who returned to villages from urban settlements increased the households of their parents and relatives.

Regarding the consumption of wood pellets, it had the largest increase in the last decade in both regions. This is reasonable since the production of wood pellets in Serbia started in 2009, so their consumption in 2010 was symbolically low. The majority of households at that time was not familiar with wood pellet. However, the situation has significantly changed in the last ten years. The wood pellet has become a very popular and appreciated fuel amongst consumers. In 2020, Serbia was the leading country in Southeastern Europe when it comes to wood pellets consumption.

The consumption of wood briquettes grew in Vojvodina. There are three reasons for that. The first one was the stable production of two big briquettes production and sale companies from this region. The second was the better pricing compared to pellets, gas and heating oil. The third one comprehends consumption habits. Many consumers have been consuming briquettes for a long time, especially the ones who are located nearby mentioned two briquettes producing companies/factories. Therefore, they do not want to replace the briquettes.

Depending on the supply chain and the timing of purchase, the prices of firewood have strong local variation (fig. 8).

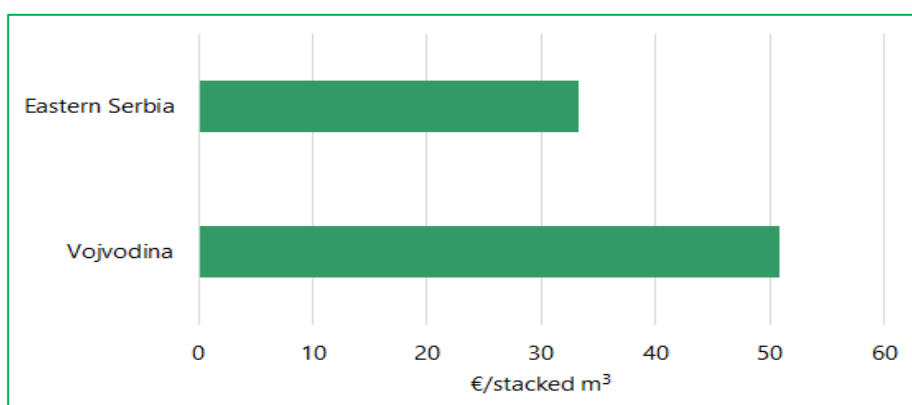


Fig. 8. Average prices at which households purchased firewood in Vojvodina and Eastern Serbia during the heating season 2020/2021

The average firewood prices in the heating season 2020/2021 amounted to 50.8 € per stacked m<sup>3</sup> in Vojvodina, and 33.3 € per stacked m<sup>3</sup> in Eastern Serbia. Such a big difference in firewood purchase prices between the two regions arises from the fact that Eastern Serbia is the most forested region of the country. Hence, the availability of wood there is significantly larger than

in Vojvodina, the least forested Serbian region with only around 6% of its area covered by forests.

The average prices of wood pellets in Vojvodina were 199.8 €/tonnes, and in Eastern Serbia 179.4 €/tonnes (the VAT included). The big difference in the purchasing prices stems from the fact, that the biggest factory for wood pellets production in Serbia is located in Eastern Serbia. Therefore, the transportation costs and trade margins are lower than in Vojvodina.

### 2.1.7 Purchase and storage of firewood for heating of households in Vojvodina and Eastern Serbia

Timing of firewood purchase relative to the beginning of the heating season is an important factor in firewood consumption because wood contains different quantities of water and that depends on the time between the moment of felling and the moment of consumption. For wood pellets and briquettes that is not the case, because their moisture is fixed in the technological process of production and amounts to approximately 8%. Reviews of households according to the timing of the purchase of firewood relative to the beginning of the heating season are given in fig. 9 and 10.

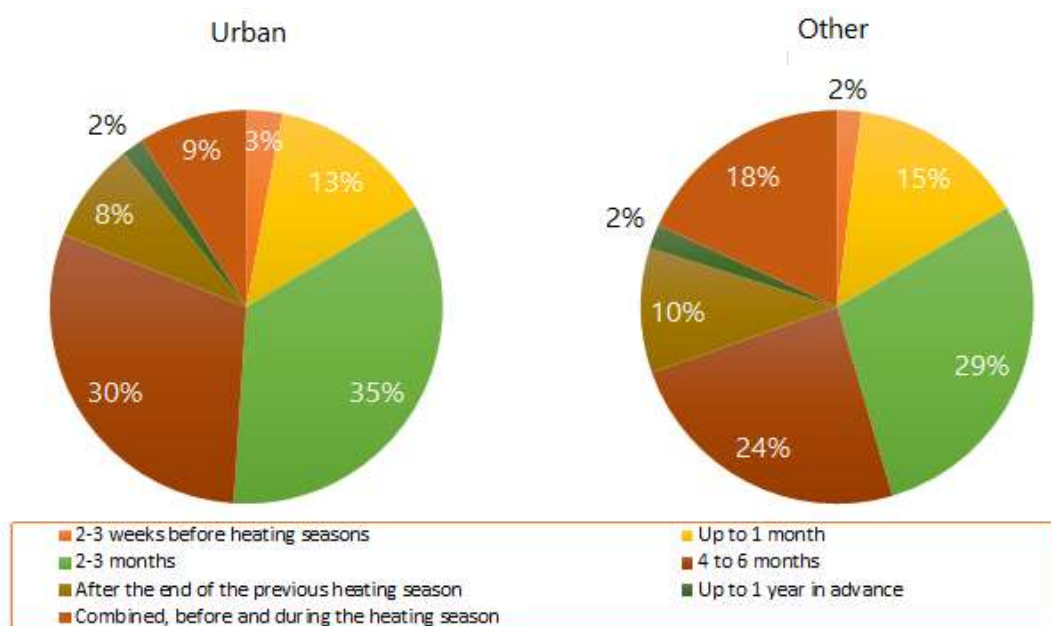


Fig. 9. Timing of purchase of firewood by households relative to the beginning of the heating season in Vojvodina

The largest number of urban households in Vojvodina purchased firewood in 2020 some two to three months before the heating season (35%). The share of households that purchased firewood some four to six months before the heating season is 30%, and those that purchased it right after the end of the previous heating season is 8%. A similar situation is in the households that are located outside urban zones. The share of households that partly purchase

firewood before the heating season, and partly during the heating season amounts to 18%. That is reasonable because of their agricultural works in the summer months. Considering the question of the complete or partial purchase of wood fuels in Vojvodina, almost 55% of households purchase the wood fuels completely before the heating season, and the rest partially: some of them before the heating season and some of them during the heating season. Since the last three winters were mild, many households decide to partially purchase the wood fuels.

Generally, the firewood purchase by households in Vojvodina is unsatisfactory because only 40% of the urban and 36% of the other households purchase firewood early enough before the heating season so that it can dry to the acceptable and energy-efficient moisture content (below 30%).

On the question "why they consume the fuels they consume", 54% of the households in Vojvodina stated that it is the cheapest solution for them (22%), that their heating appliances need exactly those fuels (18%) and that is easiest for them to purchase exactly those fuels (14%).

When it comes to storing wood fuels, the situation in Vojvodina is good. Some 85% of the households have covered storing facilities (mostly wood sheds, 77%). Only 15% of the households store their firewood in an uncovered manner, i.e. front of the house).

In Eastern Serbia, the largest number of households purchased firewood 4 to 6 months before the heating season (35% in urban, and 46% in other households), then follow households that purchased it 2 to 3 months before the heating season and those that purchased firewood right after the end of the previous heating season.

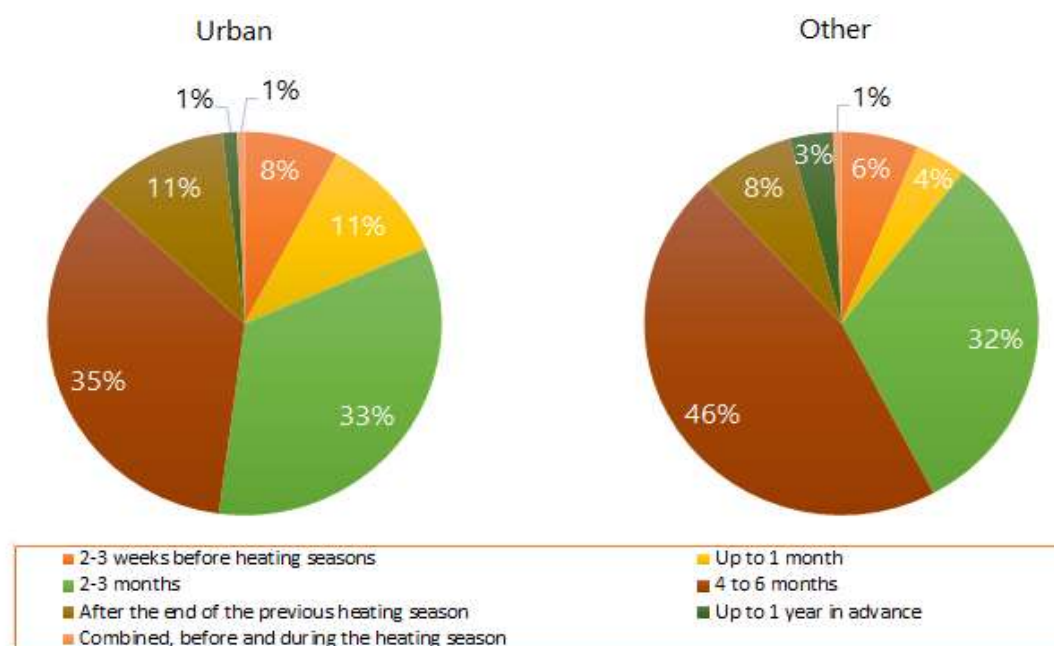


Fig. 10. Timing of purchase of firewood by households relative to the beginning of the heating season in Eastern Serbia

The situation in urban households is not satisfactory because only 47% of households purchase firewood with acceptable and energy-efficient moisture content. In the other households in Eastern Serbia, the situation is somewhat better: 57% of the households purchase firewood early enough for the wood to dry and to reduce the moisture content below 30%. Some 82% of households purchase firewood completely before the heating season, whereas only 18% purchase firewood partially: one part before, and one part during the heating season.

The main reason for the dominance of firewood in Eastern Serbia is the easiness of its purchase, i.e. the availability. This was confirmed during the survey by 70% of the interviewed households. All other reasons together were stated by the remaining 30% of the households.

When it comes to storing wood fuels (especially firewood), some 83% of the households from Eastern Serbia possess closed storage facilities (woodsheds 75%). Only 17% of the households store it in open spaces.

#### 2.1.8 Supply channels and the most frequent purposes for which firewood is used in the households from Vojvodina and Eastern Serbia

The most important wood fuels supply channel for the households from Vojvodina is heating fuels warehouses, from which the wood fuels are provided to 56% of the households. The second important supply channel consists of firewood traders. They supply 26% of the households. The share of other supply channels is under 10%. The remaining 8% of the households from Vojvodina is supplied from the state-owned forests (fig. 11), due to the small forest coverage of the territory in this region.

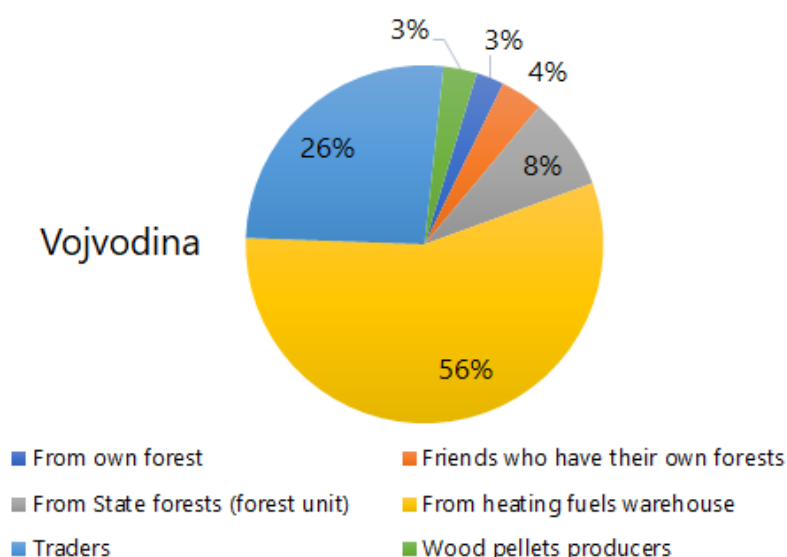


Fig. 11. Firewood supply chains of the households in Vojvodina



According to the survey, 68% of the households in Vojvodina consume firewood only for heating, 17% for heating, hot water and cooking, whereas the remaining 15% consume it additionally for the production of brandies and drying of meat and plums.

In Eastern Serbia, the supply channels are differentiated. Almost 93% of households provide firewood from three channels: from their own forests (58%), from timber traders (21.7%) and heating fuels warehouses (13%) (fig. 12).

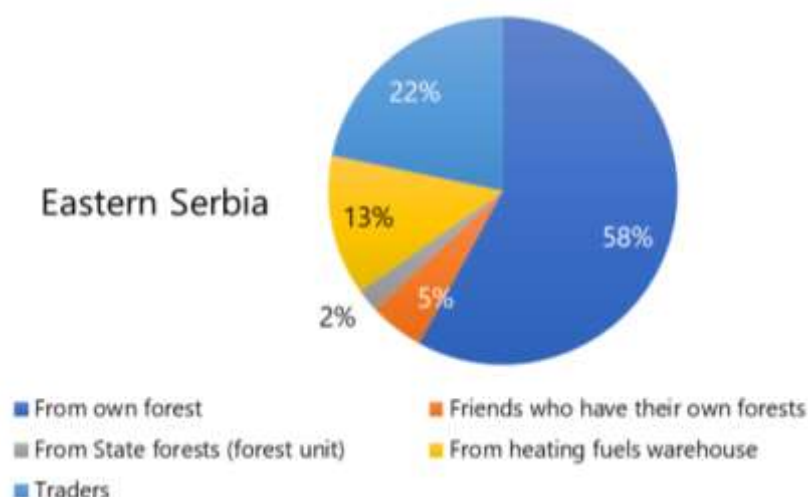


Fig. 12. Firewood supply chains of the households in Eastern Serbia

The big importance of the private forests for the supply of the households in this region is a result of the high forest coverage and numerosity of private forest owners who use their own forests resources for the supply with wood, either for their own purposes or further sale.

When it comes to firewood consumption purposes, the situation in Eastern Serbia is similar to that in Vojvodina. Some 53% of the households consume firewood only for heating, 31% only for heating, hot water and cooking, and the remaining 16% for heating and other purposes (production of brandies, drying of meat and plums).

The majority of households in both regions are familiar with the existence of the new types of wood fuels (e.g. wood pellets): in Vojvodina that is 79%, in Eastern Serbia 69% of the interviewed households. However, only 18% of the households from Vojvodina and 27% of the households from Eastern Serbia plan to replace the firewood with new fuels but wait for the subsidies from the state for the purchase of the new heating appliances.



### 2.1.9 Heating systems and characteristics of the heating appliances in the households from Vojvodina and Eastern Serbia

The heating systems are one of the most important elements on which the efficiency of consumption, as well as the consumption of wood fuels itself, depend in every household. The results of the conducted survey show that the majority of households from both regions use individual heating appliances. The share of households that use individual heating appliances in Vojvodina amounts to 56% and in Eastern Serbia 57%. The share of the households with their own central heating system in Eastern Serbia amounts to 42%, whereas in Vojvodina 35% (fig. 13).

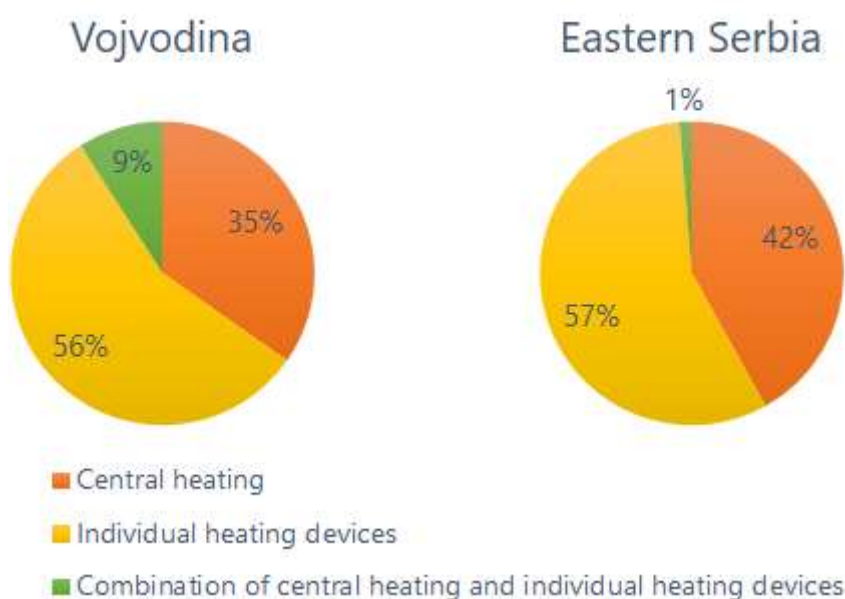


Fig. 13. The presence of particular types of heating systems in the households from Vojvodina and Eastern Serbia

The high wood energy consumption in the households from both regions could be partially explained by the inefficiency of their combustion, i.e. high share of the households with individual heating appliances. It is known that individual heating appliances are less efficient compared to heating appliances from central heating systems. Besides the heating system, the important firewood consumption and efficiency factor is the age of a heating appliance. According to the survey, 52% of households from Vojvodina possess heating appliances over 10 years old. In Eastern Serbia, this share amounts to 41% (fig. 14). The share of households with up to 5 years old heating appliances amounts to only 22% in Vojvodina and 27% in Eastern Serbia.

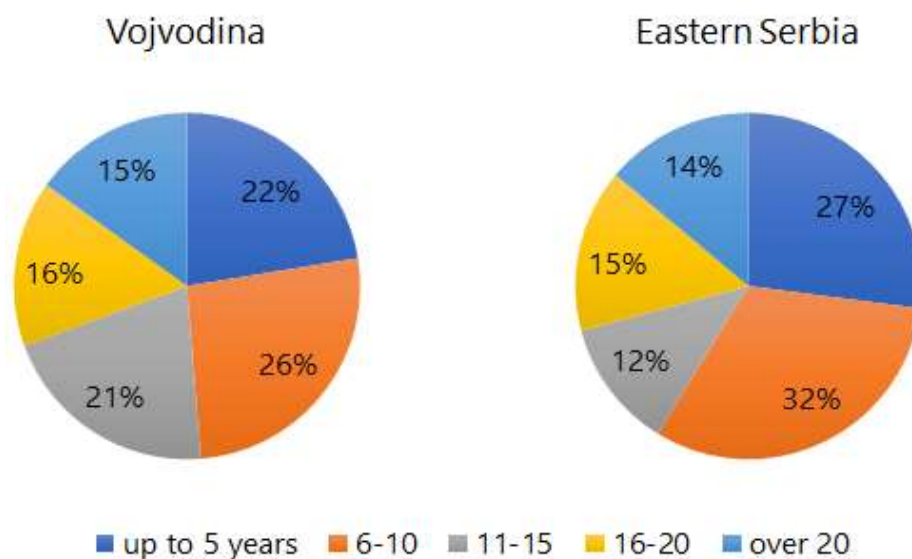


Fig. 14. Frequency of certain age ranges of heating appliances in surveyed households in Vojvodina and Eastern Serbia

Generally speaking, the state of the heating/combusting appliances in households in both regions is unsatisfactory, because the share of the appliances over 10 years old is one of the key wood energy inefficiency and consumption factors.

Regular chimney servicing is also one of the activities which are tightly connected to the efficiency of wood fuels combustion in the heating/combusting appliances, as well as to the wood fuels consumption. In both regions, the situation is satisfactory. In Vojvodina, 65% of the interviewed households regularly service their chimneys every year. That share in Eastern Serbia is even higher and amounts to 86%.

## 2.2 Wood fuels consumption in public and commercial buildings and industry for energy purposes

Wood fuels are an important energy source for a large number of public and commercial buildings. According to the results of the research within this project, wood fuels are used in pre-school and school institutions, health institutions and in facilities of local administration.

Total consumption of wood fuels in these facilities in the heating season 2020/2021. is given in Table 9 according to the type of wood fuel.

Table 9. Consumption of wood fuels in public and commercial buildings and industry in Vojvodina and Eastern Serbia

Region	Category of consumers in public sectors	Consumption of wood fuels in the heating season 2020/2021.			
		Firewood [m <sup>3</sup> ]	Wood chips [tonnes]	Wood pellets [tonnes]	Sawdust [tonnes]
<b>Vojvodina</b>	<b>TOTAL</b>	<b>3,547</b>	<b>0</b>	<b>984</b>	<b>37,972</b>
	Public buildings	2,653	0	773	0
	Commercial buildings	894	0	211	0
	District heating systems	0	0	0	0
	Wood industry	0	0	0	37,972
<b>Eastern Serbia</b>	<b>TOTAL</b>	<b>53,670</b>	<b>2,205</b>	<b>569</b>	<b>13,203</b>
	Public buildings	2,250	0	439	0
	Commercial buildings	370	0	130	0
	District heating systems	7,944	0	0	0
	Wood industry	43,106	2,205	0	13,203

Sources: 1. Survey 2021; 2. author's calculations

The most common fuel in wood fuel consumption in public and commercial buildings is firewood in both regions. The total consumption of firewood in these buildings was 3,547 m<sup>3</sup> in Vojvodina and 2,620 in Eastern Serbia. Then follow wood pellets with 984 tonnes in Vojvodina and 569 tonnes in Eastern Serbia.

The district heating systems in Vojvodina do not consume wood fuels, whereas the district heating systems in Eastern Serbia consume 7,944 m<sup>3</sup> of wood fuels. The wood processing industry in both regions mostly consumes sawdust for energy purposes: in Vojvodina 37,972 tonnes, in Eastern Serbia 13,203 tonnes. Additionally, there is a CHP plant for electricity production in Eastern Serbia, whose production is based on firewood and wood chips. In 2020, its consumption amounted to 43,106 m<sup>3</sup> of firewood and 2,205 tonnes of wood chips.

### 2.3 Review of the total consumption of wood fuels in Vojvodina and Eastern Serbia

Based on the implemented research on households, public buildings, commercial buildings, district heating systems, and industry, Table 10 shows the summary presentation of certain wood fuels consumption at the level of Vojvodina and Eastern Serbia in heating season 2020/2021.

Table 10. Total wood fuels consumption in Vojvodina and Eastern Serbia in heating season 2020/2021

Region	Type of fuel				
	Firewood [m <sup>3</sup> ]	Wood briquettes [tonnes]	Wood pellets [tonnes]	Wood chips [tonnes]	Sawdust [tonnes]
Vojvodina	1,623,801	5,004	52,786	-	37,972
Eastern Serbia	1,067,964	127	34,419	2,205	13,203

Sources: 1. Survey 2021; 2. author's calculations

The most common wood fuel for energy purposes in Vojvodina and Eastern Serbia is firewood whose consumption in heating season 2020/2021. was 1.62 million m<sup>3</sup> in Vojvodina and 1,07 million m<sup>3</sup> in Eastern Serbia.

In the second place, there are wood pellets with consumption of almost 53 thousand tonnes in Vojvodina and 34 thousand tonnes in Eastern Serbia.

Since the number of households and the number of public and commercial facilities that consume wood fuels instead of heating oil and/or coal is growing, one may expect that the wood fuels consumption will grow in the following years as well, i.e. that the wood fuels will play a significant role in satisfying the energy needs of these consumer categories in both regions.

### 2.4 The interest of households for planting forests on the abandoned agricultural and other bare lands in Vojvodina and Eastern Serbia

The abandoned agricultural and other bare land is present in both regions. It is both state and privately owned. These lands are mostly used for grazing. Hence, it is possible to use these lands for planting energy forests or energy crops. This would bring lots of benefits for the local (rural) communities and the country as well. Therefore, one of the goals of this project was to examine the interest of the population from the chosen regions for planting forests. Based on

this interest, the corresponding measures for planning and support could be proposed to the policymakers.

The first activity in the process of the examination was discovering whether the local population is familiar with the existence of the abandoned agricultural and other bare lands in their municipalities. The results of this survey show that 49% of the interviewees from Vojvodina are not familiar with that. In Eastern Serbia, the situation is the opposite: 50% of the interviewees are aware that there are abandoned agricultural and other bare lands in their municipalities (fig. 15).

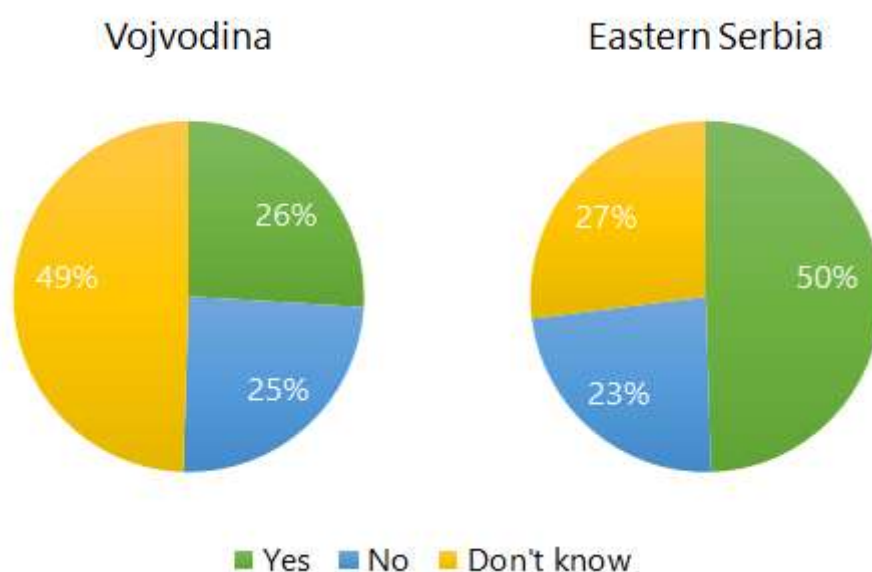


Fig. 15. Awareness of local population about the existence of the abandoned agricultural and other bare lands in Vojvodina and Eastern Serbia

Since the share of the population aware of the existence of the abandoned agricultural and other bare lands, the first step in the process of putting these lands into the function of energy crops is informing the people about the possibilities, opportunities and benefits of planting the energy forests or energy crops. This statement is supported by the answers of the interviewees about this topic. Some 62% of interviewees from Vojvodina and 78% of interviewees from Eastern Serbia do not know anything about the possibilities of income from forest plantages or energy crops (fig. 16). Only 18% of the interviewees from Vojvodina and 14% of the interviewees from Eastern Serbia are familiar with this. The remaining interviewees are only partially informed about this.



Fig. 16. Awareness of local populations about the possibilities of income from planting forests or energy crops

Regarding the interest of the interviewees in planting the forests on abandoned agricultural and other bare lands, the results of the survey show that currently only 10% of the interviewees from Vojvodina and 20% from Eastern Serbia show interest in this process, whereas all other interviewees are either not interested or did not consider these activities (fig. 17).

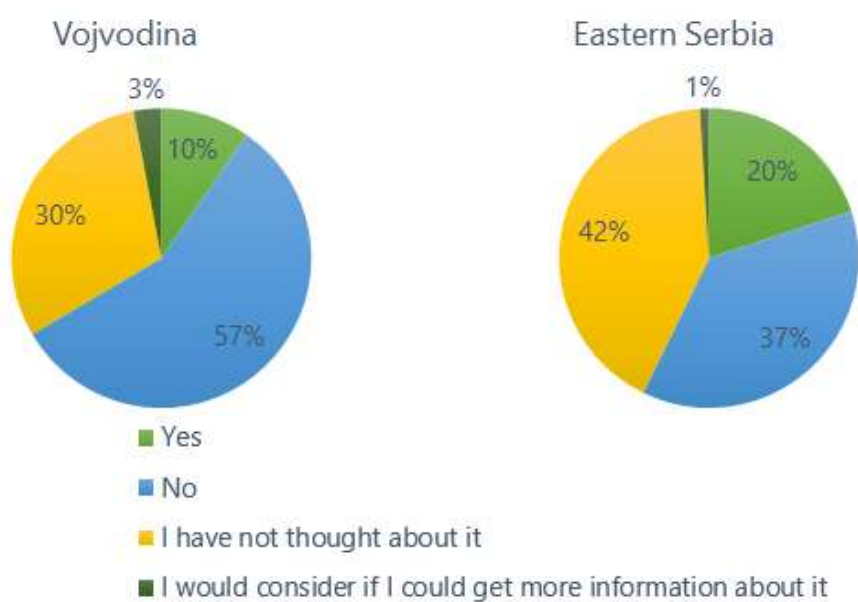


Fig. 17. Results of the survey on the interest of the interviewees for planting forests on abandoned agricultural and other bare lands in Vojvodina and Eastern Serbia

Based on the obtained results, one may conclude that situation about the interviewees' awareness of the potential benefits of planting forests on abandoned agricultural and other bare lands is unsatisfactory in both regions. Therefore, it is necessary to work a lot in two directions:

1. Educating the population about the benefits of this process, and
2. Creating and implementing the corresponding supporting measures (by policymakers).

### **3 BALANCE OF THE GHG EMISSIONS STEMMING FROM THE WOOD FUELS COMBUSTION IN VOJVODINA AND EASTERN SERBIA**

This chapter contains the calculation of the GHG emissions stemming from the process of wood fuels combustion by the most important consumers categories. It is based on the methodology adopted and described in chapter 1 of this report and on the consumption of particular wood fuels types from chapter 2. Balancing these GHG emissions was conducted for these two chosen Serbian regions for the first time. The goal was to reveal the exact possibilities of the emission reductions and contributions to the corresponding global efforts of mitigating the adverse climate changes in the sphere of wood fuels consumptions. Although the wood fuels per se are carbon neutral, with the increase of the efficiency of their combustion, one may reduce a lot of GHG emissions and free the additional capacities of the forests to absorb CO<sub>2</sub>/GHG stemming from fossil fuels. This efficiency improvement refers primarily to firewood and wood chips because there is a space for optimising the moisture content before combusting them. The GHG emissions are proportional to the moisture content in these two wood fuels types.

Underneath, one may find the GHG emissions balance for all wood fuels consumed for energy purposes in households, public and commercial facilities, district heating systems and wood processing industry, separately for each region.

Total CO<sub>2</sub> emissions stemming from the wood fuels combustion in Vojvodina during the heating season 2020/2021 are estimated to 2.05 million tonnes (see table 11). Some 97.6% of these emissions stemmed from households (2 million tonnes of CO<sub>2</sub>), whereas the remaining 2.4% stemmed from all other consumers categories. In Eastern Serbia, 1.3 million tonnes of CO<sub>2</sub> were emitted in the same period, again mostly from households (1.21 million tonnes). The emissions of nitrous oxide (N<sub>2</sub>O) were not that high: in Vojvodina 66 tonnes, in Eastern Serbia 44.4 tonnes. The emission of sulfur oxides is symbolically low from wood fuels.

The impact of wood moisture on the emissions of CO<sub>2</sub> was calculated and shown in fig. 18. The calculations were based on wood purchased 6 months before the beginning of the heating season and containing 20% moisture. Based on those emissions, the percentual changes of the CO<sub>2</sub> emissions depending on the time of purchase relative to the beginning of the heating season was derived.



Table 11. Balance of the GHG emissions stemming from the combustion of wood fuels per consumer category in Vojvodina during the heating season 2020/2021

Consumers categories	Fuel type	Unit of measure	Timing of purchase of firewood relative to the beginning of the heating season [months]	Approximate moisture content [%]	Net calorific value [MJ per unit]	Consumption in unit of measure	Energy consumption [TJ]	Emission factor [kg/TJ]		Total emissions [tonnes]		
								CO <sub>2</sub>	N <sub>2</sub> O	CO <sub>2</sub>	N <sub>2</sub> O	
I. HOUSEHOLDS	Firewood	m <sup>3</sup>	12+	18	10671	2373	25,3	108619	4	2750,3	0,10	
			6	20	10145	30542	309,8	109934	4	34062,3	1,2	
			5	25	9780	519167	5077,5	113974	4	578698,3	20,3	
			4	30	9647	485841	4686,9	118995	4	557720,2	18,7	
			3	35	9494	236842	2248,6	125446	4	282075,4	9,0	
			2	40	9315	60310	561,8	133553	4	75027,9	2,2	
			1	45	9104	285181	2596,3	143880	4	373553,9	10,4	
			0.5	50	8850	0	0,0	157439	4	0	0,0	
	SUM firewood					1620254	15506			1903888,3	62,0	
	Wood pellets	tonnes		8	17300	51802	896	98303	4	88096,7	3,6	
Wood briquettes	tonnes		8	17300	5004	87	98303	4	8510,0	0,3		
		Total households [SUM I]					16489			2000494,9	66,0	
II. Public and commercial buildings and wood industry												
Public buildings	Firewood	m <sup>3</sup>	4	30	9647	2653,0	25,6	118995	4	3045,5	0,102	
Public buildings	Wood pellets	tonnes	...	8	17300	773,0	13,4	98303	4	1314,6	0,053	
Commercial buildings	Wood pellets	tonnes	...	8	17300	211,0	3,7	98303	4	358,8	0,015	
Commercial buildings	Firewood	m <sup>3</sup>	4	30	9647	894,0	8,6	118995	4	1026,3	0,034	
Wood industry	Sawdust	tonnes	...	40	9315	37972,0	353,7	133553	4	47239,0	1,415	
			SUM II					405,0			52984,2	1,6
SUM [III=I+II]							16893,9			2053479,1	67,6	

Sources: 1.Survey 2021; 2. author's calculations

Table 12. Balance of the GHG emissions stemming from the combustion of wood fuels per consumer category in Eastern during the heating season 2020/2021

Consumers categories	Fuel type	Unit of measure	Timing of purchase of firewood relative to the beginning of the heating season [months]	Approximate moisture content [%]	Net calorific value [MJ per unit]	Consumption in unit of measure	Energy consumption [TJ]	Emission factor [kg/TJ]		Total emissions [tonnes]	
								CO <sub>2</sub>	N <sub>2</sub> O	CO <sub>2</sub>	N <sub>2</sub> O
I. HOUSEHOLDS	Firewood	m <sup>3</sup>	12+	18	10671	7142	76,2	108619	4	8278,4	0,30
			6	20	10145	38281	388,4	109934	4	42693,9	1,6
			5	25	9780	554464	5422,7	113974	4	618042,9	21,7
			4	30	9647	300201	2896,0	118995	4	344615,5	11,6
			3	35	9494	42022	399,0	125446	4	50048,0	1,6
			2	40	9315	63350	590,1	133553	4	78810,1	2,4
			1	45	9104	8833	80,4	143880	4	11570,415	0,3
			0.5	50	8850	0	0,0	157439	4	0	0,0
	SUM firewood					1014293,8	9852,8		1154059,2	39,4	
	Wood pellets	tonnes		8	17300	33850,0	585,6	98303	4	57566,7	2,3
	Wood briquettes	tonnes		8	17300	127,0	2,2	98303	4	216,0	0,0
			Total households [SUM I]				10440,6		1211841,9	41,8	
II. Public and commercial buildings and wood industry											
Public buildings	Firewood	m <sup>3</sup>	4	30	9647	2250,0	21,7	118995	4	2582,9	0,087
Public buildings	Wood pellets	tonnes	...	8	17300	439,0	7,6	98303	4	746,6	0,030
Commercial buildings	Wood pellets	tonnes	...	8	17300	130,0	2,2	98303	4	221,1	0,009
Commercial buildings	Firewood	m <sup>3</sup>	4	30	9647	370,0	3,6	118995	4	424,7	0,014
Wood industry	Sawdust	tonnes	...	40	9315	58400,0	544,0	133553	4	72652,4	2,176
District heating systems	Firewood	m <sup>3</sup>	4	30	9647	7944	76,6	118995	4	9119,3	0,307
			SUM II				579,1		85747,0	2,6	
SUM [III=I+II]							11019,7		1297588,8	44,4	

Sources: 1.Survey 2021; 2. author's calculations

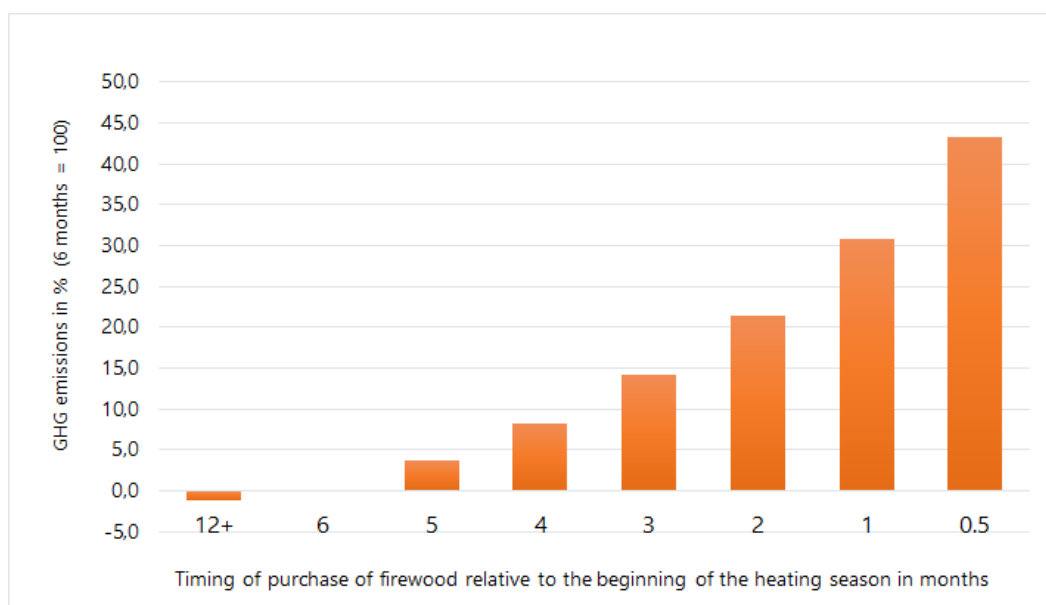


Fig.18. Percentual increase/decrease of the GHG emissions from firewood of different moisture content (relative to the purchasing period and derived from the emissions of wood purchased 6 months before the heating season)

How significant the impact of moisture content in the GHG emissions is very well shown by two extreme cases: wood purchased a half month before the beginning of the heating season with the moisture content of approximately 50% emits in the process of combustion 43.2% more GHG compared to the wood purchased 6 months before the beginning of the heating season. On the other hand, the emissions of the GHG from wood purchased 12 and more months before the beginning of the heating season are less by 1.2% compared to the emissions from wood purchased 6 months before the beginning of the heating season.

The values stated in fig. 18 should be considered as the approximate indicators because the wood moisture in the moment of combustion does not depend only on purchasing time, but also on the way and place of storing, climate conditions and technical characteristics of the combusting appliances. The purpose of fig. 18 is to lighten the necessity of education of consumers about the effects of the GHG emissions and to show them how each household can contribute to decreasing the GHG emissions and mitigating the adverse climate changes. The first step in this direction is changing purchasing habits. The consumers should purchase the wood early enough so that they could win enough time for drying and decreasing the moisture content below 30%. The minimum time for reaching this is 6 months before the beginning of the heating season.

The following example illustrates the effects that could be achieved with the mentioned approach: if all consumed firewood in Vojvodina and Eastern Serbia had been purchased 6 months before the beginning of the heating season, the total CO<sub>2</sub> emissions stemming from its combustion would be lower by approximately 120 thousand tonnes (compared to total CO<sub>2</sub>

emissions from tables 11 and 12). This is a very good illustration of how small changes in the habits of each household could significantly contribute to the efforts of decreasing GHG emissions.

## **4 CONCLUSIONS AND RECOMMENDATIONS**

The most important conclusions related to wood fuels consumption in Vojvodina and Eastern Serbia are listed below:

- The main characteristic of the wood fuels consumption in the chosen Serbian regions is the dominance of firewood;
- Total consumption of wood fuels for energy purposes in these regions in heating season 2020/2021 was the following:
  - firewood 1.6 million m<sup>3</sup> in Vojvodina and 1.07 million m<sup>3</sup> in Eastern Serbia;
  - wood pellets 52,786 tonnes in Vojvodina and 34,419 tonnes in Eastern Serbia;
  - wood chips 2,205 tonnes in Eastern Serbia;
  - wood briquettes 5,004 tonnes in Vojvodina and 127 tonnes in Eastern Serbia;
  - sawdust 37,972 tonnes in Vojvodina and 13,203 tonnes in Eastern Serbia.
- Besides the exclusive consumption of wood fuels, the consumers from Vojvodina often combine agro biomass with wood fuels, mostly with firewood and wood briquettes. Furthermore, the consumers from Vojvodina also combine LPG with wood fuels;
- The average consumption of wood energy per 1m<sup>2</sup> of the heating area in households in Vojvodina amounts to 199 kWh/m<sup>2</sup> (a) in urban households, and 214.5 kWh/m<sup>2</sup> (a) in other households. In Eastern Serbia, this consumption amounts to 232.6 kWh/m<sup>2</sup> (a) in urban households and 242.9 kWh/m<sup>2</sup> (a) in other households. Such high values of the wood energy consumption are unsatisfactory because they are beyond the values of the last class of the energy passport for residential buildings [G class > 188 kWh/m<sup>2</sup> (a)];
- In the last decade, the consumption of firewood grew in both regions: in Vojvodina by 14.7%, in Eastern Serbia by 6.3%;
- The consumption of wood pellets had the highest increase in the last ten years in both regions;
- The average prices of firewood during the heating season 2020/2021 amounted to 50,8 € per stacked m<sup>3</sup> in Vojvodina, and 33.3 € per stacked m<sup>3</sup> in Eastern Serbia. Such a big difference in the purchasing prices stems from the difference in the forest coverage in these regions. Eastern Serbia is the most forested Serbian region. Hence, the availability of wood is significantly larger compared to Vojvodina, the Serbian region with the lowest percentage of the territory covered by forests (around 6%);
- The most important supply channel with wood fuels for households from Vojvodina are heating fuel warehouses, which serve 56% of the households. The second important

supply channel consists of firewood traders, which deliver wood fuels to 26% of the households. The share of other supply channels is below 10%. In Eastern Serbia, the supply channels are differentiated in a way that almost 93% of the households supply themselves with wood fuels from three channels: from their own forests (58%), from timber traders (21.7%) and heating fuels warehouses (13%);

- The majority of households from both regions use individual appliances for heating: Vojvodina 56%, in Eastern Serbia 57%. The presence of the households with the central heating system is somewhat bigger in Eastern Serbia (42%) than in Vojvodina (35 %).
- Some 52% of households in Vojvodina possess heating appliances over 10 years old. In Eastern Serbia, the situation is better, 41% is the share of the households with heating appliances over 10 years old. The general situation regarding the heating/combusting appliances in both regions is unsatisfactory since the share of appliances older than 10 years is high.
- The most common fuel in wood fuel consumption in both public and commercial facilities in both regions is firewood. The total consumption of firewood in these facilities was 3,547 m<sup>3</sup> in Vojvodina and 2,620 in Eastern Serbia. Afterwards, follow wood pellets with 984 tonnes in Vojvodina and 569 tonnes in Eastern Serbia;

Regarding the interest of the interviewees in planting forests on abandoned agricultural and other bare lands, the results of the survey show that only 10% of the interviewees from Vojvodina and 20% of the interviewees from Eastern Serbia are curious about this process, whereas the others are either not interested or have not considered the related activities.

- Total CO<sub>2</sub> emissions stemming from the wood fuels combustion in Vojvodina during the heating season 2020/2021 are estimated to 2.05 million tonnes. Some 97.6% of those emissions stemmed from households (2 million tonnes), and the remaining 2.4% from the other consumers' categories; In Eastern Serbia, 1.3 million tonnes of CO<sub>2</sub> were emitted in the same period, again mostly from households (1.21 million tonnes). The emissions of the nitrogen oxides (N<sub>2</sub>O) were not that high: 66 tonnes in Vojvodina and 44.4 tonnes in Eastern Serbia;

### **Key recommendations**

Starting from the results of the analysis of the current situation regarding consumption of wood fuels in Vojvodina and Eastern Serbia, the most important recommendations for improvement in this area are given below:

- Taking into account that in most supply channels, the offered wood is raw or air-dried for 2-3 months at most, it is recommended to adopt a technical regulation that will set the appropriate rules, control principles, inspection mechanisms and complaints procedures, and that firewood sellers and distributors will have to abide by. Consequently, the sellers will be obliged to sell the firewood with the moisture content of max 30% to final consumers. This will help urban households which purchase wood step by step since they lack storage facilities. In some towns inspectors punish the citizens who store the wood in front of their houses on a part of the public surface;
- The education campaign for households and other consumers on the efficient usage of firewood should be conducted because that is very important both for the increase in the efficiency of the firewood usage and for the reduction of GHG emissions and air pollution. The air pollution in most urban areas in Serbia during the heating season has reached warning levels. During the heating season 2020/2021 some of them were amongst the most polluted towns/cities in the world;
- It is necessary to design and conduct an educational campaign about the benefits of the process of planting forests on abandoned agricultural and other bare lands so that the interest of the local populations for that is increased.
- It is necessary to strengthen the capacities of the domestic institutions from the areas of agriculture and energy for understanding the process of planting forests on abandoned agricultural and other bare lands, preparation and adoption of the necessary regulations. Bearing in mind the prominent increase in demand for woody biomass in the last several years and announced investments in district heating systems, the demand for it will continue to grow in the following years as well. Since the capacities of the Serbian forest fund for supplying the biomass for energy purposes have already reached their maximum, the energy plantations and planting new forests represent one of the future sustainable biomass supply channels. The role of the international organisations in this process is important as well.
- When it comes to balancing the GHG emissions stemming from wood fuels consumption, it is necessary to continue working on strengthening the capacities of the institutions charged for environmental protection and monitoring. In this process, the role of international institutions is important as well.

## **5 USED REFERENCES**

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