Interreg
Danube Transnational Programme
DanuP-2-Gas

Deliverable D.T2.1.1

Biomass Report Serbia

Activity A.T2.1: Biomass potential analysis

May, 2022

Project co-funded by the European Union funds (ERDF, IPA)
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DOCUMENT CONTROL SHEET

Project reference	
Full title of the project	Innovative model to drive energy security and diversity in the Danube Region via combination of bioenergy with surplus renewable energy
Acronym	DanuP-2-Gas
Programme priority	Priority 3
Programme priority specific objective	SO 3.2 Improve energy security and energy efficiency
Duration	01.07.2020 – 31.12.2022
Project website	www.interreg-danube.eu/danup-2-gas
Project coordinator	TZE

Short Description
The potential for exploitable organic residue for each participating country listing key aspects such as location, amount, transport options and costs.

Document Details	
Title of document	Biomass Report (Serbia)
Action	WP T2 Transnational Infrastructure and Biomass assessment & Pre-feasibility Studies
Deliverable	D.T2.1.1
Delivery date	May 2022

Version	Date	Author	Organization	Description
V1	May 2022	B. Milosav B. Viduka S. Glavaski I. Zivkovic	RDA Banat	1st version

IMPRINT

This document is issued by the consortium formed for the implementation of the DanuP-2-Gas project by the following partners:

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ERDF PP1 Energy Agency of Savinjska, Koroška and Šaleška Region (SI)

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Version	Date	Author	Organization	Description
v1	26.10.2020	Kiril Raytchev	BSERC	Initial version
v2	05.11.2020	Kiril Raytchev	BSERC	Suggestions from the Supervisory board meeting (03.11.2020)
v3	21.12.2020	Kiril Raytchev	BSERC	Suggestions from PP12
v4	21.01.2021	Kiril Raytchev	BSERC	Internal call for feedback. See Meeting-minutes-20210127_V2 and Meeting-minutes-20210121

1. METHODOLOGY

Data collection process for the development of biomass database creation, on Serbian national level, was based on the publicly available data. Although it is not clear what is the status of the privately owned biomass, it can be concluded that most of the biomass on the national level is in-use or is contracted to be used for the specific period (e.g., several years, in case of woody biomass).

Regarding biomass availability, Serbia mostly relies on harvest residues, animal manure and in smaller portion to woody biomass which was also observed during the collection of data in this work. Other biomass sources considered were usable animal waste but in lower amount than the woody and post-harvest biomass as it will be explained later. The data about post-harvest biomass (different types of straw) should be taken with reserve due to the spatial layout. The fact is that the collected data needed to be linked to a physical location of the biomass source, but biomass from one producer is spread on the wide territory. That is very challenging, but total amount of this biomass available should not be neglected. There are significant amounts of land used for various crops, but there are no fixed collection points of residual straw. In most cases, if the straw is being collected, it is being done at the spot, and having in mind that the crops are regularly circulated, the potential amount of this type of biomass cannot be correctly attached to a specific geographical location.

The same basically applies to logging and logging residues. Most of Serbina forest area is state-owned which means that the distribution of the biomass is done through public procurement and auctioning system when the amounts of logs and residues are being distributed to processors after a public cal. Again, also in this case, there is currently no fixed collection point, but the state company which is in charge of the forest management "Srbijašume" and "Vojvodinašume" (Serbian forestry companies) offers three modes of transport, with different prices: directly at the stump (the buyer is responsible of hauling the log from the woods), at the nearest point approachable by the larger transport (the buyer is responsible for organizing the haul) and the direct delivery to the customer location. Since only the last one can be uniquely linked to the geographical position, the idea of not collecting logging locations was disregarded (since the logs are less likely to be directly used in P2G processes) and the focus was on the residues in logging processing by sawmills.

The amount of residues was calculated based on the initial mass of the logs assigned to a specific user and the average amount of residues based on the currently available technologies designed for the optimal log processing (cutting). Based on the pre-defined limiting factors for this project needs only the sawmills with above 1-5 tons/day were taken into consideration. Additionally, the companies who already have residue

processing as a part of their business (production of pellets and briquets) were not included in this list but in the separate one targeting this specific sources.

For the second part of the biomass database another set of estimates has been used. Each considered company received a combination of log types the average information was also used for the specific wood characteristics for the residues (LHV, Bulk density, Moisture, Hemicellulose, Lignin, Cellulose, Ash, Contaminants, Carbon) based on the available online sources and literature. The price of this type of biomass was estimated based on the currently available prices from online sources and lowered for a certain smaller percentage (the prices available are smaller amounts, but it would be plausible that a company would offer a lower price for a continuous supply for a P2G facility). The transport price mainly reflects the fact that the transport infrastructure in Serbia is reduced down to road by trucks, and the prices would be estimated to 0.15 € per ton and per kilometre. The nearest transport hubs in this section were selected from the second database used for this work based on the aerial distance. The prices have been gathered from an interview with a sawmill/carpentry owner in Serbia.

Concerning organic and biological waste streams, they mainly include animal manure (cows, pigs and chcikens). Municipal organic waste and sewage sludge from wastewater treatment plants were not considered because there is no organized waste collection and sorting is Serbia. Also, there are only few wastewater treatment plants in Serbia whose production of biomass is neglected. The information and data collected, that is presented in the database, is gathered from the companies, that were contacted to provide information on this type of waste stream. This data should be taken with reserve.

2. BRIEF DESCRIPTION OF SERBIA BIOMASS LANDSCAPE

According to the data from the Biomass Action Plan 2010-2012, biomass represents 63% of the total potential from renewable energy sources (RES) in Serbia. Forests cover about 30% of the territory, and about 55% of the territory is arable land. In Serbia, biomass is mostly used in the traditional way, in the form of energy for heating, cooking or heating water. In addition to these uses, biomass has recently been used for pellet production, heat production through combustion in boilers and cogeneration plants for electricity and heat production, but also as a raw material for biofuel production.

In Serbia, there are several strategic documents dealing with biomass, of which in addition to the Energy Development Strategy of the Republic of Serbia until 2025 with projections until 2030 ("Official Gazette", No. 101/2015) and the Strategy of Agriculture

and Rural Development of Serbia for period 2014-2024 ("Official Gazette", No. 85/2014), the National Action Plan for the Use of Renewable Energy Sources ("Official Gazette", No. 53/2013) should also be mentioned.

According to the National Action Plan for Renewable Energy Sources, RES with an estimated technically usable potential of about 5.6 Mtoe per year can significantly contribute to lower fossil fuel use and achieve defined goals on the share of renewable sources in total final energy consumption and environmental improvement. Biomass potential is about 3.4 Mtoe per year (2.3 Mtoe is unused and 1.1 Mtoe is already in use), 1.7 Mtoe in hydro potential (0.8 Mtoe per year is unused, and 0.9 Mtoe per year is used) hydro potential), 0.2 Mtoe per year in geothermal energy, 0.1 Mtoe per year in wind energy, 0.2 Mtoe per year in solar energy and 0.04 Mtoe per year in biodegradable waste. The Republic of Serbia already uses 35% of the total available technical potential of RES (0.9 Mtoe of used hydro potential and 1.06 Mtoe of used potential of biomass and geothermal energy).

The most important part of agricultural biomass in Serbia is used through direct combustion. Previous analyzes indicate that the main problems for the economical use of straw and other harvest residues are high costs of collection (harvesting and baling or other form of compaction), transport from the place of production to the place of consumption, and handling and storage. This cost problem is primarily caused by dispersion over large areas. The small area and fragmentation of land holdings in Serbia is a major obstacle to the economic collection, processing and use of agricultural biomass in Serbia.

In terms of use, small heat generators are the most common for the combustion of agricultural biomass, both in number and in total thermal power. Most often, these are simple stoves and boilers, and the use of wheat and soybean straw dominates, and the taste. In recent years, the use of agro briquettes and pellets from wheat and soybean straw has increased significantly. The price of agro briquettes and pellets per ton is about 2.5 times higher than baled straw. This form has the advantage of automated firing. The required storage space is significantly lower (the density is six to eight times higher), so it can be used in houses that do not have storage space, they are not agricultural farms. Agro pellets, whose price ranges from 60 to 70% of the price of wood, can also be used in suburban areas. Due to the higher density, transport over longer distances is possible.

The biggest problem of the current use of agricultural biomass in Serbia is that heat generators are used, with a low degree of efficiency and high emissions of pollutants, CO, CH, PM, and even NOx. It is a typical case that the seasonal efficiency of furnaces is below 50%, and boilers below 60% (Martinov et al., 2006). It is known that the degree of efficiency decreases, and the emission of pollutants increases when the boiler operates

at partial load. This problem is overcome by installing a heat accumulator. For many users, the extra investment in a heat accumulator and the accompanying control elements is too much.

Agricultural biomass, except in the form of biogas, is not used for cogeneration, and plans for the future are modest. The reason for this is that, except for some less applied technologies, steam boilers with precise dosing of voluminous biomass and a specially controlled combustion process are required.

POTENTIAL ASSESSMENT OF AGRICULTURAL BIOMASS IN SERBIA

The system of monitoring the potential of agricultural biomass has not been established in the Republic of Serbia. Within this document, the analysis of agricultural biomass potential includes (1) analysis of crop residues, (2) pruning residue analysis, (3) biofuel production analysis, (4) livestock energy production potential and (5) biomass potential generated in processing facilities. .

Total potential means total biomass produced. The real potential is obtained by subtracting from the total potential the quantities that cannot be collected and which are used for other purposes. For example, straw is used as a mat, or a base for the production of mushrooms and for other purposes.

Table 1 shows the total real potential of agricultural biomass as an energy source in Serbia1.

Type of biomass	*Real energy potential in toe*
Harvest residues	*1.036.828,00*
Remains of pruning	*133.602,00*
Biofuels	*142.770,00*
Manure	*176.526,32*
Processing industry and biodegradable municipal waste	*42.910,00*
In total	*1.532.636,32*

Table 1: Real potential of agricultural biomass as an energy source in Serbia

Harvest residues

The calculation of the energy potential of crops (cereals and industrial plants) was done for the level of annual production and the final potentials of biomass were presented in units of tons of oil equivalent (toe, 1 toe = 41,868 MJ). Data on cereals and industrial plants are presented in relation to average sown areas (in ha) and average yields (in t) in the period 2008 - 2017, and the calculation of harvest residues was done according to accepted scientific standards, as presented in Table 1. The usable part of harvest residues that can be collected and actually used for energy production is 30% of the

total harvest residues. The energy potential of harvest residues in AP Vojvodina represents about 45% of the potential in Serbia

Crops	*Crop / biomass ratio*	*Thermal power [MJ / t]*
Corn	*1 : 1*	*13.500*
Corn cobs	*1:0,2*	*17.000*
Wheat	*1 : 1*	*14.400*
Barley	*1 : 1*	*14.700*
Раж	*1 :1,1 2*	*14.400*
Oats	*1 : 1*	*14.400*
Triticale	*1 : 1*	*14.400*
Soy	*1 :0,6*	*15.700*
Sunflower	*1 : 2*	*14.500*
Rapeseed	*1 : 2*	*17.400*

Table 2: Calculation of thermal power of biomass and yield ratio of crops and biomass

CROPS	*SOWN AREA (ha)*	*AVERAGE YIELD (t / ha)*	*TOTAL BIOMASS (t)*	*TOTAL ENERGY AT ANNUAL LEVEL (MJ)*	*TOTAL ENERGY ON ANNUAL LEVEL (toe)*	*REALLY AVAILABLE POTENTIAL ON ANNUAL LEVEL (toe)*
Corn stalks	*1.013.000*	*5,3*	*5.370.000*	*72.495.000.000*	*1.731.513,3*	*519.453,998*
Corn clip	*1.013.000*	*5,3*	*1.073.780*	*18.254.260.000*	*435.995,51*	*130.798,653*
Wheat	*607.000*	*3,3*	*2.003.100*	*28.844.640.000*	*688.942,39*	*206.682,717*
Barley	*90.000*	*3,25*	*292.500*	*4.299.750.000*	*102.697,76*	*30.809,329*
Раж	*5.000*	*2,67*	*14.952*	*215.308.800*	*5.142,56*	*1.542,769*
Oats	*35.000*	*2,33*	*81.550*	*1.174.320.000*	*28.048,15*	*8.414,445*
Triticale	*18.000*	*4,24*	*76.320*	*1.099.008.000*	*26.249,355*	*7.874,807*
Soy	*167.000*	*2,42*	*242.484*	*3.806.998.800*	*90.928,60*	*27.278,581*
Sunflower	*182.000*	*2,5*	*910.000*	*13.195.000.000*	*315.157,16*	*94.547,148*
Rapeseed oil	*14.000*	*2,7*	*75.600*	*1.315.440.000*	*31.418,745*	*9.425,623*
IN TOTAL	*2.131.000*		*10.140.286*	*144.699.725.600*	*3.456.094*	*1.036.828*

Table 3: Biomass from harvest residues of cereals and industrial plants in the Republic of Serbia

Pruning remains

Another important source of agricultural biomass is residues from pruning orchards and vineyards. These data were calculated on the basis of the areas under which the plantations are located, ie the realized fruit yields. For the analysis, the most common types of fruit in the Republic of Serbia were processed, which also have the greatest opportunity to collect biomass from the process of pruning orchards. In the calculations, the ratio of the weight of fruit and biomass (twigs) from pruning was used, which is 1: 0.325, and in the case of vines, the ratio of the weight of the vine and twigs from pruning, which is 1: 0.457, was used. For the purposes of the calculation, it was taken into account that about 80% of the biomass from the orchards can be collected in practice. It should be noted that during the analysis of official data of the Republic Bureau of Statistics, it was noticed that the area of fruit and vine plantations has not changed in the last few years, so the data on yields presented in Table 4 were used for the analysis.

Fruits and grape	*Average production area (ha) 2008-2020*	*Total annual quantity produced-average 2008-2020 (t)*	*biomass residues after pruning (t)*	*Thermal power of biomass (MJ / t)*	*Total energy per year (000 MJ)*	*Total energy on an annual basis (toe)*	*Real potential on an annual basis (toe)*
Apple	*23.531*	*378.640*	*122.820*	*15.300*	*1.879.219*	*44.880*	*35.904*
Pear	*6.802*	*68.070*	*22.120*	*15.300*	*338.487*	*8.008*	*6.406*
Apricot	*5.255*	*33.000*	*11.000*	*15.800*	*168.352*	*4.020*	*3.216*
Cherry	*3.931*	*22.140*	*7.190*	*15.900*	*114.395*	*2.730*	*2.184*
Cherry	*15.438*	*113.260*	*36.810*	*15.900*	*585.265*	*13.980*	*11.184*
Peach	*6.330*	*71.410*	*23.210*	*15.800*	*366.671*	*8.760*	*7.008*
Plum	*77.142*	*422.600*	*137.350*	*15.800*	*2.170.073*	*51.830*	*41.464*
Quince	*1.719*	*13.170*	*4.280*	*16.500*	*70.604*	*1.690*	*1.352*
Walnuts	*4.307*	*17.680*	*5.750*	*16.500*	*366.671*	*2.260*	*1.808*
Other fruits	*5.570*	*3.363*	*10.930*	*15.300*	*167.273*	*3.990*	*3.192*
Vine	*21.781*	*162.646*	*74.329*	*14.000*	*1.040.609*	*24.854*	*19.884*
IN TOTAL	*173.806*	*1.305.979*	*455.789*	/	*6.992.040*	*167.002*	*133.602*

Table 4. Biomass from orchards and vineyards in the Republic of Serbia

Biofuels

The Republic of Serbia is obliged in the process of European integration to reach the level of 10% of biofuels in the transport sector by 2020. In the Republic of Serbia, soybeans, sunflowers and oilseed rape are crops from which, according to the latest

available data on sown areas and yields , could receive about 256.629 tons of biodiesel (Table 5). Total technical capacity is calculated as 20% of the total annual potential amount of biodiesel production

There are several plants in Serbia with installed capacities for biodiesel production which can produce about 105.400 tons of biodiesel annually.

It should be emphasized that in accordance with Directive 2009/28 EC for biofuels in terms of achieving national targets can be recognized only those biofuels that meet the prescribed sustainability criteria in accordance with the said Directive. A binding sustainability criterion in the RES Directive for the production of biofuels and bioliquids is the reduction of greenhouse gas emissions to be achieved through the replacement of fossil fuels with biofuels and bioliquids and should be at least 60% provided they are produced in plants that have started with work after October 5, 2015. In plants that were put into operation before October 5, 2015, the reduction of greenhouse gas emissions must be at least 35%, or 50% after January 1, 2018. This may lead to problems in the production of diesel as a biofuel that can be verified for use in accordance with this Directive.

Oil-plant	*Average grain yield in the period 2008-2020 (t / ha)*	*Grain oil content (%)*	*Biodiesel yield (kg / ha)*	*Average area under crops in the period 2008-2020 (10^3 ha)*	*Total biodiesel production (t)*	*Total biodiesel productionTotal biodiesel production potential in (toe)*
Sunflower	*1,79*	*40*	*716*	*200*	*163.444*	*146.392*
Soy	*2,25*	*18*	*405*	*182*	*83.887*	*75.135*
Rapeseed	*1,69*	*36*	*608*	*13*	*9.298*	*8.328*
IN TOTAL					*256.629*	*229.855*

Table 5: Potential biodiesel production in the Republic of Serbia

One of the options for future biodiesel production is the production of biodiesel in smaller systems where waste edible food from restaurants and the food industry would be used as raw material. Serbia is the leading country in the region with over 400 thousand hectares under oilseeds (sunflower, soybean, oilseed rape) and with more than 17.000 tons of oil produced. It is considered to be 10% of oil production (17.000 t) can be reused for biodiesel production.

The total real energy value at the annual level of biofuels (biodiesel, bioethanol and recycled oil) is 142.770 toe.

The Republic of Serbia does not have production capacities for the production of pure bioethanol that can be used as a fuel in traffic. Ethanol produced by biomass fermentation can be used either as fuel in specially designed engines or in a 3-15% ethanol to gasoline ratio. Bearing in mind that there are currently no plants for the production of biofuels from second-generation biomass and a short period to reach the very demanding goal of 10% of biofuels in transport, the Republic of Serbia will have to plan the import of biofuels. Therefore, it is necessary to encourage and win the production of second generation biofuels in the country. It is estimated that the construction of biorefinery capacities for the production of up to 200.000 tons of bioethanol (second generation biofuels) would require investments of 100 to 150 million euros.

Legislation provides for the payment of excise duties on biofuels, which makes biofuels uncompetitive in the market compared to petroleum products. In the previous period, there were attempts to exempt biofuels from paying excise duties, but there were abuses in the fuel market.

Manure

Livestock breeding in the Republic of Serbia mostly includes the breeding of cattle, pigs, sheep, goats and poultry. An important resource for energy production is biogas generated from manure. Manure is a suitable material for the production of biogas, because in addition to containing organic matter, it also contains anaerobic bacteria that can be used to start the process of anaerobic digestion. Table 6 presents the number of animals and manure production in the Republic of Serbia.

Species	*Average number of animals (10^3) in the period 2008-2020.*	*Manure production per head per year (t)*	*Total manure produced (10^3t) per year*	*Yield m^3 CH_4 per tonne of fresh manure **	*Total potential for biogas production from manure (10^3 m^3 CH_4)*	*Total primary energy production from manure produced from manure (toe)*	*Real production of primary energy from biogas produced from manure (toe)*
Cattle	*940*	*12,35*	*11.609*	*13.6*	*157.882,4*	*135.376,99*	*81.226,19*
Pigs	*3.274*	*1,6*	*5.238,4*	*14.4*	*75.432,96*	*64.680,5*	*38.808,3*
Sheep / goats	*1.849*	*0,5*	*924,5*	*48.0*	*44.376*	*38.050,5*	*22.830,3*
Poultry	*18.256*	*0,07*	*1.277,92*	*51.2*	*65.429,5*	*56.102,97*	*33.661,52*
Manure			*19.049,82*		*343120,86*	*294.210,96*	*176.526,32*

Table 6: Potential for energy production from manure produced from manure in the Republic of Serbia

The thermal power of methane CH_4 is 35.9 MJ / m. 1 toe = 41,868 MJ. Real energy potential accounts for 60% of the total potential.

Although manure has great potential for biogas production, it should be borne in mind that a large part of livestock is located on smaller farms, from which it is not realistic to plan the use of manure as biomass for energy production.

Processing capacities

MILK PRODUCTION

Milk production in the Republic of Serbia is at the level of about 1,5 billion liters per year, of which more than half of the total production is purchased by dairies. About 130 dairies are currently active in the Republic of Serbia. The potential for biogas production from the dairy processing industry is given in Table 7.

Quantity of processed milk in dairies in RS (m^3)	*Adopted amount of wastewater from the dairy processing industry (m^3 of wastewater per m^3 of processed milk)*	*Chemical oxygen demand (COD) in wastewater (kg / m^3)*	*Methane production per kilogram of removed chemical oxygen demand COD) (m^3 / kg)*	*Total methane (m^3)*	*Total primary energy (toe)*
750.000	*3*	*5*	*0.3*	*3.375.000*	*2.890*

Table 7: Potential for biogas production from the dairy industry

SLAUGHTER INDUSTRY

The Republic of Serbia has significant processing capacities in livestock production (1.176 facilities for slaughtering cattle, pigs, sheep / goats and poultry and cutting and processing of beef, pigs, poultry and fish). The degree of capacity utilization is significantly below the projected. Residues from meat processing are an ideal raw material for biogas production, because they contain a high concentration of organic matter (proteins, fats and carbohydrates).

Year	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Cattle in slaughterhouses (10^3 head)	*143*	*147*	*151*	*162*	*170*	*178*
Pigs in slaughterhouses (10^3 head)	*1.714*	*1.783*	*2.031*	*2.218*	*2.212*	*2.079*

Table 8: Number of slaughtered animals in slaughterhouses for the period 2015-2020.

Number of slaughtered animals	Potential for biogas production (kWh / per animal)	Total (kWh)	Total primary energy (toe)
158,500 head of cattle	361	57.218.500	11.650
2,006,000 pigs	39	78.234.000	

Table 9: Potential for biogas production from the meat processing industry

OTHER PROCESSING CAPACITIES OF THE FOOD INDUSTRY

Sugar beet production in the Republic of Serbia is shown in Table 10. Average annual sugar beet production for the period 2018-2020. amounts to 2.460.182 tons. The sugar beet processing industry consumes significant water resources. Wastewater from the sugar industry contains fermentable carbohydrates that can be used to produce biogas. The potential for biogas production from wastewater from the sugar beet processing industry is shown in Table 10.

Produced sugar beet in tons Average 2018-2020.	Wastewater production per tonne of sugar beet (m^3 / t processed beet)	Chemical oxygen demand in wastewater (kg / m^3)	Methane production per kg of chemical oxygen demand removed from wastewater	Primary energy production (toe)
2.460.182	1	4	0,3	2.530

Table 10: Potential for biogas production from the wastewater industry of the sugar industry

MUNICIPAL BIODEGRADABLE WASTE

For the purpose of municipal waste treatment, energy production can be one of the options. Municipal waste generation in R Serbia for the period 2016-2020. year is shown in Table 11.

Year	2016	2017	2018	2019	2020
Total amount of waste generated (10^6 t)	2,41	2,13	1,840	1,89	2,15

Table 11: Municipal waste generation in RS for the period 2016-2020.

In the Republic of Serbia, on average for the period 2016-2020. generated 2,084 million tons of municipal waste per year. The biodegradable fraction of municipal waste can be a resource for energy production. The potential to produce biogas from municipal waste is presented in Table 12. The assumption in this calculation is that 20% of municipal waste in the Republic of Serbia can be processed by anaerobic process to obtain biogas.

Amount of municipal waste generated per year (t)	*Available for biogas production (%)*	*Biogas production per ton of municipal waste (m3 / t of municipal waste)*	*Total biogas (m3)*	*Total primary energy from municipal waste (toe)*
2.084.000	*20*	*120*	*50.016.000*	*25.800*

Table 12: Potential for biogas production from municipal waste