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Biomass Report (Croatia)

Activity A.T2.1: Biomass potential analysis

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

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CONTENT

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1. METHODOLOGY

Data collection process for the development of biomass database creation, on Croatian 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, Croatia strongly relies on woody biomass which was also observed during the collection of data in this work. Other biomass sources considered were usable animal and human waste but in lower amount than the woody biomass as it will be explained later on. Croatia also has a potential in herbaceous biomass, but this was disregarded during the data collection, due to the fact that the collected data needed to be linked to a physical location of the biomass source, which is currently not applicable in the case of Croatia. Of course, 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. Almost 80% of Croatian 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 call [1]. Again, also in this case, there is currently no fixed collection point, but the state company which is in charge of the forest management "Hrvatske šume" (*Croatian forestry company*) 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 [2]. 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.

However, it should be noted that there are plans in development by Croatian forests company, which include the development of collection centres on national level. BioRES project[1] (ended in 2017) was working on development of such centres – Biomass Logistic and Trade Centres (BLTC) – which would present the basis for the development of BLTCs in Croatia.

Since the distribution of logs is done publicly, there is data available from the procurement calls which were used to estimate the final potential of the residues. The last available data was used, as published by *Hrvatske šume d.o.o.,* as a result of the public procurement call for the logs for the year 2021 [3]. The information contains the company names and the amount of the cubic meters of logs assigned. It also contains the type of wood assigned, but the final estimate of the mass of the potential residues was done with an averaged density.

[1] http://bioresproject.eu/

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) [4]. 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. Since, as described earlier, 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 [5] [6]. 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 Croatia is reduced down to road by trucks. From the previous analysis in the Energy-Barge project the prices would still be estimated to 0.3€ 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 northern Croatia.

Concerning organic and biological waste streams, they mainly include municipal organic waste and sewage sludge from wastewater treatment plants. The information and data collected, that is presented in the database, is gathered from the utility companies, that were contacted to provide information on this type of waste stream. Since waste management system is still in development phase in Croatia, most of the utility companies do not have separate collection of waste of biological origin or utilize it already for composting purposes. In terms of sewage sludge, the information and data collected are publicly available in forms of reports, that are formed annually and presented online (Register of Environmental Pollution[2]). The Registry presents the amounts that are generated – the treatment process is not determined, which makes them potentially available for utilization for P2G.

2. BRIEF DESCRIPTION OF CROATIAN BIOMASS LANDSCAPE

As it can be seen from the previous section, where it is also highlighted, the Croatia's biomass sector strongly relies on the forestry and related industry. This is not likely to change, given the conservative approach of the Croatian industry. However, also as mentioned earlier, there are additional biomass sources available in significant amounts (crop residues).

[2] http://roo.azo.hr/

In terms of residual biomass production Croatia scores quite well, compared to other smaller EU countries. 4.8 million tonnes per year of residues are produced, of which the main sources are cereals and oil crops. Only 1 million tonnes are known to be harvested at this moment (according to the Sankey diagram in Figure 1). Although a high percentage of these residuals can be mobilised, sustainability concept needs to be taken into account, of which the main is the conservation of organic carbon in the soil

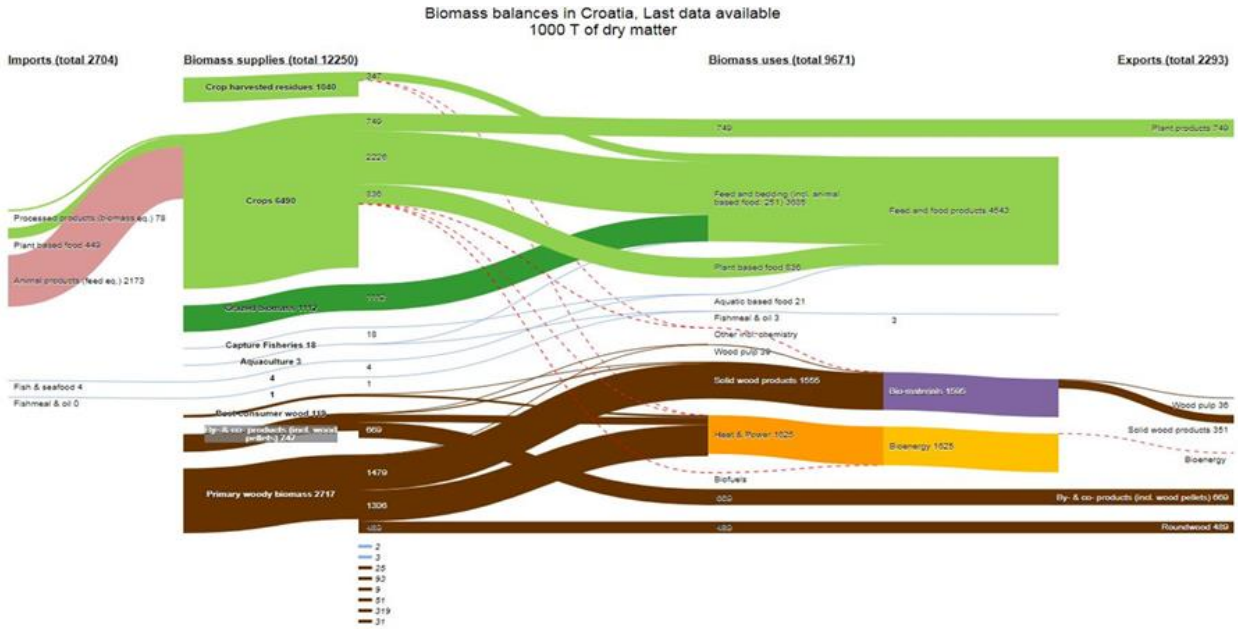

Figure 1. Biomass flows in Croatia (net trade), JRC Sanky Diagrams of biomass flows [7]

Croatia has a relatively large cropping sector and therefore the residual biomass potential from crops are certainly of interest. By-products from arable crop production are mainly in a form of straw, stalk corn and corn cobs. They are used for traditional purposes (bedding) and lately, emerging agropellets for fuel and feed.

How many crop residues (e.g. straw) can be removed sustainably, depends on several factors. The maintenance of soil organic matter is an especially relevant function of straw-removal. Also, the nutrient balance should be maintained, but nutrients are often replenished, by mineral fertilizer application practices. The input of soil organic matter, however, is often only dependent on crop residues left behind. The amount of straw to be kept in the field is complicated to estimate as it depends strongly on the soil and climate characteristics and the long-term management practices. To give a good estimate of residual biomass potentials that can be sustainable removed, Table 1 presents the results of a national assessment using average of time series data (2012-2016) as input and the methodology by [8]) and of the biomass potential assessments in the S2BIOM project [9].

Table 1. Availability of primary residual biomass from cereals and grain maize (tonne d.m.) in Croatia [10]

	Cereals straw		Maize stover (excl. cobs)	Maize stover (incl. cobs)	Corn cobs
	S2BIOM *(assuming soil carbon conservation and subtracting straw use for animal bedding & feed)*	Ćosić et al. (2011) using data 2012-2016 *(assuming soil C conservation and use for animals*	S2BIOM *(assuming soil C conservation and NO use for animals*	Ćosić et al. (2011) using data 2012-2016 *(assuming soil C conservation and use for animals)*	Ćosić et al. (2011) using data 2012-2016 *(assuming soil C conservation and use for animals*
Total	**548,496**	**1,000,000**	**1,201,316**	**350,000**	**340,000**

The amount of cereal straw is quite significant in Croatia amounting to 1 million tonnes d.m., when assessed according to the Ćosić et al., and 550,000 tonnes d.m., when assessed in the S2BIOM approach. The difference is related to the application of a carbon balance model, taking account of diversity in carbon levels in the soils in Croatia, which leads to a larger diversity in sustainable removal rates over the country then the standard fixed sustainable removal rate applied in the Ćosić et al. methodology.

The maize stover availability is also significant but given the large difference between the S2BIOM estimate and the Ćosić et al. approach, one can conclude that a large part of the stover is already going to animal bedding and feed. Still, there is an unused potential of 350,000 tonnes d.m. In addition, a similar amount of biomass should also be available from the remaining cobs. Initiatives are already starting to make pellets from these primary residues.

However, these amounts are not considered in the national biomass database, due to a simple reason – there are no specific collection points and collection should be handled directly between the provider and user. Introduction of larger sites which would serve as a trading and collection points (for both herbaceous and woody sources/residues) could enable wider use of this sourced in modern processes.

Furthermore, agri-food sector in Croatia has a long tradition and is deeply rooted in rural space, history and development of the country. Therefore, residues from this sector can also make an impact in the utilization of biomass for P2G concept. Residues from fruit processing (pits, pulp, water) represent an excellent opportunity to improve cost efficiency of agri-food processing companies. This is particularly urgent for fruit processing companies. While fruit growing agro-techniques are outdated, food processing industry is able to keep up the pace with the technological development. Generating yield from waste streams just started to be considered as a good opportunity to improve competitiveness. It is likely that hesitation lies in the necessity to step out from the current marketplace and food processing as core business. Moreover, wine producers have considered pelletizing grape pomace for either feed or fuel but without significant market uptake. Pomace is usually processed to hard spirit, similar to Italian grappa. There is room to improve competitiveness through increasing the use of by-products in the wine-making process in Croatia.

Additionally, the use of olive oil residues has been considered in numerous projects but with little success. Recently, a small olive cake pelletizing facility (6,000 t/year) in Istria started producing solid biofuels for the market. The challenge in utilising olive processing waste is their fluctuation over the time: i.e. yield in 2007 (58 hl) and yield in 2014 (11 hl) and high seasonality.

However, these biomass sources are not considered and data on the amounts for them are not publicly available. Additionally, waste amounts produced from agri-food sector and plants are mostly treated by various treatment companies, which makes these amounts unavailable for the purpose of this project.

In terms of forestry and woody biomass, Croatia has a relatively large forest potential for the small size country it is. This results in a large primary and secondary forestry potential. Forests are considered as one of the most important resources for Croatian economy, both as energy source and feedstock for wood processing industry [10]. According to the Forest Management Area plan for period 2016-2025 the Prescribed harvest (felling) in this period is 80,371,722 m^3 on total area of 1,288,821 ha (Table 2). Regarding previous management period 2006-2015, this represents a total increase in cut for 14,727,969 m^3, followed by a decrease in total area available for cut for 12,988 ha, which implies higher cut on smaller area.

Table 2. Planned and achieved cut in period 2006-2015 and prescribed harvest for period 2016/2025 [11]

FMAP 2006 -2015	Prescribed harvest	Achieved cut	% achieved	Prescribed harvest in 2016-2025 (m^3)	Prescribed harvest in 2016-2025 (tonnes d.m.)
	m^3				
Croatian forests Ltd.	57,935,018	53,639,369	93	64,196,393	36,881,791
Other legal bodies	661,366	128,463	19	525,372	301,834
Private forest owners*	7,047,369	2,392,543	34	15,649,957	8,991,135
Total period	65,643,753	56,160,375	86	80,371,722	46,174,760
Total annually	6,564,375	5,616,038	/	8,037,172	4,617,476

*The numbers regarding private owners includes wood assortments derived from management units for which management plans have not been made at the time. This number should be taken with caution due to reliability and availability of data for this estimation since for some years data were not available.

Croatian Forests Ltd. are by far the largest primary biomass producer and the largest woodchip producer at the domestic market (capacity of around 850,000 mil. m^3). The contracts for woodchip supply were assigned through contracts in 2015 for 640,000 tonnes and additional 120,000 tonnes in 2016. The existing contracts were revised in 2019, and biomass was allocated from cogenerations that have not fulfilled the requirements

to the new subjects selected through the public tender. The interest in biomass was much higher than quantities available (265,000 t of woodchips or 265,000 m^3 of fuel wood) and allocated through the public tender, which indicated a need for more biomass among energy producers. Along Croatian Forests Ltd. as main biomass producer, there are several additional smaller producers of woodchips.

Moreover, wood processing and furniture production is an important segment of Croatian economy. It represents 6.14% of industrial production, contribution 3.6% to the GDP. There are ~40 sawmills with maximal capacity of stemwood processing 1.1 mil. m^3/annually [12].

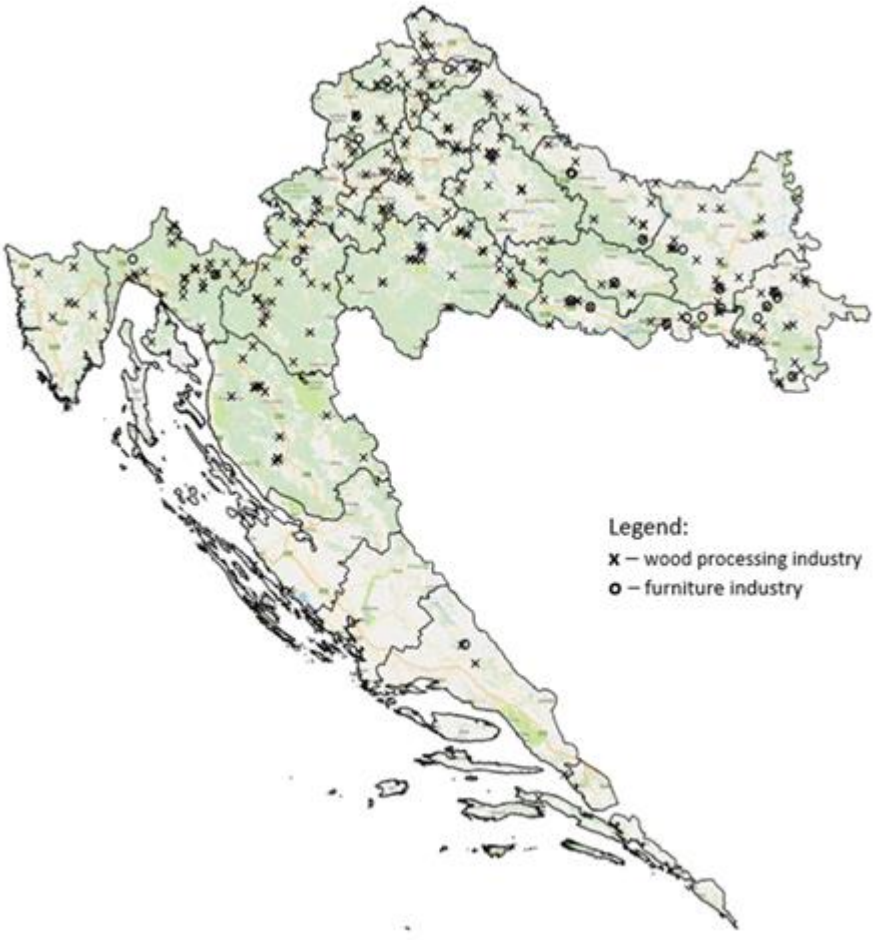

Figure 2. Distribution of wood processing subjects and furniture industry [13]

Many wood processing industries nowadays have adjacent cogeneration plants in which they utilise residues from their processes (e.g. sawdust). This has proved to be most convenient way to manage waste wood and

to secure cheaper heat and power for industrial processes. The data in the national biomass database present publicly available information on the produced secondary biomass source from wood processing industries. Yet, the exact quantity of waste wood is unknown due to incomplete reporting to the Ministry of Environment and Energy by all wood processing companies [10].

Wood industry is a significant source of wood residues that can be used for energy production or other purposes. The availability will depend on production of main products and the pathways the wood residues take (e.g. feedstock for other material products). Wood residues from wood processing industry are for the most part already being used by the industry for own energy production needs or sold on the market.

Forest harvesting residues can also be collected. However, further assessments are needed to establish their location and the available amounts which can be recovered at acceptable costs and without harmful environmental effects.

The information provided in the national biomass database are publicly available information and information collected through communication with Croatian Forests – it should also be noted that most of the presented biomass – mainly forest biomass – is utilized and planned to be utilized.

On the other hand, waste-sector biomass is not fully developed in terms of complete utilization of produced biomass – most of the waste produced still ends up in landfills. In order to satisfy the goals set for Croatia by the EU (maximum of 10% of municipal waste landfilled by 2035), the share of separately collected biodegradable waste types and biodegradable waste that should be energy and/or materially recovered will increase (e.g. collected biowaste should be above 40% by 2022). Total waste generation per category for the period 2010-2017 is presented in Table 3. These amounts are related to biodegradable non-hazardous waste categories that could be considered for waste management within the P2G hub scope. It should be mentioned that in period 2010-2013, biodegradable waste was considered only as a share of municipal waste – from 2014 a new Methodology for determining composition and amounts of municipal, i.e. mixed municipal waste by Croatian Agency for Environment and Nature was introduced, where biodegradable waste was separated in specific waste categories.

Table 3. Municipal biodegradable waste amounts produced in Croatia in period 2010-2017 [14]

Year	Amount of total produced waste [t]	Amount of landfilled waste [t]
2010	1,012,651	963,889
2011	1,017,519	937,375
2012	1,078,295	892,049
2013	1,103,593	870,434
2014	1,083,596	819,757
2015	1,070,783	828,564

2016	1,072,439	831,977
2017	1,091,066	801,238

Moreover, it should be noted that biodegradable waste in Croatia includes the following waste types: paper, cardboard, biowaste, textile and wood, etc. Since most of the aforementioned waste types are recyclable, which are planned to be treated in Waste Management Centres, the remaining waste type for energy and material recovery is biowaste. Therefore, collected data on biodegradable waste that can be used within P2G hub was obtained from communication with utility companies and the information they had available.

Additional feedstock that can be used within P2G hub is sewage sludge from wastewater treatment plants (WWTP). The amount of produced sewage sludge in Croatia is around 35,000-40,000 tonnes per year (around 20,452 tonnes of dry sludge matter) [15]. Of that amount, around 50% of the sludge is produced by and located at the site of the Central Device for Wastewater Purification of the City of Zagreb. It is additionally estimated that, on a national level, around 1,100-2,000 tonnes of sludge are used for agricultural purposes and 110-200 are composted annually[3]. The remaining sludge is mostly landfilled. Although this biomass potential is relatively small, the amounts of sewage sludge will grow in the future with construction of WWTPs with higher wastewater treatment levels (Figure 3).

[3] *CAEN, Management of sewage sludge from WWTPs when sludge is used in agriculture, 2010-2017*

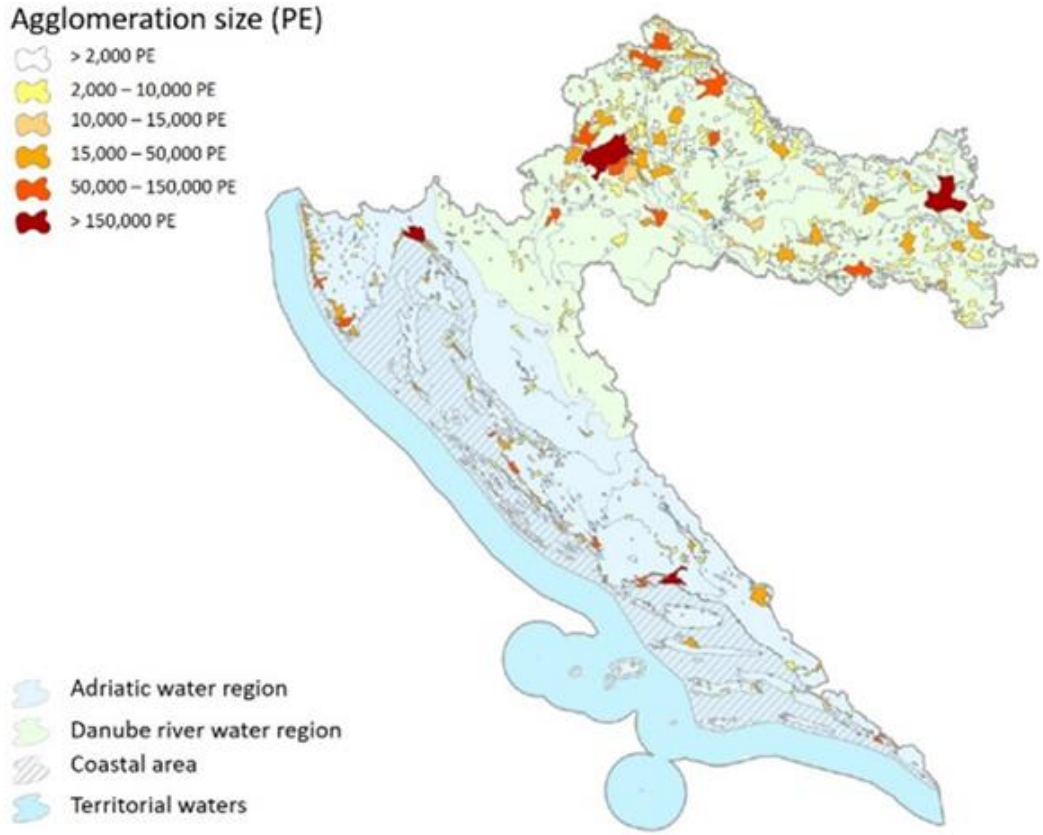

Figure 3. Spatial arrangement of agglomerations in Croatia [16]

If all future and planned WWTPs in Croatia would operate under full load, they would generate between 95,000 and 101,000 tonnes of sewage sludge dry matter per year (considering the production of 30 kg dry matter/person equivalent per year [17] (data from WWTP Zagreb), which is a significant increase compared to current state. However, currently an adequate management system for residual sludge from WWTPs is not established yet, primarily meaning the necessary infrastructure for treatment. Therefore, the obtained data presented in the national biomass database, is based on the delivered information from current sludge handlers (mainly utility companies) and publicly available data.

Additionally, a large potential still remains in using aquatic biomass, with around 6,000 kilometres of Croatian seacoast. However, this potential is still untapped and not fully discovered, as research has only recently begun to examine it.

As mentioned before, the data and information presented in this report and database are based mainly on publicly available data. There are other various sources (especially in the private sector), which could contribute to P2G hub, with available biomass sources. However, as Croatia and its stakeholders are not

familiar with the P2G concept, most of the biomass sources are already utilized for other purposes, with the goal of extracting maximum technical and financial benefits. With Danube-2-Gas project, the goal is to present other possibilities and informing biomass producers on these possibilities, potentially making them aware on other options of biomass utilization and providing information on their biomass amounts.

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