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Infrastructure Report (CROATIA)

Activity A.T2.2: Infrastructure analysis

September, 2022

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Project reference	
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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	
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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
v5	31.12.2021	Kiril Raytchev	BSERC	Synching with the Interface of the Optimization tool; Added request for information about biochar transport prices; Added request for information about costs for connecting to water / gas / electrical grid; Accompanying versions of other templates: V6_D.T2.1.2_Biomass Database_COUNTRY; V6_D.T2.2.2_Infrastructure Database_COUNTRY; V1_Pre-feasibility Study__COUNTRY; V4_D.T2.1.1_Biomass Report_COUNTRY

1. METHODOLOGY

This document provides the overview of the several infrastructure data in the case of Croatia. For gathering of the information several sources were used, mainly registers of the Croatian Energy Market Operator (HROTE d.o.o.).

Vrsta postrojenja (Plant category)	Registarski broj (Registry number)	Naziv projekta (Project)	Nositelj projekta (Project coordinator)	Grupa (Plant type)	Županija (County)	Lokacija (Location)	Električna snaga (Electrical capacity [MW])	Toplinska snaga (Thermal capacity [MW])	Vrsta rješenja (Type of approval)	Datum izvršnosti (Date of enforceability)
Sunčana elektrana - Solar power plant (3806)							378,3543	0,0000		
	00678734173-1232/17	Sunčane elektrana Gradić	LUMEN SOLIS d.o.o. za usluge	2.i.	Zadarska	BENKOVAC	9,9			
	01269966237-1005/13	Sunčana elektrana Lux-1	CASTUS LUX d.o.o.	1.a.3.	Istarska	Kaštelir – Labinci – Castellier-S. Domenica	1			
Hidroelektrana - Hydro power plant (50)							1678,0190	0,0000		
	09518585079-1226/17	HE Orlovac	HEP - Proizvodnja d.o.o. za proizvodnju električne i toplinske energije	2.a.	Splitsko-dalmatinska	SINJ	240			
	09518585079-1227/17	HE Čakovec	HEP - Proizvodnja d.o.o. za proizvodnju električne i toplinske energije	2.a.	Međimurska	Orehovica	79			
Vjetroelektrana - Wind power plant (50)							2096,3500	0,0000		
	09518585079-1205/18	VE Plat Jelenje	HEP - Proizvodnja d.o.o. za proizvodnju električne i toplinske energije	2.b.			26			
	09518585079-1299/18	Vjetroelektrana Bradarić Kosa	HEP - Proizvodnja d.o.o. za proizvodnju električne i toplinske energije	c.4.			58			
Elektrana na biomasu - Biomass power plant (120)							218,8180	386,6900		
	00759976530-0517/11	Energana Gornji Bogićevci	SINUSOIDA d.o.o. za proizvodnju, trgovinu i usluge	2.c.1.	Brodsko-posavska	Gornji Bogićevci	2,96			
	00046940402-1200/15	Kogeneracijsko postrojenje na bazi izgaranja drvne biomase	BIOENERGIJA LIPOVLJANI društvo s ograničenom odgovornošću usluge	2.c.i.	Sisačko-moslavačka	Lipovljani	2	6,2		
Elektrana na bioplin - Biogas powerplant (78)							76,2690	1126,0028		
	07396248233-1142/15	BPE BIOEL	BIOEL društvo s ograničenom odgovornošću za proizvodnju električne energije iz obnovljivih izvora energije	1.f.ii.	Bjelovarsko-bilogorska	Dubrovac	0,999	1,07		
	09542282383-1100/14	BP „SIZIM BIO-NERO"	Obiteljsko poljoprivredno gospodarstvo - OPG Zlatko Markan	2.a.i.	Koprivničko-križevačka	Legrad	2			

Figure 1. Overview of projects in the Register of renewable energy sources and cogeneration and eligible producers (Source: Ministry of Economy and Sustainable Development)

In the case of industrial powerplants, the information has been taken from the regular energy report for Croatia [1] and it was also checked whether there are direct transport hubs related to the plants. In three cases, the plants have their own freight train terminals, and in those cases that transport hub point was the one listed in the database (the secondary transport hub was not searched for).

Connection points for various energy sources were searched for using the available geographical information. Most of the data collected referred to the electrical connection points (transformation stations available in the country), which were obtained through communication with the HEP d.o.o. However, the remaining data was difficult to collect – the starting point was the schematic representation of the network provided by the national electric energy company (HEP d.o.o) [2]**, which** soon proved to be difficult to analyse, as well as time consuming. In the end, it was used as a reference for gathering detailed location information. The second source used was an online database with generally correct placement of all the transformation stations [3]. Information provided there was cross checked with the satellite imagery and the schematic representation mentioned earlier and proved to be a valid source of spatial information. The same source was used when searching for the information regarding the transnational connections, as well as providing the type of voltage connection for each point.

In terms of water connections, utility companies providing the service, were contacted, with the intention of trying to find specific points for P2G hubs to connect to the water grid. However, the feedback from utility companies was that connection points were possible anywhere near the existing water grids. As the Tool for Optimizing Sector Coupling Hubs cannot incorporate the entire water grid, only specific locations, it is considered that P2G hub can be connected anywhere along the water grid. Through communication with utility companies, it was concluded that the connection to the water grid, in financial terms, is quite low, especially in comparison to the entire P2G hub.

Regarding the gas grid the reasoning for choosing said locations were due to the uncertainty of biomethane production pressure (1 bar). Given no definitive processes are mentioned, the production pressure may be at or slightly above atmospheric pressure. Natural gas transportation network in Croatia operates at a pressure of 40 – 75 bar. In order to raise methane pressure from atmospheric to transportation pressure compressors of high power of needed. The cost of such compressors and relevant infrastructure, such as power lines, power stations, land area, etc. is enormous. The locations mentioned in the report already have such infrastructure in place. This would allow for atmospheric biomethane to be compressed into transportation pressure even if the generation took place at atmospheric conditions.

As far as transport hubs are concerned, there were several located, with first ones mentioned earlier, which were a part of the industrial plants. As the majority of the inland transport in Croatia is done by road, the work was focused on industrial freight train facilities (road-rail transport hub) which would be capable of handling larger amounts of goods [4]. The list of these industrial train stations was found in several reports also listing the potential capacities of each. Additionally, several seaports are being listed. All sea/river ports act as hubs with three modes of transportation since they usually include the train and road vehicle loading facilities.

The distances used for linking other information to the transport hubs were calculated as aerial ones based on the geographical locations and have been also checked by the Distance Matrix API supplied by Google Maps.

2. BRIEF DESCRIPTION OF CROATIAN INFRASTRUCTURE LANDSCAPE

In the recent years there has been some progress in renewable energy infrastructure installation. However, compared to other countries, Croatia still has much to improve. This is clearly visible in the case of harvesting the potential of solar energy. Despite its beneficial geographical location, Croatia is, in EU terms, only in front of Finland, Estonia, Ireland and Latvia, all of which have far worse conditions. Due to the lower installation costs, there has been some improvement in small photovoltaic installations (housing), but not so much on the larger scale. Wind energy has been harvested in higher extent, also with some new planned projects. Croatia has also traditionally relied on the hydroelectric powerplants, with some of the recent new project being held due to environmental concerns.

2.1 ELECTRICAL ENERGY SECTION

Prices for entrepeneurs as available from “Hrvatska Elektroprivreda” based on the Decision on amount of tariff items for guaranteed electricity supply [5] and are displayed in the tables below.

Table 1. Tariff items for first two months of using guaranteed supply (UT=unique tariff, HT=high tariff, LT=low tariff)

Tariff model		Tariff item for energy [EUR/kWh]		
		EN_{UT}	EN_{HT}	EN_{LT}
High voltage		/	0,137	0.055
Medium voltage		/	0,133	0.054
Low voltage	Blue	0.129	/	/
	White	/	0.15	0.088
	Red	/	0.13	0.077

Table 2. Tariff items after first two months of using guaranteed supply (UT=unique tariff, HT=high tariff, LT=low tariff)

Tariff model		Tariff item for energy [EUR/kWh]		
		EN_{UT}	EN_{HT}	EN_{LT}
High voltage		/	0,155	0,091
Medium voltage		/	0,152	0.089
Low voltage	Blue	0,148	/	/
	White	/	0,17	0,1
	Red	/	0,148	0,087

Table 3. Tariff items for the distribution of the electric energy for the first two months of operation

	Tariff model	Element					
		Work force					
		Unique tariff	High tariff	Low tariff	Peak workforce	Excessive reactive energy	Metering point charge
		HRK/kWh	EUR/kWh	EUR /kWh	EUR /kWh	EUR /kvarh	EUR /month
High voltage	White		0,142	0,083	1,858	0,021	9,025
Medium voltage	White		0,193	0,088	3,451	0,02	8,759
Low voltage	Blue	0,171				0,02	5,481
	White		0,196	0,111		0,02	5,481
	Red		0,158	0,09	5,109	0,02	5,481

Table 4. Tariff items for the distribution of the electric energy after the first two months of operation

	Tariff model	Element					
		Work force					
		Unique tariff	High tariff	Low tariff	Peak workforce	Excessive reactive energy	Metering point charge
		EUR /kWh	EUR /kWh	EUR /kWh	EUR /kWh	EUR /kvarh	EUR /month
High voltage	White		0,171	0,094	1,858	0,021	9,025
Medium voltage	White		0,17	0,099	3,451	0,02	8,759
Low voltage	Blue	0,189				0,02	5,481
	White		0,217	0,123		0,02	5,481
	Red		0,176	0,1	5,109	0,02	5,481

Higher and lower tariffs are distributed as follows:

	Low tariff	High tariff
Daylight saving time period	22 – 8	8 – 22

Rest of the year	21 – 7	7 - 21

There is an additional fee for supporting the renewable energy sources and cogeneration in the amount of 0.1050 HRK/kWh, which does not a apply to users with a special permit for greenhouse gas emissions [6].

Out of the total electrical energy production, around 57% came from renewable sources (hydropower – 43%, wind – 12%, solar and geothermal – 0,7% each) [1].

The data available for the year 2020 [1] shows that in the year 2020 the gross electrical energy consumption was 1,8024.6 GWh. In the same year the production was 13,385.3 GWh, with 7,090.6 GWh of electrical energy came from the import, and there was 2,451.3 GWh of electrical energy exported.

A rough estimate price for electrical grid connection would be around 150000 HRK/km (~20000 EUR/km) [7]

An estimate for the unit price per kilometer can be drawn using the current plan for expanding the electrical network [8] which is focusing on 20kV lines using 95/15 Al/Fe cables mostly with plastic isolation (XHE/XHP). The plan is to build 145 km of new underground lines with an estimated cost of approx. 6.3 M EUR. The current which could be pushed through these lines is approx 215A. This evaluates to

$$\frac{3 * 20}{\sqrt[2]{3}} [kV] * 215\ A = 7.5\ MW$$

Finally considering the above cost for the planned length of the gridlines:

$$\frac{6.3\ MEUR}{7.5MW * 145km} = 5.79\ \frac{EUR}{kW * km}$$

A similar approach can be used to tackle the estimation of the unit price for the transmission, assuming that the network connected to is 110 kV one. Using typical cable setup (Al/Fe 150/25 mm2) with the rated current through roughly at 270 A one can (using the same formula as above) get the amount of 50MW potential for transmission. Again, the plan envisages an investment of around 3 M EUR for 17 km long lines (over mountainous terrain) and 1.5 M EUR for continental which averages out to around 0.12 M EUR / km and the final estimated price:

$$\frac{0.12\ M\ EUR}{50\ MW * 1\ km} = 2.55\ \frac{EUR}{kW * km}$$

The prices for secondary and tertiary regulations are depended on many coefficients and can be calculated using the formulas available in the Pricing Methodology for Providing Balance Service [8] [9]

2.2 NATURAL GAS ENERGY SECTION

Gas prices are regulated according to the decision by the Croatian Energy Regulatory Agency (HERA) [10] and are show in the following tables.

Table 5. Tariffs for the gas transmission

Tariff type	Label	Title	Tariffs for the year of regulation period (no VAT included)					Unit
			T	T+1	T+2	T+3	T+4	
			2021.	2022.	2023.	2024.	2025.	
Tariffs for contracted constant capacity annually for inputs to the transport system	TU,IN	Tariff for input at the interconnection	0,338	0,337	0,347	0,360	0,361	EUR/kWh /day
	TU,PR	Tariff for input from the production	0,338	0,337	0,347	0,360	0,361	EUR/kWh /day
	TU,SK	Tariff for input from the storage	0,034	0,034	0,035	0,036	0,036	EUR/kWh /day
	TU,UPP	Tariff for input from the LNG terminal	0,287	0,286	0,197	0,206	0,205	EUR/kWh /day
Tariffs for contracted constant capacity annually for outpus from the transport system	TI,IN	Tariff for outpu at the interconnection	0,203	0,196	0,197	0,206	0,205	EUR/kWh /day
	TI,HR	Tariff for output from the country	0,203	0,196	0,197	0,206	0,205	EUR/kWh /day

Tariffs for distributions are granted to all producers separately, an example for one is given below.

Table 6. Tariffs for distribution (Brod-plin d.o.o).

Tariff types	Label	Tariff model	Tariffs for the year of regulation period (no VAT included)					Unit
			2022.	2023.	2024.	2025.	2026.	
Tariff for distributed amount of gas	Ts1	TM1	0,003	0,003	0,004	0,004	0,004	EUR /kWh
		TM2	0,003	0,003	0,004	0,004	0,004	EUR /kWh

		TM3	0,003	0,003	0,003	0,003	0,003	EUR /kWh
		TM4	0,003	0,003	0,003	0,003	0,003	EUR /kWh
		TM5	0,002	0,003	0,003	0,003	0,003	EUR /kWh
		TM6	0,002	0,002	0,002	0,003	0,003	EUR /kWh
		TM7	0,002	0,002	0,002	0,002	0,003	EUR /kWh
		TM8	0,002	0,002	0,002	0,002	0,002	EUR /kWh
		TM9	0,002	0,002	0,002	0,002	0,002	EUR /kWh
		TM10	0,002	0,002	0,002	0,002	0,002	EUR /kWh
		TM11	0,002	0,002	0,002	0,002	0,002	EUR /kWh
		TM12	0,001	0,001	0,001	0,001	0,001	EUR /kWh
Fixed monthly fee	Ts2	TM1	1,327	1,327	1,327	1,327	1,327	EUR
		TM2	1,327	1,327	1,327	1,327	1,327	EUR
		TM3	2,654	2,654	2,654	2,654	2,654	EUR
		TM4	3,981	3,981	3,981	3,981	3,981	EUR
		TM5	5,309	5,309	5,309	5,309	5,309	EUR
		TM6	7,963	7,963	7,963	7,963	7,963	EUR
		TM7	13,271	13,271	13,271	13,271	13,271	EUR
		TM8	19,907	19,907	19,907	19,907	19,907	EUR
		TM9	26,543	26,543	26,543	26,543	26,543	EUR
		TM10	39,814	39,814	39,814	39,814	39,814	EUR

		TM11	53,086	53,086	53,086	53,086	53,086	EUR
		TM12	66,357	66,357	66,357	66,357	66,357	EUR

Tariff models TM1 to TM12 ara based on the annual gas consumption and are as follows (TM1 < 5000 kWh/year, TM2: 5000 - 25000 kWh/year, M3: 25000 - 50000 kWh/year, TM4: 50000 - 100000 kWh/year, TM5: 100000 - 1000000 kWh/year, TM6: 1000000 - 25000000 kWh/year, TM7: 25000000 - 50000000 kWh/year, TM8: 50000000 - 100000000 kWh/year, TM9: 100000000 - 250000000 kWh/year, TM10: 250000000 - 500000000 kWh/year, TM11: 500000000 - 1000000000 kWh/year, TM12: > 1000000000 kWh/year).

The price for building the infrastructure depends on many factors and the prices per items can be found in the document supplied by Plinacro company (including prices for energy consent, regulation equipment, valves, assembly, etc) [11] [12]. The only fixed price is the fee for connecting to the gas grid which is regulated by the Croatian Energy Regulatory Agency (HERA) according to the Decision on the fee for connection to the gas distribution or transmission system and for increasing the connection capacity for the period of 2022.-2026. [13] which defines the prices according to the connection category:

- Category I (capacity <= 100 kWh/h) : ~122 EUR
- Category II (capacity >100 kWh/h and <= 400 kW/h) : ~388 EUR
- Category III (capacity > 400 kWh/h and <=4000 kW/h) : ~663 EUR
- Category IV (capacity > 4000 kWh/h) : ~1074 EUR

After all the documents are collected by the investor (main project of gas installation, energy compliance, cost estimate, etc) and the contract is signed with the operator, the actual work of building the gas connection is done by an authorized contractor of gas connections and installations (the list available in [14]), and the final works are done exclusively by the distribution system operator.

In case that the gas grid is not readily available and close for the immediate connection one can make an estimate on the prices based on available reports. A really rough one (based on some articles about expansion of the gas grid) of the installation cost is not so straightforward since the reported investment prices in gas grid expansion range from 20 000 to 100 000 EUR/km.

As in the case for electrical energy a rough estimate can be done by looking into available investment information, so in one case of a large pipeline with 12.8 km in length which was reported to cost around 195 000 EUR one could assume a flow of 4000 m^3/h with the total power of 38 000 kW. The cost of investment would in this case for distribution be calculated as:

$$\frac{195\,000\,EUR}{12.8km * 38000\,kW} = 0.4\,\frac{EUR}{kW * km}$$

For the transport grid investment, another pipeline of 32 km in length costs as reported around 8.3 M EUR, and assuming the 15 m/s flow through the pipeline scaled down to atmospheric pressure would yield an amount of 23.5 m^3/s which combined with the calorific value of natural gas provides a total power of around 807 600 kW. As in above, using the following formula one calculates the final estimated cost for transport grid investment:

$$\frac{8.3\ M\ EUR}{32km * 807\ 600\ kW} = 0.32\ \frac{EUR}{kW * km}$$

2.3 BIOCHAR SUPPLY SECTION

Currently there is no commercial biochar supply in Croatia on larger (or non-academic) scale, so the prices are not available.

2.4 WATER SUPPLY SECTION

Generally, connecting an industrial consumer to residential water system is not commonly done, so in the following text, the fees for drilling a well and collecting the water for processing is presented.

Water use in Croatia is regulated by the Decree on the fee for the use of water [15] (updated with 83/2012, 10/2014), the Ordinance on the calculation and collection of water use fees (NN 84/2010, 146/2012) and the Decree on the amount of water contribution (OG 78/2010, 76/2011, 19/2012, 151/2013, 83/2015, 42/2019 i 73/2020),

Table 7. The water contribution fee is prescribed by the Decree on the amount of water contribution with the following amounts (EUR / m3)

		Zone A	Zone B	Zone C
Business buildings	m^3	1,111	0,668	0,334
Production buildings	m^3	0,199	0,119	0,040
Product pipelines	m	0,196	0,133	0,065

Zone A (City of Zagreb and the protected coastline), Zonb B (the rest of the teritory except zones A and C) , Zone C (areas of the special concern for the state).

Water management fee is calculated according to the Decree on the amount of the fee for water management (82/2010, 108/2013) and the Ordinance on the calculation and collection of fees for water management (83/2010, 126/2013), and for the P2G hub case it would be 0,139 EUR/m2/month.

The fee for the use of water is calculated according to the Decree on the fee for the use of water (OG 82/2010, 83/2012, 10/2014) and the Ordinance on the calculation and collection of water use fees (NN 84/2010, 146/2012) which states that the amount of fee for the use of water for the operation of the plant, except for the plant for the production of electricity, is 0,265 EUR per year for one kilowatt (kW) of the total installed capacity of the plant.

The final fee is the one needed for the protection of the waters as defined by the Decree on the fee for water protection (82/10, 83/12, 151/2013) and the Ordinance on the calculation and payment of water protection fees (83/10, 160/2013) which define the fee with the following formulas:

A) for discharging of water used in technological processes in the public collectors:

$$N = T \times V \times k_1 \times k_2 \quad (1)$$

B) for discharging water used for cooling:

$$N = T_{\Delta t} \times V_t \times \Delta t \quad (2)$$

C) for discharging the mix of cases A and B

$$N = (T \times V \times k_1 \times k_2)+(T_{\Delta t} \times V_t \times \Delta t) \quad (3)$$

Where T denotes the base fee (for 1 m3 of the discharged water) = 0,179 EUR, $T_{\Delta t}$ is the base fee for cooling water = 0,0002 EUR / m3, V is the annual amount of discharged water (in m3), V_t is the amount of discharged water used for cooling (in m3), k1, k2, and kf are correction coefficients used for the last case and are determined after the inspection of the water being discharged. Δt is the difference between the mean values of water temperatures on the inlet and the discharge.

Price of building a water well would be negligible in the total amount of the facility installation cost.

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