

ENERGY BARGE

Building a Green Energy and Logistics Belt

Project Code: DTP1-175-3.2

Deliverable 3.2.3

Regional case studies

for biomass and bioenergy production –

Case Study Croatia: SPAČVA d.d., Vukovar/Spacva

29 June 2018

For the implementation of the project “ENERGY BARGE – Building a Green Energy and Logistics Belt” a subsidy is awarded from the European Regional Development Fund under the Danube Transnational Programme.

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I. About the ENERGY BARGE project

The Danube region offers a great potential for green energy in the form of biomass. The main objective of ENERGY BARGE is to exploit this potential in a sustainable way, considering the Renewable Energy Directive 2009/28/EC, thereby increasing energy security and efficiency in the Danube countries. The project brings together key actors along the entire value chain, biomass companies and Danube ports as well as relevant public authorities and policy stakeholders. The project maps value chains and facilitates the market uptake of biomass, supports better connected transport systems for green logistics and provides practical solutions and policy guidelines. The Agency for Renewable Resources (FNR) coordinates the ENERGY BARGE project consortium with fourteen partners from Austria, Bulgaria, Croatia, Germany, Hungary, Slovakia and Romania.

Project coordinator

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Project partners

BioCampus Straubing GmbH	BCG	Germany
Deggendorf Institute of Technology	DIT	Germany
Austrian Waterway Company	VIA	Austria
Port of Vienna	PoVi	Austria
Bioenergy2020+ GmbH	BE2020	Austria
International Centre of Applied Research and Sustainable Technology	ICARST	Slovakia
Slovak Shipping and Ports JSC	SPaP	Slovakia
National Agricultural Research and Innovation Center	NARIC	Hungary
MAHART-Freeport Co. Ltd.	MAHART	Hungary
International Centre for Sustainable Development of Energy, Water and Environment Systems	SDEWES Centre	Croatia
Public Institution Port Authority Vukovar	PoVu	Croatia
Technology Center Sofia Ltd.	TCS	Bulgaria
Romanian Association of Biomass and Biogas	ARBIO	Romania
Federation of owners of forests and grasslands in Romania	Nostra Silva	Romania

II. About this document

This report corresponds to “D.3.2.3. Regional case studies for biomass and bioenergy production” of the ENERGY BARGE project. It has been prepared by:

Due date of deliverable:	2018-06-30
Actual submission date:	2018-06-30
Start date of project:	2017-01-01
Duration:	30 months

Work package	WP3
Task	D 3.2.3
Lead contractor for this deliverable	BCG
Editor(s)	Ann-Kathrin Kaufmann (BCG), Verena Dobler (BCG), Thies Fellenberg (FNR)
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Quality reviewer	Wibke Baumgarten and Birger Kerckow, FNR

Version	Date	Author(s)	Reason for modification	Status
1.1	2018-02-01	Ann-Kathrin Kaufmann	Request for feedback & input from partners	Completed
1.2	2018-05-24	Editors + all authors	Feedback and request for modifications	Completed
1.3	2018-06-27	Ann-Kathrin Kaufmann, all authors	Final draft, to be submitted to QAM	Completed
2.0	2018-06-29	Marko Ban	Final document after QAM assessment	Completed



Background

ENERGY BARGE aims at exploiting the Danube macroregion's bioenergy potential to increase energy security and diversification of energy sources by establishing secure, efficient and sustainable bioenergy supply chains along the river. To this end, a holistic view on the bioenergy market and underlying value and supply chains is needed. Given national and regional disparities in theoretical, geographical and market potential for bioenergy, deployment, public support, and also cooperation between private and public actors, it is necessary to identify levers for tapping potential and options for market actor cooperation, business development and market uptake.

A theoretical model designed to increase the market uptake of bio-based feedstock for both material and energetic (ideally cascading) use in the Danube region and thus to address the objectives also set out in the EU Strategy for the Danube Region (EUSDR) is a concept called "Green Energy and Chemistry Belt" (see Figure 1). It was developed by the BioCampus Straubing GmbH (Project Partner 1) and aims at using the Danube River as a natural biomass corridor and sustainable transport axis for biomass. The underlying principle follows the logic of "local harvesting – decentral processing into more transport-worthy states (e.g. oils, pellets, liquids) – central refinement or end use", so that added value creation can mainly stay in rural areas along the Danube. This concept forms the basic idea of the ENERGY BARGE project.

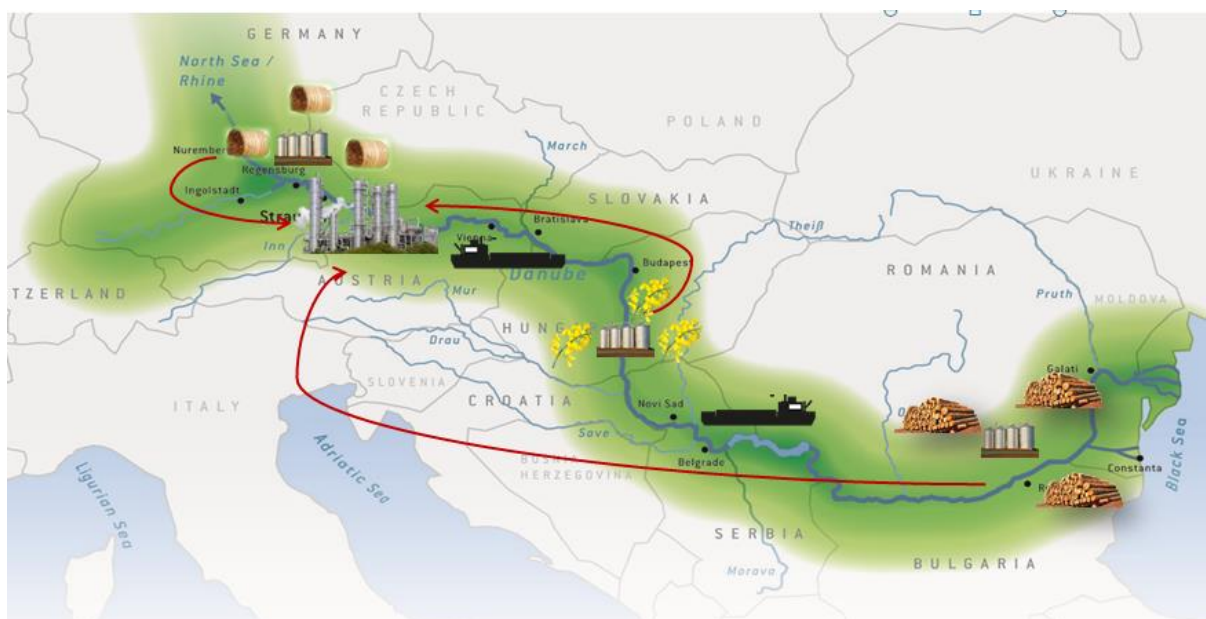


Figure 1: Green Energy and Chemistry Belt (Source: BioCampus Straubing GmbH, own visualization).

In order to reach the targets outlined above, Work Package 3 provides market-oriented mapping of the Danube region's value chains from biomass feedstock production and residues to energy generation from an integrated, transnational perspective, giving regional and transnational guidance for market development along the river (green bioenergy belt) and setting the stage for increased use of Danube logistics in the bioenergy sector. This will be achieved through a transnational market study compendium including biomass flows and sustainability aspects

(macro-perspective, Activity 3.1), business landscape mapping, case studies and identification of best practice locations for bioenergy value chain integration (micro-perspective, Activity 3.2).

Objective of the regional case studies

This deliverable “D 3.2.3 Regional case studies for biomass and bioenergy production” is based on the task as described in the latest approved version of the Application Form of the project ENERGY BARGE (Project Code: DTP1-175-3.2).

- *A3.2- Providing a systematic insight into the integrated bioenergy landscape along the Danube (lead: BCG)*

Activity 3.2 focusses on the biomass and bioenergy business sector, with the aim of mapping the state of the business landscape working along the bioenergy value and supply chain in the Danube region. This will mainly be achieved, in connection with a company inventory and a demand scenario analysis, via a set of regional case studies, focusing on exemplifying cases with already established (or currently being established) biomass and/or bioenergy markets/businesses, their future integration potential, and also covering their already existing as well as potential logistics connections with a focus on connections with nearby inland port terminals and inland waterway transport (IWT).

With D 3.2.3, the aim is to identify cases, i.e. specific real-life situations (businessdictionary, 2018), in each of the partner countries in which biomass production and/or utilisation in the bioenergy sector (as well as other utilisation sectors, e.g. chemical-material use) plays a dominant role in comparison to other cases. After identification via a standardized matrix, the objective is to coherently analyse these cases in case study reports. The focus here shall be on describing the status quo of these cases with respect to a set of characteristics and on subsequently analyzing the success factors (enablers & inhibitors) influencing this status quo. In addition to this qualitative analysis, each case shall be accompanied by a GIS-based (geographical information system) map depicting land use, as well as options for regional supply and logistics chains (roads, ports, business partners). Through the direct contact to responsible managers and other important people in charge at the cases, the project can be further disseminated. Moreover, discussions and considerations about challenges and chances of the bioenergy sector in the Danube region are spurred, contacts made and options for future integration of inland waterways and ports can be presented and discussed.

In the following project steps, the aim is to use these case studies for Output 3.2. as a basis to identify good practice examples on how and in what ways biomass and bioenergy production and utilisation can be regionally and locally integrated, how supply chains can be improved or established and – ideally - how inland ports can contribute to this integration via their logistics services as biomass and bioenergy hubs.

Case study SPAČVA d.d. - extending the reach (Croatia)

Executive summary

The case study is analysing the activities of Spačva d.d., one of the largest biomass processors in Croatia. It is a private company, located in the eastern part of the country, in the city of Vinkovci which is also in the vicinity of Danube (~22km),

Biomass in Croatia has traditionally been used for generation of heat, mainly in private households in a form of firewood. In the past decade, there has been a new trend to utilize the state of the art technologies for large scale energy production using biomass fired power plants. With the new acts on incentives for electric energy production (OG 100/2015) there have been many new ventures into building these kinds of instalments. On the other hand, most of the projects getting the preferred producer status seem to be speculative, with the intent of selling to the next investor, blocking the readily available projects for realization due to the missing national quotas for the electric energy production (Poslovni dnevnik, n.d.) .

Also, the rise of the alternative use of biomass started the production of new heating sources (pellets and briquettes) with several companies using the available woody biomass for extending their current portfolio (usually being upgraded from some type of processing – flooring, furniture or sawmills) and some using it to start as a new business. This has not been followed by the consumer side with most of the smaller consumers making a transfer mostly to gas or keeping the old means of using wood for burning in small furnaces, having a vast majority of pellets exported to the neighbouring countries (Drvni pelet, 2018).

Spačva d.d. being located in the east part of the country has a long tradition of processing wood, both having a successful flooring and doors production and the motivation to become the biggest pellet/briquette producer in the country within the next few years, making them an important actor in the Croatian biomass market. It also uses biomass residues from the processes to fire two large furnaces producing the heat for the company needs on site. One of the key points is that, although depending strongly on the export of their bioenergy products, it has the largest share of both pellets and briquettes being placed in the national market (mostly through the big retailers). Being located on the far east of the country, the transport of the products to the countries located to the west lowers the overall profitability of such endeavours. However, since the company is located within 20 kilometers to the port of Vukovar on the Danube river, it seems a viable option to have the company's reach extended to the east/north by using alternate modes of transport (rail, waterway) which can prove to be more energy and environmentally efficient.

This study aims at analysing the current operation modes for logistics of Spačva d.d. company suggesting the additional options for transport using the alternate methods which might lower both the cost and overall environmental impact.

1. Case study methodology

Overall, six partner countries present case studies: Austria, Germany, Hungary (2 studies), Croatia, Slovakia, and Romania. Each country's case study report is designed as additional information to the interactive ENERGY BARGE platform. A summarizing case study report is made available in order to get an overview to the whole case study area and the sites chosen.

In Figure 2, an overview of the Danube region and all cases covered (red dots) is presented. The map is an extract from the ENERGY BARGE modal shift platform (www.energy-barge.eu) and also depicts an abstracted level of bioenergy company locations in the macro region (green dots).

The Croatian case study has been conducted primarily by interviewing the management of the company and obtaining the relevant information for the project's aims. Most of the other information, e.g. on socio-economic indicators has been gathered via desk research on official documents from cities' and counties' sources.

Special attention was given in this study to quantitatively estimate the options of transferring the transport to the Danube, comparing it with the other transport modes. For this purpose several logistics companies have been contacted in order to determine the transport prices for the potential company's cargo being shipped abroad. The number of the contacted actors in this part has been affected by the fact that Croatia has quite limited quantities of logistic companies handling the rail (HŽ Cargo and PPD Transport) and inland water transport (Dunavski Lloyd and Dunavska plovidba – Vukovar).

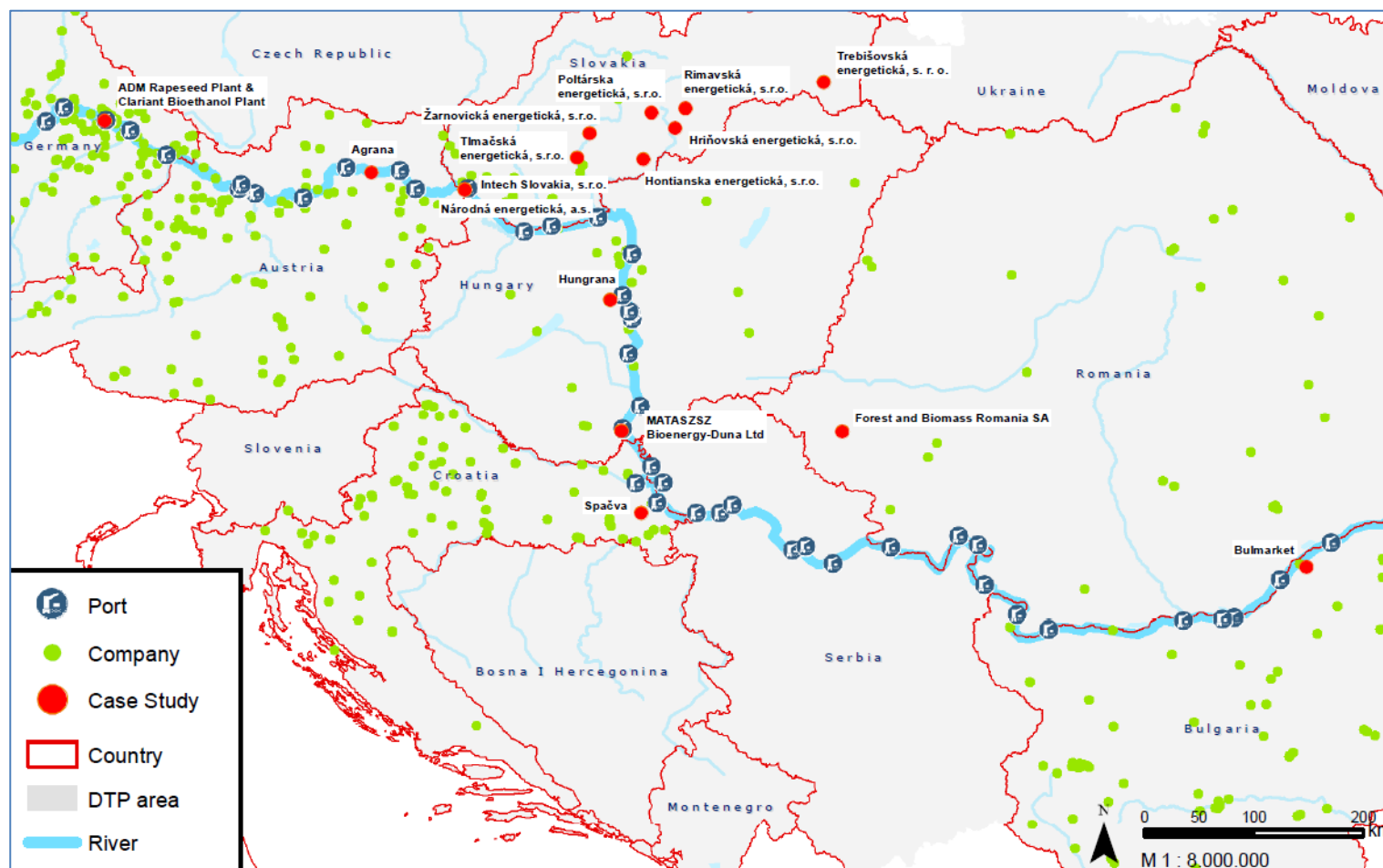


Figure 2: Overview of the location of the selected cases in the Danube region (DIT, 2018 source: open street map)

2. Case description

For the case study in Croatia, one of the largest biomass processors has been selected. It is a private company Spačva d.d., located in the eastern part of the country, in the city of Vinkovci which is also in the vicinity of Danube (~22km). The company, in the present form and name, has been established in the 1950s, and has employed mostly people from the nearby area.

The geographical coordinates of Spačva d.d are (more detailed information available in section 7): 45.29520, 18.78288

Vukovar-Srijem County covers 2,454 km² and has a population of around 180,000. The county's economy is in the first place based on the electricity, steam and gas supply, then the manufacturing industry, followed by the wholesale and retail trade with agriculture and forestry on the fourth place (Županijska komora Vukovar, 2016) with around 10% of the overall income in 2015.

Spačva is a geographic micro region in Croatia. It is located in the south-western part of Syrmia—the latter being divided by Croatia and Serbia—and the south-eastern part of Slavonia macro region of Croatia, around Spačva river and river Studva. The region is famous for its biggest contiguous oak (*Quercus robur*) forest in the Europe relating to a history of wood industry making it important in the economic life of the County (Lucić, 2014).



Figure 3: Aerial view (Spacva)

Spačva d.d. consists of five factories: sawmill, parquet production, final products factory, veneer factory and bio-fuels factory. It employs 850 workers, which makes it one of the leading employers, both in Vinkovci and in the county. For the most part, it is exporting to the European market (mostly Italy, Hungary and Serbia), with the goal of even stronger breakthrough in the export of finished products, primarily parquet floors, peasant flooring and doors, and the production of bio-fuels, in whose facility

considerable investment funds have recently been invested (last investment has been of over one million euros for upgrading the drying process in 2014. Finally increasing their pellet production threefold (Spačva, Spačva d.d., about us, 2018)). Inland water transport has not yet been considered and the entire transport is currently done by road.

The sawmill annually, on average, processes 35-40,000 cubic meters of raw materials, of which about 80% is Slavonian oak, 10% ash, and the rest are other types of wood. The plant for production of finished products per year, together with parquet production, produces over 400,000 square meters of flooring, and the veneer factory produces between 8 and 9 million square meters, for the most part, oak veneer.

Pellet/briquette production facilities have been originally installed in the mid-2000s, but the production has been suspended due to the economic crisis which hit the country hard by the end of the decade. Almost ten years later the production facilities have been refurbished and the company is now second largest producer of bioenergy products in Croatia (around 38,000 t per year). Bioenergy production capacity (pellets and briquettes), on an annual basis is 55,000 t which is planned to be achieved within the next short period putting the company at the top nationwide.

The company currently owns three trucks for road transport which are used to haul raw material from the nearby sources and outsources the transport for delivering the products to traders (mostly large retailers). They also encourage the use of pellet furnaces in schools which have recently switched from burning oil to pellets, and they supply several schools in the region with their products.

Within the factory, there are three boilers with a total of 17.5 MW of produced heat which is used for their own purposes. The boilers burn over 15,000 t of biomass (residues from the other processes) and the total need for heat is 400,00MWh per year (Perković, 2016).

Spačva d.d., being a privately owned company that operates on a regional sourcing basis, depends on a few actors in the nearby region, mainly related to the raw material transport and the product placement. Also, an important actor in the wood sector of Croatia is the Wood Cluster SLAVONSKI HRAST (Slavonski Hrast, 2018).

Currently the biggest problem the company is facing is the lack of raw material to satisfy the production process requirements. Currently the biggest supplier of raw material is the nationally owned company Hrvatske šume d.o.o. (national forest owner) which, through smaller sub-companies, sells the wooden material through the process of public procurement or public auction. Company Šumska biomasa d.o.o., a sub-company of Hrvatske šume d.o.o., is currently under a type of restructuring, affecting all the actors in the area depending on its products.

In the vicinity of the Spačva d.d. are several other biomass end users which also take a portion of the raw woody feedstock – Uni Viridas bioenergy plant, in Babina Greda, producing 9.7MW of electricity and projected 16MW of heat. Also, the first operational CHP plant selling the electricity into the grid is located around 30 kilometers away in Strizivojna (company Hrast) with 3.3 MW of installed electrical energy capacity and 15MW of heat. Newly built biomass combined heat and power plant in Osijek, owned by the national power company HEP has an installed capacity of 3MW electrical and 10MW of thermal power. All these companies are competing for wood biomass feedstock.

In the vicinity of the company there are several others which have the similar business model, such as Spin Valis d.d. furniture producers who also, besides the production of furniture and pellets/briquettes, have built a CHP plant burning woody biomass and producing 1,5 MW of electric and 8,8 MW of thermal power consuming in total around 50,000 t of raw biomass on a yearly basis. Therefore, it can be said that the region is qualified for wood-processing industries integrating their value chains into the bioenergy sector, mainly due to the rich wood resources available.

The transport sector in the area is mainly oriented on the road and rail. The company Spačva d.d. has a rail infrastructure within the company grounds (it is not often used, though) directly connected to the Danube port in Vukovar which also provides an interesting approach to enhance the transport of both raw material and finished products (mainly bioenergy products). In the rail transport section, the biggest actor would again be the national railway company of Croatia, Croatian Railways (Hrvatske željeznice – HŽ) with the sub-company HŽ Cargo. There is one privately owned rail transport company PPD Transport (previously Adria transport), currently without any available information on the amount of transported goods.

As stated in the previous section, the company itself has three trucks used for hauling the raw material from the nearby sources, and outsources the rest of the transport using mostly Ricardo d.d. as the transport service, with the base in the nearby city of Osijek. The company has been established in 1992 and, as claimed by the employees in Spačva d.d. has so far been proven as a reliable transport option. A search through various registers of transport/logistics companies in Croatia provides over 150 registered companies using road transport.

Inland waterway companies are also quite scarce in Croatia, with several being mentioned here. Croatian inland waterways include only the Danube (international transport) and Sava rivers being only navigable in the country, with a small section of Drava river (from Osijek to Danube). Two rivers meet only in Serbia without the connection between them in the country making it difficult to organise the transport from Sava river to upstream destinations on the Danube. Several companies provide service for both domestic and international transport: Dunavski Lloyd in Sisak and Dunavska plovidba – Vukovar.

As for the end users of the company's products, the bioenergy sources produced by Spačva d.d. are distributed to the large retailers in the country, with several having the shops also in the vicinity, e.g. Konzum, Spar/Interspar etc. However, in some cases the shipping goes to the retailer's storage/warehouse which is located in a larger distance, then shipped using their own transport back to the vicinity of the Spačva d.d..

3. Socio-economic indicators

According to the latest census published in 2011, there are 180,117 inhabitants in Vukovar-Srijem County (which is 4.2% of the total population of Croatia); this results in a population density of 73.58 inhabitants per km². It is worth mentioning that in 1991 there were 231,241 inhabitants (28% more). This decline is a result of negative natural increase of the population, negative balance of migration and the war in the 1990s, which also had a long-term negative impact on the region's economy.

The county records a below-average share of the educated population, i.e. the population with a formal education (finished high school) older than 15 years (County average 59.2%, Croatian average 69%, according to data in 2011). This means that 40.7% of the population has either no education at all or has only finished elementary school (30.3%). The majority of the population,

49.8%, has finished high school (national average is 52.6%), and 9.4% has a high or higher education (BSc or MSc). There is a particular difference in the share of people with specialist study and PhD in adult population compared to national the average (0.24%, which is significantly lower than 0.85%, or the Croatian average, according to data in 2011) which in addition confirms the poor educational structure of the population (Vukovarsko-srijemska županija, Informacija o stanju gospodarstva Vukovarsko-srijemske županije, 2017).

When it comes to the share of the County's economy in the economy of the Republic of Croatia it amounts to only 2.33%, and the most representative activities are agriculture, forestry and fisheries of 8.86%, public administration and defence, education, health care and social welfare activities of 3.46%, construction 3.23%, real estate business 3.17%, while for example manufacturing only at the 5th place with a share of 2.07%.

The county has rich natural resources, the most important being the processing areas, forests, oilfields, gas, clay and gravel, and a developed hydrographic network. The most significant economic activities are supply of electricity, gas and steam (29.4% attributed to the headquarters of the Croatian natural gas supplier PPD in Vukovar), manufacturing industry takes up 22.6%, followed by wholesale and retail trade (20.9%), and agriculture, forestry and fisheries (13.2%) (Vukovarsko-srijemska županija, Informacija o stanju gospodarstva Vukovarsko-srijemske županije, 2017).

Agriculture is one of the most important segments of the entire economy of Vukovar-Srijem County. 149,703 ha (61%) of the County's total area are used as agricultural land. In the structure of agricultural production, the following cultures are most common: corn, wheat, soy, sugar beet, sunflower, rapeseed oil, barley, etc. Most of the agricultural production is based on primary agricultural production and is dominated by 'classical' (corn, wheat) low-income agricultural crops.

The most important resources of the County are the location, high quality land and the world's largest known contiguous oak tree forest. There is about 20 million m³ of available wood and the annual felling is about 290,000 m³. This was a good basis for the development of the wood processing industry, whose capacity is mainly installed in two large companies. However, the majority of wood is exported, resulting in domestic companies, which do not have enough raw materials to create added-value products inside the Croatian market (Županijska komora Vukovar, 2016).

The County has development potential in the wood and food sector, i.e. availability of raw materials, processing capacities etc., a favourable geopolitical position, especially in the transport and logistics segment, lower operating costs compared to other areas of the Republic of Croatia, i.e. lower labour costs, tax incentives, etc., and existing capacities of entrepreneurial support institutions and entrepreneurial zones with a tendency of further strengthening. Investors have the option of tax reliefs for potential investors because of the County's status of a less developed area and the programme of interest subsidies on entrepreneurial loans offered by the County.

The County wants to focus on the development of agro-food production, irrigation and the development of the wood industry. Several specialized centres are established to conduct Project co-funded by European Union funds (ERDF)

research on Slavonian oak utilisation properties, including bio-technology, joining and combining the oak with advanced materials and exploring new technologies and processes of oak drying, also support to the agro-food industry and to implement applied research in agriculture as a link between the needs of industry, producers of crops and vegetables and the scientific-research sector (Vukovarsko-srijemska županija, Razvojna strategija Vukovarsko-srijemske županije za razdoblje do 2020. godine, 2017).

4. Biomass availability and utilization

Spačva d.d. located in the city of Vinkovci, resides next to the Spačva basin, which is the biggest contiguous oak (*Quercus robur*) forest in the Europe. Other than that the whole area has historically been oriented on agriculture and wood production/processing. As stated by the latest report from the County, main economic potentials are natural resources, arable land, forests, oil and gas fields, sand and gravel excavation and various other services.

Total forest area takes about 70,000 ha, or 28.4% of the County's area. Total available woody biomass in the County is estimated at around 19 million m³ with the annual yield of 344,000 m³. All mentioned types of wood are of interest to Spačva d.d. for their primary production of final wood products and also serve as a good basis for bioenergy products .

From the statistical side it is difficult to distinguish the biomass related economy indicators. Agriculture and forestry are reported to provide around 10% of the total income on the County basis, with manufacturing covering 24% (this would include also the wood processing industry), and electricity, heat and gas supply covering 30% (this includes bioenergy plants in the area) (Vukovarsko-srijemska županija, Informacija o stanju gospodarstva Vukovarsko-srijemske županije, 2017).

As stated in the introduction section, the company's sawmill annually, on average, processes 35-40,000 cubic meters of raw materials, producing at this point around 38,000 t of bioenergy products with an estimate of the maximum production of 55,000 t to be reached within couple of years, as indicated by the company's management during interview.

Since the Spačva basin is the biggest *Quercus robur* forest in the Europe it also has areas which are protected and cannot be used to harvest raw material. Reservation Lože, covering the Spačva basin area of around 100 ha has been protected since 1975. It is mainly intended for the use of scientific research and education. The protection has been prescribed to last for the next 200 years, and only the sanitizing of the area is allowed (removal of dried, broken or knocked down trees). Another protected area in the County is "Vukovarske dunavske ade" reservation, covering 120 ha next to the Danube river, next to the city of Vukovar. Protected since 1989., and is mostly covered by the black and white poplar woods. There are several smaller areas turned into parks and protected due to holding significantly aged specimens (Vukovarsko-srijemska županija, Godišnji program zaštite, održavanja, očuvanja, promicanja i korištenja zaštićenih područja za 2017. godinu, 2017).

As mentioned above, there are numerous processors and end users of the woody biomass from this area. From the biggest consumers of woody biomass, besides Spačva d.d. Šišarka d.o.o. should be mentioned, currently biggest producer of pellets in the country with the capacity of 50,000 t annually. Many smaller sawmills reside in the area, and from the bioenergy point of view there is Uni Viridas in Babina Greda, which needs 80,000 t of wood chips annually for full planned operation (Blažanović, 2016). Also in the vicinity, just outside the county border is one of the first CHP biomass plants located in Strizivojna, operated by the company Strizivojna HRAST (Ćurić, 2016). The CHP plant has 3.3 MW of installed electrical energy capacity and 15MW of heat. The company, as is the case with Spačva d.d., primarily produces hardwood floors, and in total consumes around 60,000 m³ of raw wood.

5. Bioenergy production and utilization

Since the Vukovar – Srijem County is one of main rural areas of Croatia, currently only bio-energy production on a large scale is used for electricity production. CHP plants in the area are almost entirely built and used on private company grounds to produce heat for various manufacturing processes (or drying) and eventually selling the electricity into the grid (Uni Viridas, Strizivojna Hrast). This is also true for Spačva d.d.: The new biomass powered plant in Osijek will be included in the upcoming period in the district heating of the city (currently in the final testing phase). Company Spačva can, with its own example as one of the biggest (private) employers in the area, provide a good example on using both river transport to extend the export reach and extending the bioenergy products production thus showing that it is possible to conduct a viable business in the affected area (currently one of the lowest in employment rates and average income).

Smaller towns in the area, for covering the heat demand on a larger scale (not households) usually burn natural gas; Vukovar has several boiler rooms, built and managed by Tehnoston company, biggest one producing 5.2 MW of heat used in the city. In the city of Vinkovci, where the case study is being located, local company GTG Vinkovci, holding the permit to conduct the energy activity, has installed six boiler rooms around the city with the total capacity of just over 17MW, with the biggest boiler using fuel oil to produce 6.7MW, and other smaller ones burning natural gas. All are located in the narrow city area covering almost entirely apartment buildings. Table 1 shows the energy consumption by main sectors for the year 2014 (Aron26 d.o.o., 2016).

Table 1: Energy consumption in the Vukovar-Srijem County for the year 2014

in PJ	Gasoline	Firewood & biomass	Diesel	Biodiesel	Electric energy	Fuel oil	Natural gas	District heating	LPG	Total
Industry		0,043	0,003		0,363	0,027	0,263	0,008		0,707
Transport	0,982		2,002	0,0003	0,025				0,762	3,771
Other sectors		0,918	0,151		1,117	0,069	0,926		0,117	3,298
Total	0,982	0,961	2,131	0,0003	1,480	0,096	1,189	0,008	0,879	7,780

The similar report for the other sectors lists that the energy consumption of biomass is generated by households (also compared in total to other sectors: services, agriculture and construction) which use around 0.92 PJ of energy from biomass sources which accounts for 40% of total energy consumption (other energy sources included in the statistics are electrical energy and natural gas). Biomass energy sources in households are all listed as firewood, but the sources do not specify how much of the electricity (0.771 PJ) is used also for heating, as well as for the natural gas (0.572 PJ). Compared to national data for the year 2014 (Ministry of Economy, 2015), the share of biomass energy and electricity consumption is higher, 40% against 31% nationally and 34% vs. 10% respectively, which is due to the fact that over half of the population is living in urban areas where natural gas is predominant source of heating energy (60% versus 25% in Vukovar-Srijem County). Total energy consumption share of the County in overall national consumption, limited to electricity, natural gas and biomass, is just under 2%.

It can be derived from the above mentioned sources that most of the bioenergy installations are in private households, in terms of small furnaces burning firewood/briquettes, with a considerably smaller amount of pellet installations.

As for the other renewable energy sources in the area, there is around 1.4MW of electric energy produced from solar, 21 MW from biogas installations and around 2.4MW of CHP (natural gas fired).

Spačva d.d. being a raw wood processor, also depends on woody biomass, as described in previous sections. The feedstock is used primarily in production of the main company products, and the remaining material is used both in the production of pellets and as a fuel for the steam production in the in-house furnaces.

Taking into account the above figures, it is evident that the area has an enormous potential for efficient use of biomass for energy production purposes, which is not implemented optimally. The majority of the biomass used for energy production goes into the households as firewood. Also, biodiesel production has been suspended due to legislative barriers (e.g. national quotas for blending biodiesel into regular fuel are not being met by fuel distributors, which are not penalized or, if they are, the penalties are financially lower than actually buying the needed biofuel for blending).

6. Infrastructure, logistics & integration of supply chain and logistics

The company Spačva d.d., is located in the heart of continental Croatia. The logistics the company uses to deliver the final products and to get the raw material is entirely road based, with the company owning three trucks to haul feedstock from the local forests, and outsourcing the transport for delivering the products to retailers. Since the company also delivers pellets to several schools in the area, for this purpose, a special version of the truck using a hose to deploy the pellets to the storage is used.

From the interview with the managers at the company, information has been acquired that there have been some attempts to re-utilize the availability of the currently unused rail infrastructure, but in their words, it has proven to be less than satisfactory in terms of the final price and the efficiency of transport (speed, mostly). They have not considered using the nearby waterways (Danube) for transportation of both feedstock (for their purposes) and final products (for export). The aim of this study will be to evaluate the possibilities to enhance the reach of the company by employing the available transport modes in the area.

Geographically speaking, the company is favourably situated regarding all three transport modes in question:

- national highway, going to Zagreb and Slovenia in the west and the Serbian border on the east (E-70) is at a road distance at around 25km to the south
- small transport rail infrastructure is situated within the company grounds and is therefore immediately accessible. From this point, rail goes to the east to Vinkovci main station where it forks to north-east towards Vukovar (and the Danube port, single track) and to south-east towards Serbia (two tracks). To the west there's a combination of two and single track rail to Zagreb and Slovenia. From Slovenian to Serbian border, the tracks are electrified unlike the section Vinkovci to Vukovar (total distance between the terminals is around 18.5 km) (HŽ Infrastruktura, 2018)
- nearest waterway and port is located in Vukovar, distance by rail is 18.5km (as from the previous bullet) and by road is around 21.5 km

As seen from the list there is a potential in shifting a part of the transport both to the rail and to the Danube waterway (and combined).

Currently, the transport of both raw material and final products (bioenergy and other) is entirely done by road. Existing company partnerships and customers do not foresee to change the transport medium. As from the interview with the company's management, the road transport is profitable to some margin with the projected cost of around 1.1€ per t and per kilometre of distance travelled. Using a standard truck for transport, a profit can be gained with the distances lower than 1,000 kilometres.

The company uses the feedstock entirely, for producing the flooring/doors as the primary products, and pellets/briquettes as the secondary, up to burning the residues in the furnaces for the processing of steam and heat (Perković, 2016).

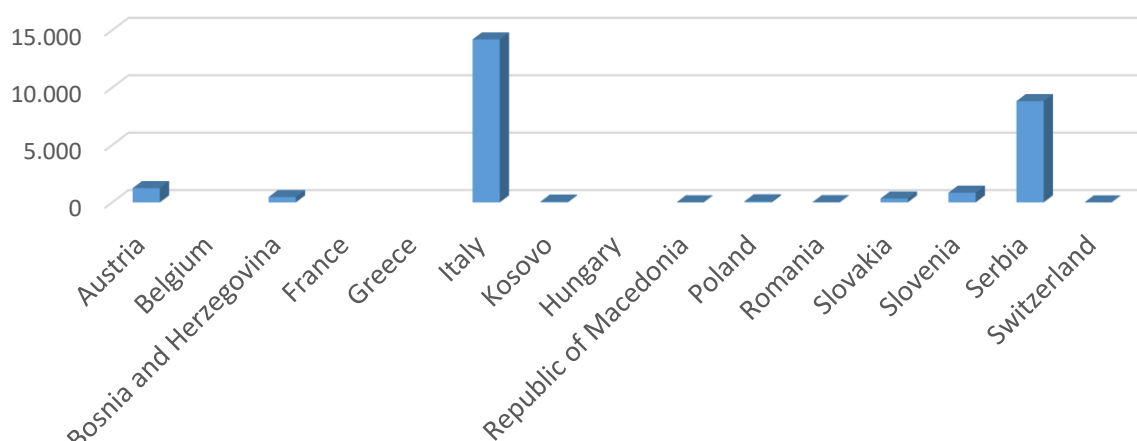
Current logistics operation modes in the company's supply chain are displayed in Figure 4, showing an all-road transport both for feedstock intake and for delivering the products to end-users (domestic and export), concentrated on the bioenergy products. The feedstock is mostly obtained by the methods of public procurement or auction from the nationally owned company Hrvatske šume (*Croatian Woods*), or in small scale from private forestries. The raw material is hauled by the company's trucks to the company grounds where it is processed in the sawmill and other factory's facilities producing flooring, solid oak doors (interior/exterior), oak staircases and bioenergy products (pellets and briquettes). All products are then shipped to the end users using a contracted logistics company regardless on the final destination (local or international).



Figure 4: Current supply chain logistics (Spacva)

Currently the company distributes their bioenergy products to around 100 companies in 15 European states with the volume as depicted in Figure 5 (latest available data, for year 2017).

Pellet export (in tonnes) by Spačva d.d.



Briquette export (in tonnes) by Spačva d.d.

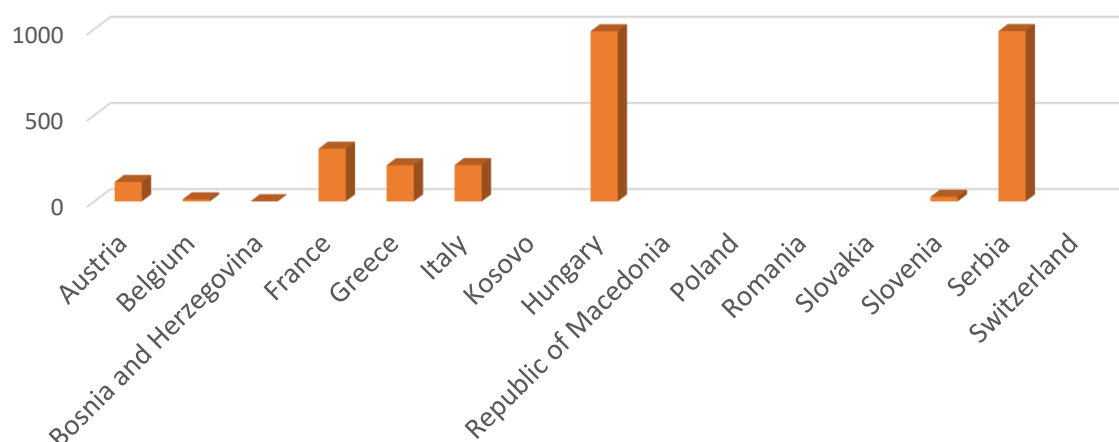


Figure 5: Export of bioenergy products to European countries

The company ships all their products by road with total annual count of 2,827 shipments (both domestic and export) and the maximum distance covered by a single shipment being around 1,500 km. Raw material is entirely local, for bioenergy products they haul around 110 m³ and 45,000 t in 2,100 shipments. Since the company uses the raw material in its entirety, they currently have no cooperation with other companies for creating an added value to their product portfolio.

The company grounds being located about 20 kilometers from the Danube port of Vukovar, connected to it also by rail (non-electrified). A price for the transport of the products in the case of using the waterway from Vukovar to the port of Constanza (Romania) was reported to be as shown in Table 2 (data provided by a shipping agent through PA Vukovar). The travel distance

between the two ports is around 1,100 kilometers. Company reports that this would be the limit for the road transport regarding the profit compared to shipping price. There is also an expected difference in the price of the upstream transport, as seen in the table for the case of transporting the goods from Vukovar to Straubing (similar distance as from Vukovar to Constanza).

Table 2: Distribution of costs for barge shipping from Vukovar to Constanza (Romania)

Type	Price
Transshipment (direct cost)	4 €/t
Transshipment (indirect cost)	6 €/t
Transport by barge downstream (Vukovar – Constanza)	16 €/t
Transport by barge upstream (roughly the same distance as above - Vukovar-Straubing)	22-24 €/t
Shipping agent	110 €/barge
Port tariffs	0.3€/t – 0.4€/t

The distance between the end points of the route is nearly the same using the road. However, if the area to which the products are to be delivered is further away from the Danube, multimodal transport should be used (post-haulage from destination port to final destination), increasing the final prices. Also the price may vary when travelling upstream.

Using the fact that the company already has an access to the rail, the final suggested supply chain might be as depicted in Figure 6.

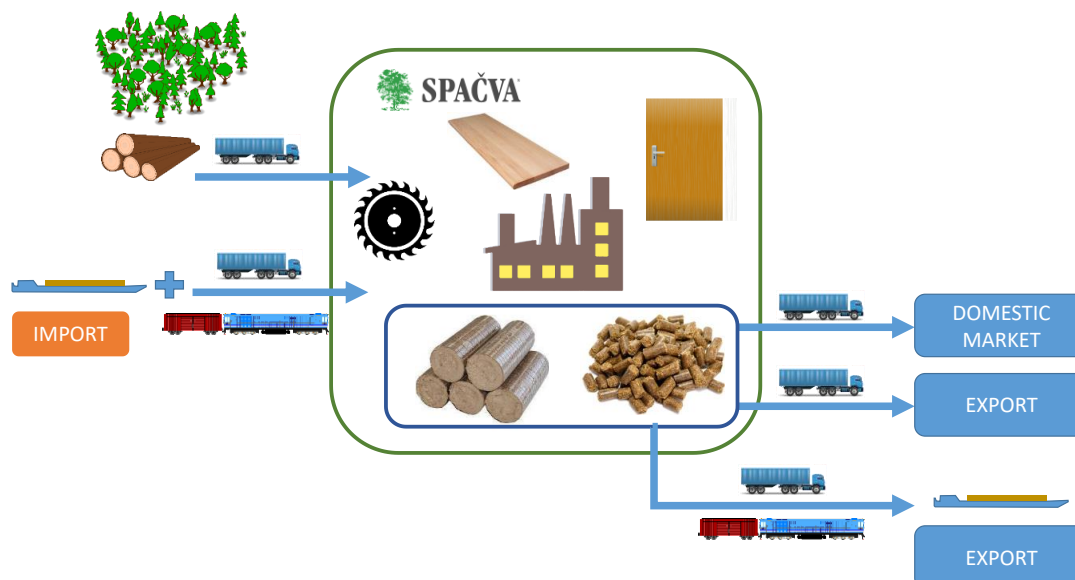


Figure 6: Updated supply chain logistics (own visualization)

In Figure 6 it is suggested that the security of the feedstock supply is enhanced by additional option of import from the neighbouring countries using the waterways combined with either road or rail transport (20 km from the port to the company). On the other side of the supply chain, the

reach of the company can be extended by moving some of the export to the waterways, again combined with road and rail.

Domestic transport would remain unchanged since there are no quality waterways in the vicinity, nor is the railroad infrastructure of the desired quality to take on the part of the company's logistics.

7. GIS-map

For the case study, a map visualizing geographical conditions and context based on a geo-information system (GIS) was designed. It is a set of aspects defining the case and its surrounding area with a particular focus on the proximity to the Danube and relevant ports. For the case, a catchment area with a radius of 50 km has been defined in order to allow for theoretically economically viable pre- and post-haulage logistics. Within this area, also the companies along the biomass and bioenergy value chain as well as the port locations as identified in the course of the ENERGY BARGE project are depicted via icons.

The following information is provided on the map:

- Location of the case
- Land cover categories on NUTS 3 level (CORINE land cover data, Eurostat, 2012)
- Land use data on NUTS 2 level for selected biomass feedstock (Eurostat, 2017)
- Market actors in the biomass and bioenergy sector in the region ([ENERGY BARGE D3.2.1 Transnational inventory of biomass and bioenergy companies in the Danube corridor](#))
- [Danube port locations with equipment for biomass handling](#)

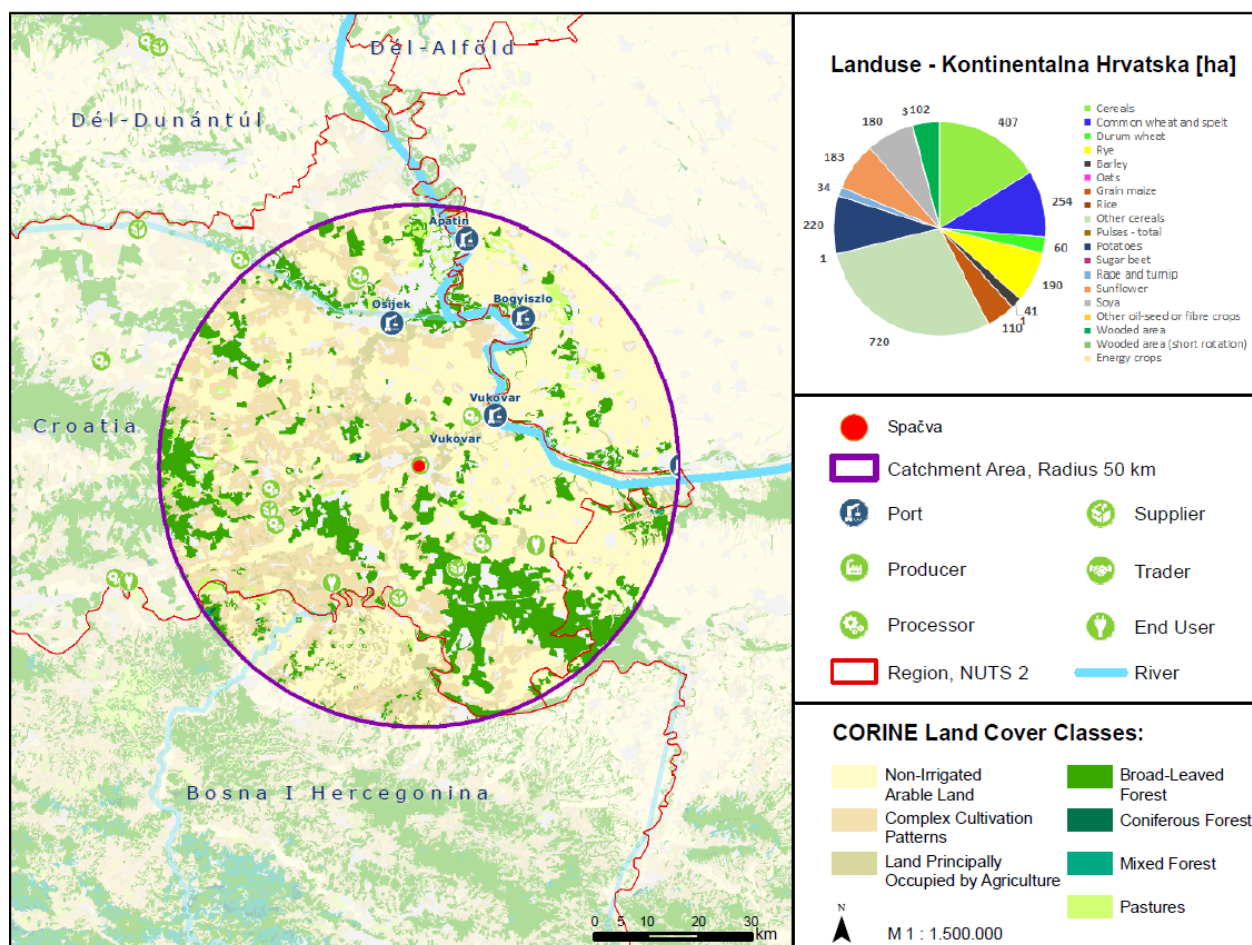


Figure 7: GIS analysis of the case location (visualization: DIT for ENERGY BARGE project; sources: ENERGY BARGE, 2017/2018; EUROSTAT land use data, 2017; CORINE landcover data, EUROSTAT, 2012).

8. Analysis of success factors & lessons to be learnt: enablers and barriers

Based on the following table (Table 3), a brief indication of the success factors (enabler / barriers) of this case is listed, as well as the lessons to be learnt also for other regions (national and international).

Table 3: Success factors Croatian Case

	Enablers	Barriers	Learning and degree of transferability
Biomass availability	Spačva d.d. is located in the area rich in traditional forests, and readily available feedstock from the other biomass rich parts of the country	Most of the forests in the country are owned by the state and the national company Hrvatske Šume. The company has recently started the process of restructuring, putting on hold some of the processes on which a good part of the Croatian wood processing sector depends on.	Domestic biomass availability is indeed fixed and dependant on the public procurement and auctioning systems, but there is a possibility of obtaining the feedstock from abroad, prerequisite is economic viability of imports
Biomass utilization/valorization	The case study subject has an integrated biomass utilization system, producing furniture etc. as primary products and bioenergy products as secondary products; additionally supplying process utilities (steam, electricity) in their own bioenergy facilities; there are some incentives on more efficient and sustainable use of biomass, but is depending on the local authorities and their agility to put them in action	Complex administration is a major hurdle in starting any new biomass related project (e.g. selling the electricity produced by burning wood to the grid)	The integrated use of the woody biomass as resource for several products clearly depicts a good case practice transferable to other companies in the wood-processing sector. Current business as usual scenario for the company is not likely to change, since the biomass is used to its maximum potential. Additionally, the furnaces could be upgraded to utilize the energy for electricity production, but the lack of national quotas puts this idea on hold.

Bioenergy production / utilization	Availability of raw material in the area, and traditional use of wood biomass for heating could make new types of products more appealing to small household consumers	Administrative and political barriers somewhat prevent the marketing on using the alternative ways to use biomass (e.g. making a public perception of using gas more appealing for heating)	Nationwide, the producers of biomass based energy products export most of what they produce, while there is no knowledge transfer to smaller users on benefits and gains of using bioenergy; it is important to strengthen the end-user side of the Croatian bioenergy market to deploy the potential available
Existence of a strategy or concept	Both on local and national level there are numerous strategies on promoting ventures into renewable energy sources, both by creating clusters and assistance in applying for various project calls	Apart from delivering a comprehensive set of strategies, goals and theoretic means to achieving them, administrative barriers and lack of implementation of the above, on all level, still make it far from realistic	A sound strategy (which is already available on several levels) is always a good start. More initiative on the local administration side would certainly make a positive difference; the initiatives started in the Spacva County could serve as a role model for regions with similar socio-economic and geographical characteristics

Role of stakeholders	Both national and local strategies on business development encourage clustering and higher integration of the private companies into the overall national strategy on both economic and energy efficiency part. Actors such as the Croatian Wood Cluster are important messengers for the bioenergy and biomass sector.	Clusters, or companies by themselves, still play no significant role in decision making which prevents efficient legislation and administration	Higher level of inclusion of biomass stakeholders in the processes of decision making and (re)structuring the administrative processes would benefit all parties involved
Role of socio-economic factors	Area in question in this study still has a high share of using woody biomass for heating purposes with a great potential of switching to novel and more efficient options; the resources available are favourable; low wage levels could attract foreign investment	The knowledge on the new findings and availability of new technologies is low. Current household budgets in the area are small compared to the needed investment for making the switch to new forms of (primarily) heating	Higher level of information provided by the local authorities and potentials for obtaining the funds would benefit the jump-start the integration of new technologies
Integration of supply chains	With the raw material being readily available in the area, the supply chain in this case is relatively short and with an overseeable number of actors, which makes it simple to operate. Sourcing is primarily done on a regional level.	This kind of short supply chain heavily depends on each of the components. In this case, raw material is hauled from the nationally owned forests and depends on several factors which endanger the process of obtaining it	Strong dependence on a single part of the supply chain can be mitigated by introduction the alternate options (extending the transport to new modes is highly beneficial in this case), e.g. by establishing or at least investigating new supply routes.

Role of logistics infrastructure	Traditionally strongly dependant on the road traffic, the area shows great potential of switching the transport modes to alternative ones (mainly waterways).	Again, low level of information available to the potential users of the alternative transport modes prevents them for being more used. Also, economic viability is not entirely ensured; road transport solutions are oftentimes without competition, pricewise.	With increased amount of information to producers on using waterways might open new possibilities both for more efficient transport and opening to the new markets. This would also benefit the local infrastructure which would be forced to upgrade (e.g. new technologies for loading cargo at ports, accessibility of different transport modes, etc.)
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9. Recommendations & suggestions for future development

The case of Spačva d.d. can be seen a potential driver of the local economy and the one in the neighbouring area. Its surroundings is mainly oriented to agriculture and highly dependent on the national (government) incentives. Showing that there is an option to run a successful business, with an added value of providing a “green” products could be a good example to spark the transition from traditional ventures into green-economy with high prospects of reaching the markets which have not previously been considered (central/northern Europe, Bulgaria or Romania).

After conducting the study in the case of extending the reach of Spačva d.d. in terms of distribution of their bioenergy products, one can come to the following recommendations and suggestions for future development:

- 1) Vicinity to the Danube port should surely be used to extend both the transport modes and the export quantities to countries previously not being targeted or currently having not significant amount of products exported to e.g. Slovakia, Hungary, or Bulgaria;
- 2) Security of supply of raw material could also be improved by using the same approach, by importing the feedstock from other neighbouring countries;
- 3) Points 1) and 2) should be supported by projects similar or following up to ENERGY BARGE to promote the bioenergy products/feedstock and know-how through the regional business-to-business meetings on regular basis;
- 4) The region (in Croatia) would highly benefit in promoting the river transport within the local businesses which have high-volume bioenergy products ready for export, not only in the biomass sectors;

- 5) One of the national goals of increasing the environmental efficiency of transport can be the transition to intermodal transport, including extension of electrified rails, incentive prices for transport to/from the waterways or railways;
- 6) Centralising regional bio-economy: This transition could be supported by establishing logistic/trading centers in the ports, which would make the transshipment more flexible and affordable for smaller businesses and equip ports with additional sources of revenue generation.

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