WOODY BIOMASS POTENTIAL AND LOGISTICS STUDY FOR THE CITY OF VALJEVO

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Contents

1. Definition of Tasks.................................................................................................................. 6
2. Methodology applied ............................................................................................................... 7
3. Executive Summary ............................................................................................................... 8
4. Kolubara region...................................................................................................................... 11
5. Biomass potentials and realistic biomass supply ................................................................. 14
  5.1 Specification of available woody biomass potential from Srbijašume and private forests in Kolubara region and adjacent municipalities of Kosjerić, Lazarevac and Koceljeva...................................................................................................................... 14
  5.2 Existing wood processors in the Region ............................................................................ 17
  5.3 Estimation of roadside, riverbed and park biomass ............................................................ 18
6. Biomass market situation and input prices .......................................................................... 20
7. Biomass supply and logistics ................................................................................................ 23
  7.1 Technical requirements and machinery in use ................................................................. 23
  7.2 Supply chain management ............................................................................................ 28
  7.3 Biomass storage.............................................................................................................. 31
8. Financial analysis and economic indicators of biomass supply organization and financing options .................................................................................................................................................. 36
  8.1 Investments in hardware and operational costs .............................................................. 36
  8.2 Economic indicators ....................................................................................................... 38
9. Legal aspects related to biomass utilization ......................................................................... 40
10. Conclusion and recommendations ..................................................................................... 43
11. Literature............................................................................................................................ 44
List of Tables

Table 1: Road distance of Valjevo to neighbouring cities in km -cca ........................................12
Table 2: Average annual fuel consumption at PUC Toplana Valjevo........................................13
Table 3: Forest area distribution by regions, municipalities and ownerships.............................16
Table 4: Registered wood processing companies by type of production in Kolubara and Mačva Regions in 2011..................................................................................................17
Table 5: Forestry related road structure in Kolubara Region, according to the categories .........18
Table 6: Wood assortments production in FAU Valjevo 2016...................................................21
Table 7: Main characteristics of wood chippers........................................................................23
Table 8: List of wood chipper producers..................................................................................24
Table 9: List of wood chipper producers..................................................................................26
Table 10: Machinery necessary for biomass mobilization.......................................................36
Table 11: Annual operational costs of woody biomass storage and logistics unit...............36
Table 12: Analysis of sensitivity of fuel savings on fuels prices fluctuation .........................38
List of Figures

Figure 1: Administrative regions of the Republic of Serbia .......................................................... 11
Figure 2: City of Valjevo .................................................................................................................. 12
Figure 3: Toplana Valjevo – main building .................................................................................. 13
Figure 4: Forested area .................................................................................................................... 14
Figure 5: Unfavorable conditions in private forests ...................................................................... 15
Figure 6: Small mobile wood chipper at PUC ‘Vidrak’ Valjevo ...................................................... 19
Figure 7: Wood chips telescopic loader tractor ............................................................................. 27
Figure 8: Tractor with telescopic handler with fork lifter ............................................................... 27
Figure 9: Supplying wood directly from forest, option I ................................................................ 28
Figure 10: Supplying wood from forest to the storage or logistic center and continuing flow from there to end user, option II ................................................................................. 28
Figure 11: Logistics and supply chain options for supply of wood chips ..................................... 29
Figure 12: Trailer with hydraulic lifter ......................................................................................... 30
Figure 13: Tractor with telescopic handler with fork lifter ............................................................. 30
Figure 14: Toplana – up and storage – down: 500m distance ......................................................... 31
Figure 15: Toplana: heavy fuel boiler – black, planned biomass boiler - red and recommended small biomass storage – green circle ................................................................. 32
Figure 16: Mobile chipper with telehandler .................................................................................. 32
Figure 17: Central storage - Source: Techno-economic analysis of the possibilities of using biomass from the area of exploitation of open pit RB Kolubara for thermal purposes ........ 33
Figure 18: Storage with roof ......................................................................................................... 34
Figure 19: Roof storage with hydraulic tractor trailer for wood chips ........................................ 34
Figure 20: Tractor with special adapted trailer for wood chips .................................................... 35
Figure 21: Tractor with telescopic front loader ............................................................................ 35
List of Abbreviations

a  Annum
Ag  Agriculture
BMZ  German Federal Ministry for Economic Cooperation and Development
CBR  Cost Benefit Ratio
CC  Constitutional Court
CHP  Combined Heat and Power
DHC  District Heating Company
DKTI  German Climate Technology Initiative
€  EUR
EU  European Union
FA  Forest Estate
FAU  Forest Administration Unit
FIFO  First-in = First-out
GHG  Green House Gasses
GIZ  Deutsche Gesellschaft für Internationale Zusammenarbeit
h  Hour
ha  Hectare
HoB  Heat Only Boiler
km  Kilometer
kg  kilogram
LC  Lumber Camp
m  Meter
MW  Megawatt
No  Number
PC  Public Company
PPP  Public-Private Partnership
PUC  Public Utility Company
RS  Republic of Serbia
t  Ton
1. Definition of Tasks

Development of Woody biomass potential and logistics study for City of Valjevo is supported by the Programme ‘Development of a Sustainable Bioenergy Market in Serbia’, funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) under the German Climate Technology Initiative (DKTI), and implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

The goal of the Study is determination of realistic woody biomass potential in the region of the City of Valjevo, including entire Kolubara / Kolubarski region and adjacent municipalities of Kosjerić, Lazarevac and Koceljeva and provision of critical information and data for potential investors in Heat-Only-Boiler (HoB) biomass heating plant, which would be run by City of Valjevo. More phases are possible and besides the option of investing itself, City of Valjevo also has an option of Public-Private Partnership with private investor.

Tasks and activities

1. Biomass potentials and realistic biomass supply
   - Specification of available woody biomass potential from Srbijašume and private forests in Kolubarski region and adjacent municipalities of Kosjerić, Lazarevac and Koceljeva
   - Available woody biomass (wood processing residues by type and quantity)
   - Estimation of roadside, riverbed and park biomass
   - Determination of technical potentials and realistic biomass supply

2. Biomass supply and logistics
   - Biomass market situation in Kolubarski region and adjacent municipalities of Kosjerić, Lazarevac and Koceljeva
   - Identification of potential suppliers (specialized woody biomass mobilization companies, major wood processing companies, and producers of wood chips and wood pellets, etc..) and their potentials and propensity for supply in terms of quantity, quality and other properties
   - Technical requirements and machinery in use respectively necessary for sustainable biomass supply
   - Supply chain management – recommended management procedures
   - Biomass storage and overview on technology and machinery used in biomass harvest and logistic chains

3. Financial analysis and economic indicators of biomass supply organization and financing options
   - Investments in machinery, equipment, storage, quality control
   - Operational costs
   - Economic indicators based on the recommended solution, including sensitivity of savings on the fuel prices calculation

4. Legal aspects related to biomass utilization
2. Methodology applied

Woody biomass potential and logistics study for Valjevo should serve as a basis for further development of the project of establishment of a new biomass heating plant in the City of Valjevo, which should in the first phase have 9 MW single wood chips boiler to cover a base load consumption, with 10,000 t/a of wood chips necessary. The Study is based on both desk research and field investigation. Methodology applied in order to meet the goal of the Study encompasses following activities:

1) Desk research of relevant data regarding: situation in the designated Region regarding forestry, biomass market, wood processing, roadside biomass, infrastructure related to the establishment of a new plant biomass storage and recommended options for organizing the supply chain, stakeholders in the potential project at the supply side, and market research.

2) Review of selected literature on the topics of biomass fuels, referent legal framework, and available good/ bad practice examples.

3) Interviews with selected stakeholders representing local administration, relevant local and national public companies, wood processors and entrepreneurs. Structure of the interviews was following: a) standard questions on biomass production and the sectors of forestry and wood processing industry b) data on specific operations of a particular stakeholder c) professional and personal experience and attitude towards the project of a new biomass HoB plant and potential involvement. Interviews were conducted as a phone interviews and face to face interviews during the field visits.

4) Field visits were conducted to specific stakeholders selected by the authors as well as suggested by relevant local representatives.

5) Comparison and analysis of data gathered from different sources related to respective sectors, calculation and estimation, followed by consultations with experts in the field of agriculture, thermal and electrical engineering.

6) Evaluation of the results of analysis according to development of different scenarios of the project’s implementation, i.e. to the application of different technologies.

7) Financial analysis

8) Conclusions and recommendations

9) Reporting to GIZ

Time frame of conducted assessment was from April- May 2017.
3. Executive Summary

One of priorities of local development of the City of Valjevo is lowering of green-house gasses emissions and improving the quality of air. This can be achieved through utilization of biomass energy sources in district heating. Currently, City of Valjevo is unfortunately leading in air pollution and consequent occurrences of asthma and malign lung diseases. The first step in this strategic task would be achieved through the establishment of biomass fired boiler within district heating plant with capacity of 9 MW and 10,000 t/a of wood chips per year necessary, which will be located on the site of Valjevo’s Toplana.

PUC Toplana Valjevo, is a district heating company - DHC in charge of production and distribution of the heating energy to 193 objects including 4,491 residential units, 411 businesses and 27 public objects, with total of 344,988 m² of heated space. There are currently four operating boiler rooms, one runs on heavy fuel oil – mazut while the other three run on coal. It has average annual consumption of 5,000 t of heavy fuel oil – mazut and 150 t of coal. Biomass potential data from both National Forest Inventory and Srbijašume sources show that there is comfortably enough biomass available to provide Toplana Valjevo with 10,000 t/a of 30% moisture wood chips within 50 km circle from Valjevo. This renewable fuel would therefore substitute around 3,000 t/a of mazut.

Investment costs in storage and machinery are estimated at 342,000 €, while annual operation costs for the first years of operation are estimated at 522,060 €/a – see Tables10 and 11. If Toplana Valjevo has good supply chain management and if it pays prudently, it can be expected that operational costs would drop towards 450,000 €/a.

PUC Toplana Valjevo and City of Valjevo owns 2ha of asphalted open space just 500 m from the main boiler rooms, which means also from the site of planned biomass boiler plant. All legal property ownership issues are solved. This 2 ha site we recommend as the main storage area. Available area for the main storage of 2 ha has more than enough space to store woody biomass (metric wood, wood residuals, firewood and logs) in open air storage. Therefore, in total there would be enough wood chips ready for one month of consumption, with the rest of the wood stored in the open air and ready to be chipped on the FIFO basis (first in – first out). This way the driest wood always gets chipped. Biomass should be collected in the period May – September on the main storage. During other months only smaller quantities of biomass could be expected to arrive.

Additionally, covered storage for wood chips, (cover roof - shed form) is needed to store cca 1 month consumption need for wood chips or around 1,600 t. We recommend that besides central storage shed with 1 month capacity (which would be situated at 2ha area), there should be a few days small covered storage for 150 t - shed adjacent to the biomass boiler room.

In total 4 additional workers would be necessary to operate machines, receive biomass and measure quality. There should be 4 tractor drivers, one of them should be also manager. Heating season lasts from October to April, while biomass is received from May to September, with minor quantities received over other months.

This project will be financed from City of Valjevo through banking loan. Proposed solution is introducing biomass supply logistics (storage, machinery, staff) as an organizational unit within PUC Toplana Valjevo. Therefore, this biomass logistics unit is analysed as point of
cost rather than point of profit. Consequently, savings are in the centre of financial analysis instead of profit. Complete profit analysis should be done for the company as a whole, based on the data for revenues – heat selling prices and income, costs of biomass plant itself and costs of financing.

Since Toplana Valjevo has 2ha of asphalted land at approximately 500 m from the plant and this is in their legal possession, the best option is to buy logs and firewood at usual moisture content at 40-50% and price of 25-30 €/t on average. Up to 30 €/t it could be expected in the first year of operation and then it should drop towards 25 €/t if Toplana Valjevo manages the supply chain well and pays its suppliers on time. This way, toplana gets use of its vast storage space, since the wood dries down at open air (about 8 - 8,500 t should be stored at the beginning of the heating season). Additional 1,750 t should be stored in covered storages as bulk wood chips. This way, with storing wet wood at 40-50% and getting it dried to 30%, and with gaining experience and reputation with supply chain, the price of wood chips for toplana with current prices will eventually be around 35 €/t, which is lower than current market price which varies between 40 €/t and 50 €/t.

In price sensitivity analysis we bring what we believe to be a realistic price of final wood chips after a gaining experience in raw material procurement and after establishing reputation as a solid buyer. This solution brings savings of 1,006,000 €/a at current average prices of wood, chipping and heavy fuel oil - mazut of 450 €/t – as seen in Table 12. Price sensitivity analysis also shows price variation of both mazut and wood chips of +/- 30%. In the first years we can conservatively estimate savings at 950,000 € due to learning curve in wood procurement, at the current price of mazut. This is not a significant change. Price sensitivity analysis shows that at the worst assumed scenario, where at the same time price of wood chips (both wood and chipping) rises by 30% and price of mazut drops by 30% the savings are 500,000 €/t. In the opposite case, if price of mazut rises 30% and price of wood chips conservatively estimated drops by 15 %, the savings are 1,500,000 €/t. Therefore, it is safe to assume that the logistical part of investment, which is at focus of this study would be repaid in less than one year from the fuel switch savings.

As future user of renewable energy fuel, Toplana Valjevo will be eligible to apply for GHG emission reduction, government subsidies for using renewable energy, international financial institutions and local commercial banks special and favourable credit lines for renewable energy and energy efficiency.

We recommend renting chipper able to process metric wood. After additional phase of fuel switch project when more biomass will be necessary for additional boilers or CHP plant, buying of the chipper should be considered. By then experience will be gained about the necessary wood diameter and other categories that chipper needs to be able to process. The chipper needs to have self-propelled crane for feeding. Price for chipping with own chipper is around 6 €/t of wood chips with humidity around 50% (wood coming directly from forest). However, it is better to rent for 8 €/t for this quantity of wood and before experience in wood supply chain is gained.

The recommended option to Toplana Valjevo is to separate procurement of raw wood from production of wood chips. Therefore, suppliers of wood, which supply high moisture wood directly from forest would be independent from renter of wood chipper. This way Toplana
Valjevo gets use of its storage where the wood dries and is able to negotiate better prices on both ends.

Sales contracts on goods in Serbia are regulated by Law on Obligations, which stipulates usual provisions on such contracts (the subject of the contract; price and terms of payment; terms of delivery; quality requirements, quantity and quality control and consequences of failing to perform; risk of loss; amendments; cancellation). However, wood chips quality control measures and consequences of failures in meeting required quality – e.g. required moisture content in case of contracting wood chips are among essential provisions of the future contract.

One of potential biomass supplier can be ‘Micelini doo’, wood harvesting company experienced with all forestry related activities (harvesting, skidding and transporting of raw material).

In general, our findings are that:

1) There is enough biomass available to satisfy needs of Toplana Valjevo fuel switch project in the area of 50 km distance from Valjevo
2) The storage area is available and it is owned by Toplana / City
3) Investment in supply chain and logistics can be paid from fuel switch savings in less than 1 year
4) We recommend renting chipper able to process metric wood and separating procurement of raw wood from production of wood chips.

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1https://micelini-valjevo.ls.rs/rs/
4. Kolubara region

Kolubara region is situated in the western part of the Republic of Serbia, close to the border to Bosnia and Herzegovina and bordering Belgrade region. It is surrounded by Mačva Region from the north-west, while mountain chain separates it from southern Zlatibor region. On the South-East it borders Moravica and Serbian central Šumadija regions. It consists of City of Valjevo, and Municipalities of Osečina, Ub, Mionica, Lajkovac and Ljig, with total area of 2,474km², and population of 174,513 people².

![Figure 1: Administrative regions of the Republic of Serbia³](https://commons.wikimedia.org/wiki/File:Serbia,_administrative_divisions_(provinces%2Bdistricts)_-_de_-_colored.svg)

**City of Valjevo** is the administrative and economic centre of the Kolubara region. According to the 2011 Census City of Valjevo has 90,312 inhabitants, and urban area of Valjevo town has 59,073.

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¹2011 Census of Population, Households and Dwellings in the Republic of Serbia
³ https://commons.wikimedia.org/wiki/File:Serbia,_administrative_divisions_(provinces%2Bdistricts)_-_de_-_colored.svg
One of priorities of local development of the City of Valjevo is lowering of green-house gasses emissions and improving the quality of air. The important step towards this goal would be achieved through utilization of biomass energy sources in district heating. Currently, City of Valjevo is unfortunately leading in air pollution and consequent occurrences of asthma and malign lung diseases. One of the priorities of the Valjevo authorities is the establishment of biomass heating plant.

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>km</th>
</tr>
</thead>
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<td>Valjevo</td>
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</tr>
<tr>
<td>Valjevo</td>
<td>Lazarevac</td>
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<td>Valjevo</td>
<td>Šabac</td>
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<tr>
<td>Valjevo</td>
<td>Osečina</td>
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<tr>
<td>Valjevo</td>
<td>Loznica</td>
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<tr>
<td>Valjevo</td>
<td>Bajina Bašta</td>
<td>49.64</td>
</tr>
</tbody>
</table>

Table 1: Road distance of Valjevo to neighbouring cities in km -cca
PUC Toplana Valjevo, is in charge of production and distribution of the heating energy to 193 objects including 4,491 residential units, 411 businesses and 27 public objects, with total of 344,988 m² of heated space. There are currently four operating boiler rooms, one runs on heavy fuel oil – mazut while the other three run on coal.

Figure 3: Toplana Valjevo – main building

<table>
<thead>
<tr>
<th>Fuel</th>
<th>HFO - mazut</th>
<th>coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average consumption</td>
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<td>150</td>
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</table>

Table 2: Average annual fuel consumption at PUC Toplana Valjevo
5. Biomass potentials and realistic biomass supply

5.1 Specification of available woody biomass potential from Srbijašume and private forests in Kolubara region and adjacent municipalities of Kosjerić, Lazarevac and Koceljeva

National forest inventory from 2008 finally defined basic data on forest resources in Serbia at the level of 29.1%, with very unfavourable state of afforested area in Vojvodina region of 7.1%. Total area of forests is 2,252,400 ha, with high nature forests on the area of 621,000 ha (27.6%), coppice nature forests on 1,465,400 ha (64.6%), 174,800 ha (7.8%) of forest plantations and other forest land on 382,400 ha. Total area of forests and other forest land is 2,634,800 ha.

![Figure 4: Forested area](image)

Forest area: **2,252,400 ha**

Wood Volume: **362.5 milion m³**

Annual increment: **9,079 million m³**

Total (standing) volume is 362,487,418 m³ and annual volume increment of 9,079,773 m³. Average value of wood volume is modest 160.9 m³/ha and volume increment of 4.0 m³/ha. Concerning the ownership structure, state forests represent 53.0% (1,194,000 ha) and private forests 47.0% (1,058,400 ha).

Share of forest area in total area of the Kolubara Region (together with adjacent municipalities Koceljeva, Lazarevac and Kosjerić) is 29%, which is Serbia average. Majority of forests in the Kolubara Region are privately owned (70%). Management of forests is responsibility of Public Enterprise “Srbijašume”, Forest Estate (FE) “Boranja”, Loznica, through Forest Administration Unit (FAU) in Valjevo, while adjacent municipality Kosjerić is

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6National Forest Inventory (2008).
encompass in the FE Užice, and Lazarevac area is a part of responsibility of FE Belgrade. Additionally, Srbijašume has responsibilities for private forests to ensure kind of extension services for expert and technical support to the private forest owners.

Based on Srbijašume data, and data from National Forest Inventory (2008), overall forest area in Kolubara Region and adjacent municipalities has 101,200 ha, out of which state owned area has 30,400 ha (30%), and privately owned area has 70,800 ha (70%). In total, in Kolubara Region together with adjacent municipalities, share of forest area is around 12%. National Forest Inventory from 2008 is the most comprehensive data source. However, Srbijašume up-to-date sources have more precise data especially for the territory that they manage. Still, how much wood exists on territory of Serbia can currently only be roughly estimated. What is important is that data show that there is more than enough wood available for the needs of Valjevo Toplana fuel switch project. It should be added that forests on agricultural land is not well accounted, as well as forests alongside roads and riverbeds. In both cases there is more than enough wood available.

It is important to emphasize that City of Valjevo recently has taken over the responsibility of around 300 ha of forests in their vicinity. Mentioned area still is not in operational management because of lack of planning document for sustainable forest management. As soon as City of Valjevo provide Forest Management Plan, it will be possible to continue management with these forests. Table 3 shows distribution of forests in regional municipalities by areas, wood volume, increment and properties. It is evident domination of private forests in all municipalities, and leaded by forestry sciences possible theoretical harvesting is around 253,500 m³ annually. Taken into account present situation in forests, it is obvious that theoretically possible annual cut will be significantly reduced because of different reasons, like forest conditions, accessibility of the forests, condition of forest roads and related infrastructure, terrain conditions (inclination, erosion potentials, soil protection, etc.), forest age structure, unknown present ownership structure in many private forests, etc. It can be estimated that annual cut (etat) both state and private forests will be around 150,000 m³.

Figure 5: Unfavourable conditions in private forests
Table 3: Forest area distribution by regions, municipalities and ownerships

<table>
<thead>
<tr>
<th>Region</th>
<th>Municipality</th>
<th>Ownership</th>
<th>Area</th>
<th>Wood volume</th>
<th>Increment</th>
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<td></td>
<td></td>
<td></td>
<td>TOTAL</td>
<td>per ha</td>
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</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>38,400</td>
<td>8,000</td>
<td>21</td>
<td>1,036,043</td>
</tr>
<tr>
<td></td>
<td>Belgrade</td>
<td>STATE</td>
<td>42,400</td>
<td>30,400</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PRIVATE</td>
<td>304,400</td>
<td>70,800</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>346,800</td>
<td>101,200</td>
<td>29</td>
<td>16,585,661</td>
</tr>
</tbody>
</table>

Table 3: Forest area distribution by regions, municipalities and ownerships

---

7 Source: National Forest Inventory (2008) Note: Areas refer to forest management units, not to municipalities. In the meantime restitution process lead to more private forest, which makes wood cheaper on the market.
5.2 Existing wood processors in the Region

Based on available sources, field research and interviews, it is evident that wood industry in Kolubara region is not dominantly present like in some of other regions. It was recorded around 80 mainly very small facilities, with overall annual processing around 8,000 m³ of logs. Only one medium large facility is situated in Valjevo, “Samedi”, with annual processing of around 5,000 m³ of logs. Residues given in the mentioned facilities consumed either local population, or facility itself for additional energy purposes (steaming and drying kilns). Residues from sawmills are mainly slabs and sawdust. Sawdust is delivered to the Kronospan with containers.

According to 2011 data, Kolubara and Mačva Regions have 119 economy subject in different wood processing and manufacturing.

<table>
<thead>
<tr>
<th>Kolubara and Mačva Regions</th>
<th>Production of sawn timber</th>
<th>61</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacture of wood</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Production of construction joinery</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Manufacture of veneer sheets and wood-based panels</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Manufacture of other products of wood</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>119</td>
</tr>
</tbody>
</table>

Table 4: Registered wood processing companies by type of production in Kolubara and Mačva Regions in 2011⁸

5.3 Estimation of roadside, riverbed and park biomass

Taking into account all relevant planning documents regarding Kolubara region, with specific attention on development plans from different sectors, forestry planning documents, interview with relevant stakeholders, it is estimated that in Kolubara region has around 2,000 km of public roads with modern roadway. Additional part is road network in forest complexes, which is shown in table below:

<table>
<thead>
<tr>
<th>Municipalities</th>
<th>Total</th>
<th>Modern roads</th>
<th>Magistral Total</th>
<th>Modern roads</th>
<th>Regional Total</th>
<th>Modern roads</th>
<th>Local Total</th>
<th>Modern roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valjevo</td>
<td>521</td>
<td>434</td>
<td>79</td>
<td>79</td>
<td>194</td>
<td>184</td>
<td>248</td>
<td>171</td>
</tr>
<tr>
<td>Lajkovac</td>
<td>196</td>
<td>167</td>
<td>68</td>
<td>68</td>
<td>54</td>
<td>50</td>
<td>74</td>
<td>49</td>
</tr>
<tr>
<td>Ljig</td>
<td>280</td>
<td>173</td>
<td>22</td>
<td>22</td>
<td>112</td>
<td>86</td>
<td>146</td>
<td>65</td>
</tr>
<tr>
<td>Mionica</td>
<td>296</td>
<td>144</td>
<td>-</td>
<td>-</td>
<td>94</td>
<td>58</td>
<td>202</td>
<td>86</td>
</tr>
<tr>
<td>Osečina</td>
<td>431</td>
<td>115</td>
<td>18</td>
<td>18</td>
<td>86</td>
<td>57</td>
<td>327</td>
<td>40</td>
</tr>
<tr>
<td>Ub</td>
<td>243</td>
<td>175</td>
<td>6</td>
<td>6</td>
<td>122</td>
<td>119</td>
<td>115</td>
<td>50</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,967</strong></td>
<td><strong>1,208</strong></td>
<td><strong>193</strong></td>
<td><strong>193</strong></td>
<td><strong>662</strong></td>
<td><strong>554</strong></td>
<td><strong>1112</strong></td>
<td><strong>461</strong></td>
</tr>
</tbody>
</table>

Table 5: Forestry related road structure in Kolubara Region, according to the categories

Table shown that the region has:

- 193 km of magistral roads (9.81%)
- 662 km of regional roads (33.65%)
- 1,112 km of local roads (56.53%)

In total: 1,967 km (100.00%)

Length of all categories of roads with modern pavement is 1,208 km or 61.41%. Roadsides are calculated 3 m on each side of the road. Therefore, there are around 1,180 ha of roadside land in the Region. It is estimated that on 1 km of roadside maintenance can be collected around 10-20 m³ of wood material of very low quality, often not even for burning. It means that in total it could be collected more than 20,000 m³ of wood from roadside maintenance. However, special study using spatial tools would be needed for more precise estimations.

Maintenance of road network in Kolubara Region is responsibility of PE “PuteviSrbije”, while forestry infrastructure maintains Srbijašume. All wood related material from roadside maintenance PUC ‘PuteviSrbije’ leaves to the local people for their own purposes. Regarding forest roads network, all activities related with open up of forest roads and cut material is part of regular forestry activities where all cut wood is not extra recorded, but included into forest compartment Plan of Operations.

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9Source: General Forest Management Plan FE Boranja, Loznica
Additionally, riverbanks management and potentially wood material from maintenance of river banks is also not being collected, but it is left for local people. It is estimated that around 50 m³ per ha can be collected at riverbanks maintenance, but high additional costs for utilization of such material was discourage for potential collectors. Until now, there are no reliable data on amount of wood that can be provided from riverbanks maintenance.

PUC ‘Vidrak’, is Valjevo’s company maintaining parks and streets greenery. It is also dealing with non-hazardous waste. Department in charge of city green maintains green areas of the city (regular inspection, planting, pruning, and cutting). Around 100 t of woody biomass that is collected annually consists of tree benches, tree trunks, and stumps. According to data gathered at the field, all of park woody residues are chopped up in order to return organic matter into the soil, which is the instruction of agricultural/forestry experts. Due to combining of winter and summer park tree pruning, there are not many residuals.

Figure 6: Small mobile wood chipper at PUC ‘Vidrak’ Valjevo

10 Source: Greenery Service, Valjevo
11 Source: http://www.kolubarske.rs/sr/vesti/valjevo/4146/%E2%80%9EVidrak%E2%80%9D-kupio-drobilicu-za-drvo.htm
6. Biomass market situation and input prices

Forest estate ‘Boranja’, Loznica is in charge of 33,695ha of state owned forests, and also provides technical services at 109,306ha of privately owned forests. However, FE ‘Boranja’ covers large territory of the Regions of Maćva and Kolubara; Obrenovac and Lazarevac municipalities at territory of the City of Belgrade; and parts of municipalities of Bajina Bašta and Kosjerić in the Zlatibor Region\(^\text{12}\). On a basis of a ten-year plan of PE ‘Srbijašume’, 109,000m³ of wood in state owned forests is cut annually at whole territory of FE ‘Boranja’, with total of 15,000m³ of wood residuals\(^\text{13}\). Regardless the fact that around 98,000m³ annually is allowed for cutting in privately owned forests, it is estimated that additional quantity of over 110,000m³ of wood is illegally cut in privately owned forests. Wood cut in privately owned forests is mostly used as firewood\(^\text{14}\), according to Mr. Dragic Tomic from FAU Valjevo.

Regarding woody biomass production, several aspects are important. Firstly it is the identification appropriate needs for raw material (fuel wood, wood chips, or other wood based fuel), then the raw material identification, and finally possibilities for production (fuel wood, forest residues, wood industry residues, wood biomass from parks and nearby roadside, etc.); and additional requirements like machinery and its capacity for production.

For fuel wood, the price depends on the season and general demand. The most of the year it varies between 20 - 30 €/m³. A long-term buyer should be able to negotiate the price at the lower end or even below.

For residuals, the sawdust carries the lowest cost, followed by slabs, and then forest residuals, which are most expensive commodity given monopolistic nature of forest management company Srbijašume. Due to the lack of a domestic market for wood residuals, price data are based on the field survey in Srbijašume. Based on the market demands, prices are as follows: for sawdust app. 2-3 €/m³, price for slabs of approximately 10 €/m³, solid dry waste 15 €/m³. The published price list of Srbijašume is cca30 €/m³ for hardwood and cca 20 €/m³ for softwood on a truck roadside. This is price for raw material and additionally transport cost need to be added, which is about 10 €/m³ for transport distance of up to 50 km. Chipping services is cca 8 €/m³.

Regarding the prices related to wood chips shown in tons, are as follows:

- price of wood chips delivered to the final consumer (FCO consumer) for softwood is around 40 €/t, while for hardwood is 50 €/t
- chipping services is from 6-10 €/t (depending of types of wood, field conditions, etc.)
- transport costs up to 150 km is around 5-10 €/t.

Real price in the field can be different, but in Kolubara Region around 65% of wood come from private forests, which in effect can’t significantly reduce the price of forestry enterprises.

\[^{12}\text{http://www.Srbijašume.rs/pdf/30osnove.pdf}\]
\[^{13}\text{Source: FE ‘Boranja’, Valjevo Office}\]
\[^{14}\text{Ibid}\]
It is difficult to estimate how much the price can be reduced, but it is sometimes even 30 - 40% lower than the price of forestry enterprises. In addition, General Manager of forestry enterprise has the right to give a 10% discount.

In order to set the right pricing strategy, including the possible incentives for the suppliers, it is necessary to know what material would be preferred from the processing side. Thus, final users could stimulate suppliers to collect the most desired material.

There is no accurate General Forest Management Plan (Forest Area Development Plan) and new inventory data of forests per ownership is still missing. In accordance with the Serbian Law on Property Restitution and Compensation (Official Gazette of the RS No 72/2011, 108/2013, 142/2014 and 88/2015 – Decision of the CC), there are changes in the ownership structure of particular forest areas, and similar changes are yet to come.

Because of mentioned facts, there are usual inconsistency regarding the ownerships data, but also wood volume and increment. However these issues do not affect recommendations for Toplana Valjevo.

Regarding woody biomass productions, main tools of the lumberjacks are chainsaws and axes; horses haul timber to forest roads. Most of wood residuals stay in the forests, due to labour intensive collecting process lack of skilled workers. Most of the workers come from Bosnia and Herzegovina. Certain quantities of residuals at forest roads are mainly left to residents of local villages who collect them, transport them by tractor trailers, and use them as a firewood.

FAU Valjevo operates on territory of several municipalities (Ub, Mionica, Ljig, Osečina and Lajkovac), but also in part of territory of municipalities Kosjerić, Lazarevac and Koceljeva, with total annual cut in state forests of around 30,000 m³ and around 43,000 m³ in private forests.

<table>
<thead>
<tr>
<th>FAU</th>
<th>Assortment structure</th>
<th>State forests m³</th>
<th>Private forests m³</th>
<th>TOTAL m³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Softwood</td>
<td>Hardwood</td>
<td>Total</td>
</tr>
<tr>
<td>Valjevo</td>
<td>Technical wood</td>
<td>797</td>
<td>14,280</td>
<td>15,077</td>
</tr>
<tr>
<td></td>
<td>Fuelwood</td>
<td>1,317</td>
<td>10,824</td>
<td>12,142</td>
</tr>
<tr>
<td></td>
<td>Residues</td>
<td>211</td>
<td>2,510</td>
<td>2,721</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>2,326</td>
<td>27,614</td>
<td>29,941</td>
</tr>
</tbody>
</table>

Table 6: Wood assortments production in FAU Valjevo 2016.\(^{15}\)

Average quantity of firewood sold by FAU Valjevo is ~12,000m³ annually. Complete annual wood production of FAU Valjevo is sold by the end of November, each year. Additionally, ~30,000 m³ from private forests are delivered to households and placed on market.

\(^{15}\)Source: Forest Administration Unit Valjevo (2016)
Concerning potential increase of wood production, the greatest possibilities lie on the side of private forests.

There is one significant wood processor in the respective area - Samedi doo, Valjevo, with annual production of 5,000m³. Small entrepreneurial sawmills mainly oriented on service cutting (on demand cutting) are scattered around the region, with small capacity and low quality of processing, process additionally 5,000m³ of logs. In addition, numbers of small entrepreneurs dealing with wood are actually trade companies.

With respect to aforementioned, realistic biomass potential for the future Valjevo heating plant available at road distance in radius of 50km is around 40,000m³ of fuel wood from state and private forests.

Another potential source for woody biomass for City of Valjevo would be energy plantations, including poplar and willow on the land owned by the City of Valjevo.
7. Biomass supply and logistics

7.1 Technical requirements and machinery in use

Procurement strategy in general and the collection strategy in particular is also reflecting the need to be a responsible community player, who respects the environment and is considered as a good social player. It is recommend that the collection of raw material wood should be outsourced to local contractors (‘deal makers’) who would be able to negotiate deals with the raw material suppliers/wood processors on the spot. This option also leaves more flexibility to the contractor, able to construct his/her own procurement modus operandi. For instance, general strategic intention is to source all the material out of e.g. 50 km fiber shred. However, if a contractor is able to sustain the cost of bringing in fiber from further away, it is left up to him/her (cheaper transport, higher quality wood, cheaper price that the contractor might be able to arrange).

Concerning the requirements, for machinery and possible scenarios, there are several types of wood chipper categories and operational characteristics that can be recommended.

<table>
<thead>
<tr>
<th>Category of wood chippers</th>
<th>Max. Diameter of wood biomass (cm)</th>
<th>Feed opening (cm):</th>
<th>Size of wood chips (mm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- width</td>
<td>- height</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>from 2 to 37</td>
<td>from 16 to 65</td>
<td>from 12 to 35</td>
<td>from 9 to 45</td>
</tr>
<tr>
<td>2</td>
<td>from 15 to 75</td>
<td>from 24 to 165</td>
<td>from 18 to 300</td>
<td>from 17 to 57</td>
</tr>
<tr>
<td>3</td>
<td>from 45 to 100</td>
<td>from 66 to 208</td>
<td>from 60 to 300</td>
<td>from 17 to 105</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category of wood chippers</th>
<th>Power requirement (kW)</th>
<th>Average productivity (bulk m³/h)</th>
<th>Average no. of working hour in life time</th>
<th>Price range (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>from 15 up to 55</td>
<td>from 5 up to 30</td>
<td>4930</td>
<td>from 8,000 up to 60,000</td>
</tr>
<tr>
<td>2</td>
<td>from 30 up to 500</td>
<td>from 30 up to 100</td>
<td>7363</td>
<td>from 12,000 up to 250,000</td>
</tr>
<tr>
<td>3</td>
<td>from 240 up to 550</td>
<td>more than 100</td>
<td>10675</td>
<td>from 260,000 up to 800,000</td>
</tr>
</tbody>
</table>

Table 7: Main characteristics of wood chippers

Current production need of wood chips for Toplana Valjevo is planned at 10,000 t/a.

With reference to forest harvesting operations, it is possible to differentiate between the following working phases:

- **felling**: cutting a tree from its stump so that the tree falls to the ground;
- **processing**: de limbing (removing branches from the trunk and topping it) and cross-cutting (cutting the trunk to predetermined lengths);
- **skidding**: transporting wood from felling site to extraction routes and transporting wood along extraction routes to the landing site;

---

debarking: partially or completely removing the bark from a log
transporting: moving wood using forest roads and public roads;

The importance of chipping operation has been growing in the last few years. This is due to the fact that chipping makes it possible to exploit and make the most of woody biomass otherwise unused.

<table>
<thead>
<tr>
<th>AHWI Eurochipper</th>
<th>Jenz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berkili</td>
<td>Kirchmayr</td>
</tr>
<tr>
<td>Bruks-Klöckner</td>
<td>Komptech</td>
</tr>
<tr>
<td>CBI (Continental Biomass Industries)</td>
<td>KRONE</td>
</tr>
<tr>
<td>Doppstadt</td>
<td>Laimet</td>
</tr>
<tr>
<td>Dutch Dragon</td>
<td>MUS-MAX</td>
</tr>
<tr>
<td>Eschiböck</td>
<td>Pezzolato</td>
</tr>
<tr>
<td>Euroklip</td>
<td>Schliesing</td>
</tr>
<tr>
<td>Hakkuri</td>
<td>Silvatec</td>
</tr>
<tr>
<td>HAMA</td>
<td>Starchl</td>
</tr>
<tr>
<td>Husmann</td>
<td>Stark</td>
</tr>
<tr>
<td>Jensen</td>
<td>Willibald</td>
</tr>
<tr>
<td>Wüst</td>
<td></td>
</tr>
</tbody>
</table>

Table 8: List of wood chipper producers

There are two main working systems in forest harvesting operations:

- Short Wood System - SWS: processing is completed on the falling site in the forest, commercial logs are transported;
- Tree System - FTS: after felling the whole tree is hauled and processing is performed either on the forest road or on the landing site.

Although in South-eastern Europe SWS is the most predominantly used system, the FTS system is becoming more and more common, particularly in the mountain areas, especially when cable cranes are used: with this method, forest residues (branches and tops) are collected either at the roadside or at the landing site, ready to be chipped.

A review of the most important machines and equipment involved in chipping operations, with reference to the Slovenian and Italian market, is presented in next table. The range of the most frequent values is indicated for each machine. Hourly cost, when specified, includes the staff costs. All prices are in € and exclusive of VAT.

<table>
<thead>
<tr>
<th>Chainsaw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase cost: 500–1.000 €</td>
</tr>
<tr>
<td>Productivity in high forests:</td>
</tr>
<tr>
<td>0,8–1,2 m³/h (thinning operations)</td>
</tr>
<tr>
<td>2–2,5 m³/h (final cutting)</td>
</tr>
<tr>
<td>Productivity in coppice forests:</td>
</tr>
<tr>
<td>0,4–0,7 stacked m³/h (average conditions)</td>
</tr>
<tr>
<td>0,8–1,8 stacked m³/h (good conditions)</td>
</tr>
</tbody>
</table>
### Tractor (farm tractor adopted for forest operations) and winch
- Purchase cost: tractor 45,000–80,000 €
- Purchase cost: winch 3,000–8,000 €
- Productivity in high forest: 3–8 m³/h
- Productivity in coppice: 3–7 stacked m³/h
- Fuel consumption per hour: 4–8 l/h
- Hourly cost ≈ 35–45 € (2 del.)

### Tractor (farm tractor adopted for forest operations) and trailer
- Purchase cost: tractor 45,000–80,000 €
- Purchase cost: trailer 8,000–25,000 €
- Loading capacity: 5 – 15 t
- Productivity: 5–12 m³/h (depending on skidding distance)
- Fuel consumption per hour: 5–10 l/h
- Hourly cost ≈ 40–50 €

### Tractor (farm tractor adopted for forest operations) with processor
- Purchase cost: tractor 45,000–80,000 €
- Purchase cost: processor 45,000 €
- Max cutting diameter: 48 cm
- Max delimb diameter: 40 cm
- Productivity: 10–15 m³/h
- Fuel consumption per hour: 4–5 l/h
- Hourly cost ≈ 35 €

### Skidder
- Purchase cost: 120,000–150,000 €
- Skidding capacity: up to 3 t
- Max negotiable slope: 20%
- Productivity: 8 – 12 solid m³/h (depending on hauling distance)
- Fuel consumption per hour: 6–10 l/h
- Hourly cost ≈ 45–55 €

### Harvester
- Purchase cost (with processor head): 300,000–370,000 €
- Max cutting diameter: 65–70 cm
- Max delimb diameter: 45–60 cm
- Max negotiable slope: 35% (wheels) and 60% (tracks) (with optimal soil bearing capacity)
- Productivity in high forest: 8–20 m³/h
- Fuel consumption per hour: 11–16 l/h
- Hourly cost ≈ 70–90 €
**Hybrid harvester**

<table>
<thead>
<tr>
<th>Purchase cost: of harvester with processor:</th>
<th>240,000 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max cutting diameter:</td>
<td>55 cm</td>
</tr>
<tr>
<td>Max delimb diameter:</td>
<td>50 cm</td>
</tr>
<tr>
<td>Max negotiable slope:</td>
<td>45–60 %</td>
</tr>
<tr>
<td>Productivity:</td>
<td>10–15 m³/h</td>
</tr>
<tr>
<td>Fuel consumption per hour:</td>
<td>10–12 l/h</td>
</tr>
<tr>
<td>Hourly cost ≈ 70–80 €</td>
<td></td>
</tr>
</tbody>
</table>

**Excavator-based processor**

<table>
<thead>
<tr>
<th>Excavator purchase cost:</th>
<th>170,000 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor purchase cost:</td>
<td>60,000 €</td>
</tr>
<tr>
<td>Max cutting diameter:</td>
<td>65 cm</td>
</tr>
<tr>
<td>Max delimb diameter:</td>
<td>60 cm</td>
</tr>
<tr>
<td>Productivity:</td>
<td>15-40 solid m³/h</td>
</tr>
<tr>
<td>Fuel consumption per hour:</td>
<td>15 - 17 l</td>
</tr>
<tr>
<td>Hourly cost ≈ 85 €</td>
<td></td>
</tr>
</tbody>
</table>

**Forwarder**

<table>
<thead>
<tr>
<th>Purchase cost:</th>
<th>180,000 – 270,000 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading capacity:</td>
<td>10 - 14 t</td>
</tr>
<tr>
<td>Max negotiable slope:</td>
<td>30 - 35%</td>
</tr>
<tr>
<td>Logs length:</td>
<td>up to 6 m</td>
</tr>
<tr>
<td>Productivity:</td>
<td>12-20 solid m³/h</td>
</tr>
<tr>
<td>(depending on hauling distance)</td>
<td></td>
</tr>
<tr>
<td>Fuel consumption per hour:</td>
<td>7 - 11 l</td>
</tr>
<tr>
<td>Hourly cost ≈ 65 - 80 €</td>
<td></td>
</tr>
</tbody>
</table>


### Chippers

**Small (driven by tractor)**

<table>
<thead>
<tr>
<th>Purchase cost:</th>
<th>4,500–35,000 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working diameter:</td>
<td>20 cm</td>
</tr>
<tr>
<td>Productivity:</td>
<td>2–3 t/h</td>
</tr>
<tr>
<td>Fuel consumption per hour:</td>
<td>5–8 l/h</td>
</tr>
<tr>
<td>Hourly cost ≈ 15 – 22 €</td>
<td></td>
</tr>
</tbody>
</table>

**Medium (driven by tractor)**

<table>
<thead>
<tr>
<th>Purchase cost:</th>
<th>20,000–85,000 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working diameter:</td>
<td>max 30 cm</td>
</tr>
<tr>
<td>Productivity:</td>
<td>7–15 t/h</td>
</tr>
<tr>
<td>Fuel consumption per hour:</td>
<td>10–14 l/h</td>
</tr>
<tr>
<td>Hourly cost ≈ 22 - 30 €</td>
<td></td>
</tr>
</tbody>
</table>

**Large**

<table>
<thead>
<tr>
<th>Purchase cost:</th>
<th>85,000 – 400,000 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working diameter:</td>
<td>&gt; 30 cm</td>
</tr>
<tr>
<td>Productivity:</td>
<td>20 – 35 t/h</td>
</tr>
<tr>
<td>Hourly cost ≈ 120 - 170 €</td>
<td></td>
</tr>
</tbody>
</table>

Table 9: List of wood chipper producers

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Among all costs categories for middle size wood chipper (shown at the picture) fuel represents nearly 30%, followed by depreciations and maintenance costs. Labor and biomass costs are not taken into consideration in this calculation costs.

Figure 7: Wood chips telescopic loader tractor\textsuperscript{18}

Figure 8: Tractor with telescopic handler with fork lifter\textsuperscript{19}

\textsuperscript{18} Source: Internet (https://www.youtube.com/watch?v=qA2B9_2hOBg)

\textsuperscript{19} Source: Internet (https://www.youtube.com/watch?v=qA2B9_2hOBg)
7.2 Supply chain management

The situation on the field described in previous chapters refers to the solution of several suppliers or a consortium with one or two lead entrepreneurs as the most apparent solution for supplying the future plant.

There are two basic options that can be considered regarding supply chain management.

Figure 9: Supplying wood directly from forest, option I

Figure 10: Supplying wood from forest to the storage or logistic centre and continuing flow from there to end user, option II

The first option is to store raw wood material at the truck road, to chip it there and to bring wood chips as a final product to toplana. The second option is to bring raw wood material to central storage, to store it there, chip it there when it is dried and then to store wood chips

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also for further drying. We recommend option two, where central storage is 2 ha of asphalted land at 500 m distance from toplana.

Figure 11: Logistics and supply chain options for supply of wood chips

In the majority of cases, entrepreneurs conclude business arrangements to deliver wood chips directly to storages / end users. In such cases wood chips have the highest price, because of a more intermediaries and VAT charged to the buyers.

The recommended option to Toplana Valjevo is to separate procurement of raw wood from production of wood chips. Therefore, suppliers of wood, which supply high moisture wood directly from forest would be independent from renter of wood chipper. This way Toplana Valjevo gets use of its storage where the wood dries and is able to negotiate better prices on both ends.

Sales contracts on goods in Serbia are regulated by Law on Obligations, which stipulates usual provisions on such contracts (the subject of the contract; price and terms of payment; terms of delivery; quality requirements, quantity and quality control and consequences of failing to perform; risk of loss; amendments; cancellation). However, wood chips quality control measures and consequences of failures in meeting required quality – e.g. required moisture content in case of contracting wood chips are among essential provisions of the future contract.

One of potential biomass supplier can be ‘Micelini doo’, wood harvesting company experienced with all forestry related activities (harvesting, skidding and transporting of raw material).

Figure 12: Trailer with hydraulic lifter

Figure 13: Tractor with telescopic handler with fork lifter

23 https://micelini-valjevo.ls.rs/rs/
25 Source: http://www.ryetec.net/product.php?id_product=77
### 7.3 Biomass storage

PUC Toplana Valjevo and City of Valjevo own 2ha of asphalted open space just 500 m from the main boiler rooms, which means also from the site of planned biomass boiler plant. This 2 ha site we recommend as the main storage area. Available area for the main storage of 2 ha has more than enough space to store woody biomass (metric wood, wood residuals, firewood and logs) in open air storage. Around 12,000 t of biomass should be stored in open air at the beginning of the heating season.

Additionally, covered storage for wood chips, (cover roof - shed form) is needed to store cca 1 month consumption need for wood chips or around 1,600 t. With wood chips height of 5 - 6m, covered storage needs to have 1,500 m² in order to leave space for manipulation. We recommend that besides central storage shed with 1 month capacity (which would be situated at 2ha area), there should be a few days small covered storage for 150 t - shed adjacent to the biomass boiler room. We estimate that approximately 150m² which would be enough is readily available for a few days storage – shed. Therefore, in total there would be enough wood chips ready for one month of consumption, with the rest of the wood stored in the open air and ready to be chipped on the FIFO basis (first in – first out). This way the driest wood always gets chipped.

Biomass should be collected in the period May – September on the main storage. During other months only smaller quantities of biomass could be expected. There should be 1,600 t of wood chips stored in the shed on the central storage location and 150t of wood chips on the weekly storage next to the biomass boiler room itself- in total 1,750 t of stored wood chips under roof. The rest of approximately 10.000 –10.500 t of wood would be placed in open storage at the central storage location. Depending on the material, total cost for building two sheds, pre-fab office and protection garage should not exceed 180,000 € and it could be less since conservative financial estimates are made. The fact that the storage area has a clear legal situation without liabilities leaves open space for decision making and taking action.

26 Data maps ©2017. Google
Manipulation with woody biomass and wood chips, including wood chips loading, should be operated with telescopic handler. Telescopic handler should be equipped with fork lifter and loading bucket. Telescopic handler should have elevation possibility for loading or stacking of 6 - 7 meters.
The necessary machinery is hydraulic tractor trailer with crane from 70-90 kW, power, or a truck with a crane and a trailer, depending on the system operation.

We recommend renting chipper able to process metric wood. After phase two when more biomass will be necessary for additional boilers or CHP plant, buying of the chipper should

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28 Glavonjic, B. (2012): Techno-economic analysis of the possibilities of using biomass from the area of exploitation of open pit RB Kolubara for thermal purposes, Faculty of Forestry, Belgrade
be considered. By then experience will be gained about the necessary wood diameter and other categories that chipper needs to be able to process. The chipper needs to have self-propelled crane for feeding. Price for chipping with own chipper is around 6 €/t of wood chips with humidity around 50% (wood coming directly from forest). However, it is better to rent for 8 €/t for this quantity of wood and before experience in wood supply chain is gained. For permanent production it is necessary to procure machines and extensions listed in Table 10.
Figure 20: Tractor with special adapted trailer for wood chips

Figure 21: Tractor with telescopic front loader

²⁹https://i.ytimg.com/vi/Je9owF9TpW4/maxresdefault.jpg
8. Financial analysis and economic indicators of biomass supply organization and financing options

8.1 Investments in hardware and operational costs

The results of research show that there is enough biomass available and there are available mobile chippers that could be rented to chip at the storage facility of Toplana. Mobile chipper, equipped with telescopic handlers and cranes could be rented to chip wood at price of 8 €/t.

Investment costs in storage and machinery are estimated at 342,000 €, while annual operation costs for the first years of operation are estimated at 522,060 €/a – see Tables 10 and 11. If Toplana Valjevo has good supply chain management and pays prudently, it can be expected that operational costs would drop towards 450,000 €/a.

<table>
<thead>
<tr>
<th>Machinery and equipment</th>
<th>Unit Price (€)</th>
<th>No of Units</th>
<th>Total Cost (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor of 80 kW</td>
<td>25,000</td>
<td>3</td>
<td>75,000</td>
</tr>
<tr>
<td>Telescopic front loader</td>
<td>5,000</td>
<td>2</td>
<td>10,000</td>
</tr>
<tr>
<td>Transport trailer with crane 40 nm³</td>
<td>22,000</td>
<td>1</td>
<td>22,000</td>
</tr>
<tr>
<td>Trailer with extension for wood chips transport – 10 t</td>
<td>15,000</td>
<td>2</td>
<td>30,000</td>
</tr>
<tr>
<td>Scale 100 t</td>
<td>25,000</td>
<td>1</td>
<td>25,000</td>
</tr>
<tr>
<td>Storages, facilities</td>
<td>180,000</td>
<td></td>
<td>180,000</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td><strong>342,000</strong></td>
</tr>
</tbody>
</table>

Table 10: Machinery necessary for biomass mobilization

Operational costs include expenses of the supplier for: salaries, purchase of wood (logs and firewood, with option to use residuals from wood processing industry such as slabs and roadside and park biomass), manipulation, transport, and storing. Indirect costs and maintenance are also included in operational costs. Due to the only 500 m distance between the storage and biomass plant, fuel and maintenance costs are sharply decreased. Still, indirect and maintenance costs are conservatively estimated at 5%.

<table>
<thead>
<tr>
<th>Annual Operational Costs</th>
<th>4* gross salary*12 months</th>
<th>3<em>800</em>12</th>
<th>1<em>1,200</em>12</th>
<th>43,200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries</td>
<td></td>
<td></td>
<td></td>
<td>43,200</td>
</tr>
<tr>
<td>Wood biomass 40%-45% of moisture franco storage</td>
<td>12,000</td>
<td>t app. = m³</td>
<td>29</td>
<td>348,000</td>
</tr>
<tr>
<td>Chipping 30% moisture wood</td>
<td>12,000</td>
<td>m³</td>
<td>8</td>
<td>96,000</td>
</tr>
<tr>
<td>Manipulation, loading, unloading, transport</td>
<td>10000</td>
<td>t</td>
<td>1</td>
<td>10,000</td>
</tr>
<tr>
<td>Indirect costs and maintenance 5% due to proximity of storage</td>
<td></td>
<td></td>
<td></td>
<td>24,860</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>522,060</strong></td>
</tr>
</tbody>
</table>

Table 11: Annual operational costs of woody biomass storage and logistics unit

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30 Data gathered by on-line and phone inquiry
In total 4 additional workers would be necessary to operate machines, receive biomass and measure quality. There should be 4 tractor drivers, one of them should be also manager. Heating season lasts from October to April, while biomass is received from May to September, with minor quantities received over other months.
8.2 Economic indicators

This project will be financed from City of Valjevo through banking loan. Proposed solution is introducing biomass supply logistics (storage, machinery, staff) as an organizational unit within PUC Toplana Valjevo. Therefore, this biomass logistics unit is analysed as point of cost rather than point of profit. Consequently, savings are in the centre of financial analysis instead of profit. Complete profit analysis should be done for the company as a whole, based on the data for revenues – heat selling prices and income, costs of biomass plant itself and costs of financing.

Since Toplana Valjevo has 2 ha of asphalted land at approximately 500 m from the plant and this is in their legal possession, the best option is to buy logs and firewood at usual moisture content at 40-50% and price of 25-30 €/t on average. Up to 30 €/t it could be expected in the first year of operation and then it should drop towards 25 €/t if Toplana Valjevo manages the supply chain well and pays its suppliers on time. This way, toplana gets use of its vast storage space, since the wood dries down at open air (about 8 - 8,500 t should be stored at the beginning of the heating season). As mentioned above, additional 1,750 t should be stored in covered storages as bulk wood chips. This way, with storing wet wood at 40-50% and getting it dried to 30%, and with gaining experience and reputation with supply chain, the price of wood chips for toplana with current prices will eventually be around 35 €/t, which is lower than current market price which varies between 40 €/t and 50 €/t.

<table>
<thead>
<tr>
<th>Wood chips: Price in €</th>
<th>Heavy fuel oil – mazut: Price in €</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>36</td>
</tr>
<tr>
<td>-10%</td>
<td>32</td>
</tr>
<tr>
<td>-15%</td>
<td>30</td>
</tr>
<tr>
<td>10%</td>
<td>39</td>
</tr>
<tr>
<td>15%</td>
<td>41</td>
</tr>
<tr>
<td>20%</td>
<td>43</td>
</tr>
<tr>
<td>25%</td>
<td>45</td>
</tr>
<tr>
<td>30%</td>
<td>46</td>
</tr>
<tr>
<td><strong>30%</strong></td>
<td>490</td>
</tr>
</tbody>
</table>

In price sensitivity analysis we bring what we believe to be a realistic price of final wood chips after a gaining experience in raw material procurement and after establishing reputation as a solid buyer. This solution brings savings of 1,006,000 €/a at current average prices of wood, chipping and heavy fuel oil - mazut of 450 €/t – as seen in Table 12. Price sensitivity analysis also shows price variation of +/- 30%. In the first years we can conservatively estimate savings at 950,000 € due to learning curve in wood procurement, at
the current price of mazut. This is not a significant change. Price sensitivity analysis shows that at the worst assumed scenario, where at the same time price of wood chips (both wood and chipping) rises by 30% and price of mazut drops by 30% the savings are 500,000 €/t. In the opposite case, if price of mazut rises 30% and price of wood chips conservatively estimated drops by 15 %, the savings are 1,500,000 €/t. Therefore, it is safe to assume that the logistical part of investment, which is at focus of this study would be repaid in less than one year from the fuel switch savings. In addition, this investment would open four new work places.

As future user of renewable energy fuel, Toplana Valjevo will be eligible to apply for GHG emission reduction, government subsidies for using renewable energy, international financial institutions and local commercial banks special and favourable credit lines for renewable energy and energy efficiency.

...
9. Legal aspects related to biomass utilization

Legal framework in Serbia related to biomass utilization consists of laws, by-laws, and rule books, which stipulate referent sectors.

- **Law on Energy** (Official Gazette of the Republic of Serbia No 145/20014) regulates the production and distribution of energy.

- **Law on Efficient Use of Energy** (Official Gazette of the Republic of Serbia No 25/2013) among other stipulates metering and billing based on the consumption; introduces ESCO, and defines energy service.

- **Law on Public-Private Partnerships and Concessions** (Official Gazette of the Republic of Serbia No 88/2011 and 15/2016) regulates institutional and contractual PPP, and concessions between public bodies and private partners. According to this Law, tendering procedure in compliance with the Law on Public Procurement is obligatory in the process of establishing institutional and contractual PPP without concessions.

- **Law on Public Procurement** (Official Gazette of the Republic of Serbia No 124/2012, 14/2015 and 68/2015) prescribes detailed procedures for procurement of goods, procurement of works, and procurement of services.


- **Law on Public Companies** (Official Gazette of the Republic of Serbia No 15/2016) regulates establishment and functioning of companies founded by state and local governments in order to performing operations of public interest.


- **Law on Environmental Impact Assessment** (Official Gazette of the Republic of Serbia No 135/2004 and 36/2009) regulates the impact assessment procedure for projects that may have significant effects on the environment.


- **Law on Integrated Prevention and Control of Environmental Pollution** (Official Gazette of the Republic of Serbia No 135/2004 and 25/2015)

Law on Forests (Official Gazette of the Republic of Serbia No 30/2010, 93/2012 and 89/2015) regulates the conservation, protection, planning, cultivation, use and management of forests and forest land on the territory of the Republic of Serbia, including all necessary rules and requirements defining the control over the implementation of provided rules, monitoring, inspection, as well as other issues relevant to forests and forest land and areas. The provisions of this Law are related to forests and forest land in all forms of property.


Law on Safety and Health on Work (Official Gazette of the Republic of Serbia No 101/2005 and 91/2015)


Law on Agriculture Land (Official Gazette of the Republic of Serbia No 62/2006,65/2008,41/2009, 112/2015) - Amendments to the Law on agricultural land, for the first time explicitly mentioned "energy production from renewable sources - biomass" in Art. 61, where for this purpose allows the lease of agricultural land owned by the state for 30 years. Essentially, this thematic subject in the Agricultural Land Act, dealing Art. 22-25; then Art. 48, and Art. 60-62, 64 and 67.

Other important regulations are:

- Regulation on methodology of determining the price of thermal energy for final users (Official Gazette of the RS No 63/2015)

- Regulation on activities which affect environment (Official Gazette of the RS No 109/2009 and 8/2010)

- Regulation on the types of projects for which environmental impact assessment is obligatory or can be required (Official Gazette of the RS No 114/2008)
Regulation on requirements for the location (Official Gazette of the RS No 114/2008)

Rule Books:

- Rule Book on energy permits (Official Gazette of the RS No 15/2015)
- Rule Book on unified electronic procedure (Official Gazette of the RS No 113/2015)
- Rule Book on technical requirements for designing, construction, and control of equipment under pressure (Official Gazette of the RS No 87/2011)
10. Conclusion and recommendations

- The Valjevo authorities are determined to implementing a fuel switch project to the benefit of the citizens, to provide necessary support during preparation works.

- Furthermore, the project is in accordance with National Renewable Energy Action Plan of the Republic of Serbia.

- There is than more sufficient quantity of woody biomass in the area of the City of Valjevo to supply the needed 10,000 t of wood chips for HoB boiler.

- There are potential fuel suppliers at local market interested in a long term business agreements.

- It is necessary to be a reliable buyer who pays responsibly and efficiently in order to encourage private entrepreneurs join supply chain of wood to the heating plant.

- Roadside and riverbed biomass collection will be revived when there is newly established need for biomass as a fuel

- With respect to the listed above, as well as to the subject of this Study, we can conclude that the project of establishment of HoB plant in the City of Valjevo is feasible.

- There are potential fuel suppliers at local market interested in a long term business agreements.

- Using biomass locally will reduce the outflow of biomass resources from the region, which would contribute to security of supply of raw material.

- Establishment of the District heating plant will indisputably enhance the wood chips market development in the area of Valjevo.

In general, our conclusions are that:

1) There is enough biomass available to satisfy needs of Toplana Valjevo fuel switch project in the area of 50 km distance from Valjevo
2) The storage area is available and it is owned by Toplana / City
3) Investment in supply chain and logistics can be paid from fuel switch savings in less than 1 year
4) We recommend renting chipper able to process metric wood and separating procurement of raw wood from production of wood chips.
11. Literature

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