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FORBIOENERGY - Forest Bioenergy in the Protected Mediterranean Areas

Planning sustainable forest-wood-energy supply chain in the protected areas
Annex 2: Study area report - SLOVENIA

Work package 3 - Testing

Activity A.3.8. - Planning sustainable forest-wood-energy supply chain in the protected areas

Deliverable D.3.8.1 – Planning sustainable forest-wood-energy supply chain in the protected areas

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1 INTRODUCTION

In general, more than 50 % of the households in Slovenia are using wood biomass for heating. The most commonly used wood fuel type in Slovenia is firewood, but the use of wood chips and pellets increases rapidly. Almost 60 % of the country is covered by forest, which creates a huge potential for biomass exploitation. When establishing a biomass supply chains, we need to be aware of nature conservation as well. Slovenia is one of the countries with the greatest biodiversity in Europe and has a long tradition of nature conservation. Close-to-nature forestry management ensures both; exploitation of forests as well as nature conservation.

This Study area report is prepared following the instructions of the Guidelines 3.8.1 – Planning sustainable forest-wood-energy supply chain in the protected areas. To analyse biomass supply chains, two biomass districts identified in deliverable 3.4.1 were taken in consideration (biomass districts Pivka and Divača within pilot areas Pivka Lakes Nature Park and Škocjan caves Regional park). In this report we have analysed the existing parts of biomass supply chains and gave the recommendations on establishing a whole chain in the local environment. When describing a local supply chain, we have followed 8 main steps (Picture 1) described in the Guidelines 3.8.1.

Pivka Municipality owns 76,02 ha of forests which is mainly heavily changed forest of black pine and forests of a former agricultural area, used as pastures, that are more and more overgrown with shrubs. Because of the abandonment of the agriculture and farming, overgrowing present quite a big problem. The share of meadows and pastures, mainly abandoned, is high - 36 % of the area. The average growing stock for the forest stands is low (136,6 m^3/ha). This is a reflection of a heavily changed forests and a consequence of the ice break, which caused severe damage in 2014. In Forest Property Management Plan for forests owned by Pivka municipality (deliverable 3.7.1) we have focused mainly on potentials from overgrowing areas (approximately 93,8 m^3/ha). Clearing of these areas would provide biomass for wood chips and at the same time preserve the meadows and species protected by Natura 2000. In the deliverable 3.4.1 we have presented the theoretic market annual quantities of lower-quality wood in the area of Primorsko-notranjska region, which represent 54.246 m^3/year. Wood chips gained from this area could be used for heating municipal and privat buildings. Krpanov dom, local school and kindergarten are already connected with district heating system on wood chips. There is also a potential to include other buildings nearby (apartment complex – 4 buildings and 91 houses).

Five wood chips and four wood pellets producers are active in the area (Obalno-kraška and Primorsko-notranjska region). An overview on the prices of wood fuels (firewood, wood chips, pellets and briquettes) were prepared as well as recommendations on storage of wood fuels and final recommendations for investors.

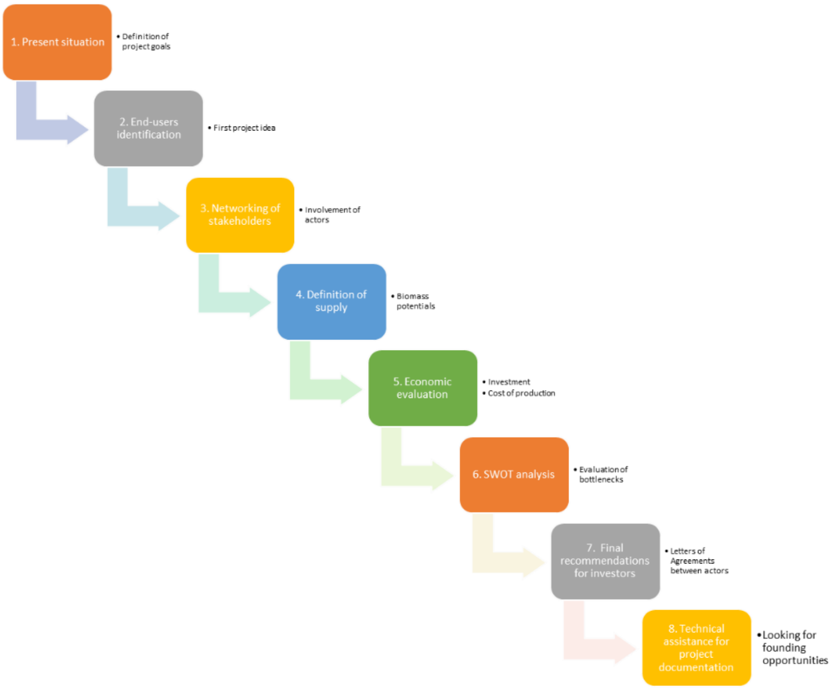
Park authorities, local authorities, wood fuel producers and forest owners are the key actors needed when establishing local energy supply chain. In the frame of WP 4, we have organized trainings and workshops where we presented project activities and results to our main stakeholders. Furthermore, in the end of the project we signed two agreements (Agreement on the Action Plan for unblocking administrative barriers and Agreement on the integration of bioenergy issues in strategies/plans regarding rural areas) with our key stakeholders. Our goal was to give them knowledge and opportunity for networking and creating a local wood-energy supply chain.

2 MAIN STEPS IN ESTABLISHING A WOOD ENERGY SUPPLY CHAIN

Biomass supply chain analyses includes analyses of potentials, present use and possible new biomass projects but also includes all stakeholders along supply chain like forest owners, forest entrepreneurs, transport enterprises, biomass traders, and mainly public customers. Wood biomass production chains did not start from zero but was built from existing organisations or individuals, while only identified missing links were proposed.

Looking from this point of view, the main steps in establishing wood biomass production in our pilot area are:

1st step Analysis of the present situation
2nd step Identification of end-users
3rd step Networking of interested stakeholders
4th step Analysis of the potentials for biomass supply
5th step Economical evaluation of a planned production chain
6th step Evaluation of possible bottlenecks (weaknesses and strengths analysis)
7th step Final recommendations for investors
8th step Technical assistance for project documentation preparation and finding funds for investments



Picture 1. *Steps in establishing biomass production chains*

2.1 Step 1: Analysis of the present situation

A simple analysis of the present situation of the market was prepared using existing data (data gathered in the activity 3.4.1, data obtained from the relevant statistical office, public authority, park administration, public forest service and other publicly available data sets).

Collected data were used to get an insight into biomass potentials, existing producers, and existing and potential consumers.

A: Supply side

a) Existing wood fuel market. The existing wood fuel market was already described in in the frame of D3.4. and D3.5.

b) Wood biomass producers – a list of larger biomass producers was prepared as these are possible wood biomass suppliers (see Chapter 2.5.2 Wood fuel producers).

B: Demand side

a) Existing wood biomass users

Table 1 lists the energy sources used in Public buildings in the biomass district of Pivka. Only three buildings use wood biomass as a source of energy. There are no wood biomass users in the biomass district Divača (Table 2). The data were collected from the Local energy concepts that are prepared for each municipality. Although the documents were released in 2012 (Pivka) and 2011 (Divača), no district heating is planned for the near future.

Table 1. Public buildings and energy sources used in the heating systems in the biomass district of Pivka (Public buildings that use biomass as an energy source are marked in bold).

Public building	Area (m^2)	Energy source (unit)	Average yearly consumption of energy source
Pivka Elementary School + Skala Sport Hall	**3.941**	**District Heating – wood chips (MWh) / light fuel oil as a reserve (l)**	**243 +107**
Kindergarten Pivka - Unit Vetrnica	1.110	Liquefied gas (Sm^3)	5.000
Šmihel Elementary School	331	light fuel oil (l)	5.000
Zagorje Elementary School	160	light fuel oil (l)	Currently not in use
Košana Elementary School and Košana Kindergarten	**2.500**	**Wood biomass - pellets (MWh)**	**160**
Manucipality Building Pivka	565	Liquefied gas (Sm^3)	1.997
Krpanov dom Hall	**2.532**	**District Heating – wood chips (MWh)**	**325**
Health Centre in Kraške Pharmacy Pivka	1.232	light fuel oil (l)	6.700

Table 2. Public buildings and energy sources used in the heating systems in the biomass district of Divača.

Public building	Area (m^2)	Energy source (unit)	Average yearly consumption of energy source
Divača Elementary School	3.280	light fuel oil (l)	35.518
Senožeče Elementary School	940	light fuel oil (l)	17.884

Vremski Britof Elementary School	498	light fuel oil (l)	3.846
Kosovelova knjižnica Divača Public Library	293	UNP (Sm³)	928
Kindergarten Divača		light fuel oil (l)	5235
LIV Vreme – Famlje Hall	400	light fuel oil (l)	310
Divača Elementary School – Old Building	150	light fuel oil (l)	1.002
Manucipality Building Divača	434	UNP (Sm³)	2.149
Divača Health Centre	200	UNP (l)	3.770
Senožeče Health Centre	80	UNP (l)	1.548
Divača Pharmacy	50	UNP (l)	425
Škrateljnova domačija Museum	480	UNP (Sm³)	2.033

C: Other issues

e) Existing environmental and other limitations (existing concessions for natural gas, limitations for the use of wood biomass due to air pollution...).

There are no specific limitations for wood biomass production as long as existing forest management plans are followed.

2.2 Step 2: End users' identification

General goal for wood biomass use in pilot area is:

To heat public buildings inside the biomass districts with wood biomass, obtained through the maintenance of protected areas. The main aim is to enlarge the existing micro biomass heating system based in Krpanov dom in Pivka (Picture 3).

The only opportunity that can be seen in the near future would be the extension of existing biomass heating system in Pivka (Krpanov dom). Four nearby multi-apartment residential buildings could be connected to the system (Table 3). This would increase the area using the biomass as an energy source for further 5.446,6 m^2 with an annual consumption of approximately 650 MWh. 91 further single-family houses are in the same area. The extension of the existing biomass heating system would increase the area heated with biomass for further 11.000 m^2, with the annual energy consumption of approximately 1300 MWh.

Table 3. Potential users of district heating system

Potential users adress	Building type	Number of buildings
Postojnska cesta	house	4
Vilharjeva ulica	house	46
Levstikova ulica	house	11
Murnova ulica	house	10
Kettejeva ulica	house	20
Vilharjeva ulica	appartment building	4

Pi

Existing heating system in Krpanov dom (blue circle), school and kindergarten connected to heating system (green circle) and potential users - multi-apartment residential buildings (red circle) source: google maps

2.3 Step 3: Networking of interested stakeholders and providing support for establishment of cooperatives

Various stakeholders have different knowledge and capacities with regards to wood biomass production. Therefore, it is necessary to bring their knowledge and capacities to a similar level. The optimal way to do this is to gather relevant and interested stakeholders at the beginning of the planning process. All capacity building activities should be carefully planned and designed for specific target groups.

All stakeholders that will operate in the protected area must possess knowledge about conservation principles and limitations in the area, as well as about consequences and possible negative impacts that forest utilization can have on the area. Administrators in the protected areas often lack capacities for planning new biomass supply chains, so capacity building activities for them should be directed towards this issue. Private forest owners are usually not aware of the benefits they could gain from wood utilization and joint initiatives, therefore work with them should include these aspects. Capacity building is also necessary for experts coming from different sectors. Although experts in their respective fields, they usually do not have an in-depth understanding of other fields, therefore mediation between different sectors could be necessary. Biomass producers should have enough knowledge about the biomass supply chain, the technologies they use and the modern technologies they can benefit from.

Promotional activities are also very important. They should be used to “spread the word” and to increase the level of knowledge the general public has about forest utilization activities in the protected areas. If the general public does not approve these activities, conflicts are possible to happen.

In Table 4 target groups and the most important first three steps to reach the goals are presented. Promotion of the idea among target groups is the first important step to reach our goals. Local public authorities and park authorities might be the most accessible and responsive target groups. Since they are public and visible, they could present a good practice example which local inhabitants could follow.

Through the promotion and round tables, we could access the target groups and present them the idea of wood-energy supply chains, give them the knowledge to obtain technical and financial support and help them connect to each other in groups (e.g. forest owner associations, cooperatives and machinery rings). The ideal connection of target groups would be establishing a cooperative. In this case land owners, contractors and producers could work together and appear on the market together.

In the frame of Forbioenergy project Work package 4, we organized 6 training events and 6 workshops where we presented project activities and results to our main target groups (park authorities, local authorities, wood fuel producers, forest owners…). Furthermore, by the end of the project we will sign two agreements (Agreement on the Action Plan for unblocking administrative barriers and Agreement on the integration of bioenergy issues in strategies/plans regarding rural areas) with our key stakeholders. Our goal was to give them knowledge and opportunity for networking and creating a local wood-energy supply chain.

Table 4. Engagement of target groups and first steps for achieving specific goals

Goal	Target group	The most important first 3 steps
To heat public buildings inside the park area with wood biomass obtained through the maintenance of protected areas	Park authorities, local authorities, wood fuel producers, forest owners	1. Promotion of the idea among decision makers in local communities 2. Organization of local supply chains 3. Looking for possible investor and funds

2.4 Step 4: Analysis of the potentials for biomass supply

In the Primorsko-notranjska Region the biomass districts of Divača and Pivka were identified. The area of both was delineated with respective municipality borders of the municipalities of Pivka and Divača. In both biomass districts a theoretical and a practical source of biomass from forests and biomass resulting from overgrowth removal from areas affected by the process of traditional agricultural management practices abandonment is present.

The **theoretical market potential** is a maximum quantity of wood which could be sustainably cut down and offered on the market. The **actual market potential** is the actual average quantity of lower quality wood which was felled in the last five years and offered on the market.

The collection of basic data of the biomass districts and the theoretical potentials of wood biomass from forests and agricultural area, is presented in the Deliverable 3.4.1 Geographical identification and description of biomass districts in the protected areas. In the Deliverable 3.5.1 Impact assessment of increase biomass use in the short, medium and long term in the protected areas, some socio-economic indicators are gathered and presented.

2.4.1 Biomass from forests

For the identification of areas with potential for biomass extraction from forests we mapped (Elaborate in the sense of GIS and shapes acquired from MKGP) the Land use classified as codes 311, 312, 313 in the CORINE Land Cover nomenclature within the biomass district. In the biomass district of Divača the total area covered by forests (CLC level two code 31) is 9.612 ha whilst in the biomass district of Pivka the corresponding area of forests is 15.679 ha.

Table 5. Estimated theoretic market annual quantities of lower-quality wood in selected biomass districts in the Primorsko-noranjska Region

Municipality	State forest Conifers [m³]	State forest Deciduous [m³]	Private forests Conifers [m³]	Private forests Deciduous [m³]	Total [m³]
Divača	1.702	2.185	5.516	8.455	17.859
Pivka	5.622	10.333	4.660	15.773	36.387
Total	**7.324**	**12.518**	**10.176**	**24.228**	**54.246**

The theoretical market potential of biomass from forests in both biomass districts combined is 54.246 m^3 per year. Most of the potential biomass from forests derives from privately owned deciduous forest, 24.228 m^3 per year. The amount of biomass that actually entering the market per year is 22.589 m^3, most of which originates from stately owned deciduous forests. This indicates that the biomass utilization in both biomass districts is low, especially from the utilization from the privately-owned forests Table 5 and Table 6). The estimated theoretic annual market potential for privately-owned forests is 34.404 m^3 per year, whilst the actual annual market quantity per year is 9.511 m^3 which represents only 27,6% of the theoretic potential. The deciduous trees are the most suitable for the biomass production. Of the estimated 36.746 m^3 per year of potential forest biomass derived from deciduous tree species only 30, 9% (11.355 m^3) enter the market.

Table 6. Estimated actual market annual quantities of lower-quality wood in selected biomass districts in the Primorsko-noranjska Region

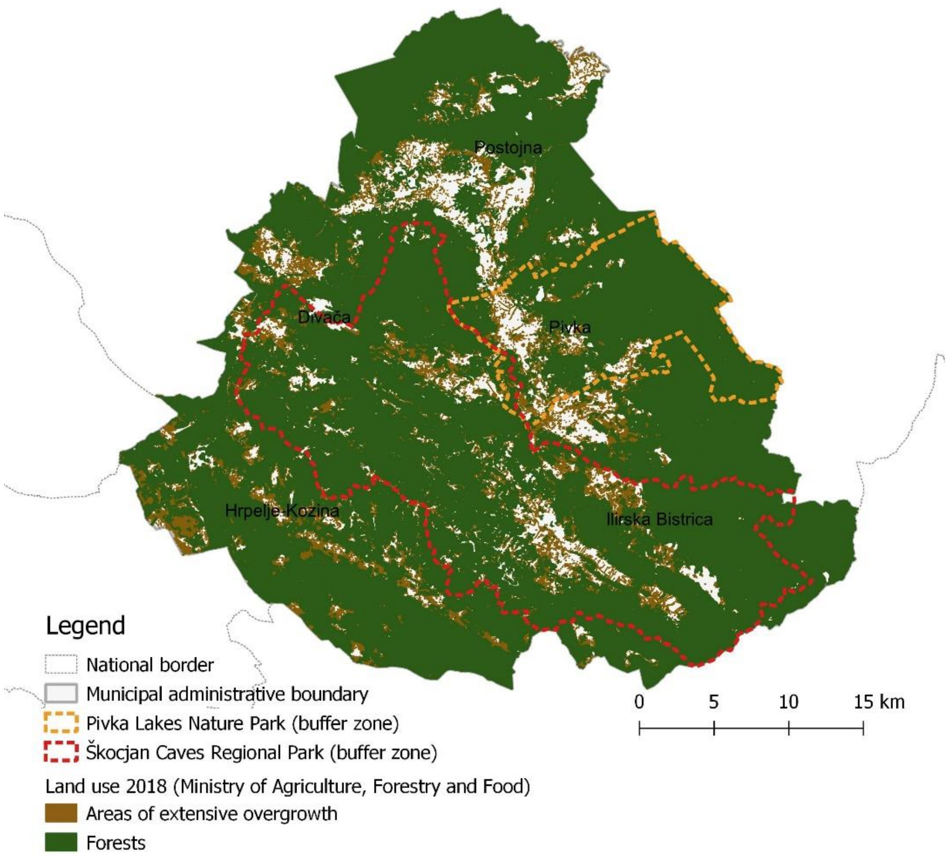
Municipality	State forest Conifers [m³]	State forest Deciduous [m³]	Private forests* Conifers [m³]	Private forests* Deciduous [m³]	Total [m³]
Divača	64	278	5.832	1.231	7.405
Pivka	3.976	8.760	1.362	1.086	15.184
Total	**4.040**	**9.038**	**7.194**	**2.317**	**22.589**

*It is necessary to be cautious with interpretation of results, as the analyses of the actual potential observed only the timber that was marked for harvesting by district forester, while in reality the harvested quantities are likely greater especially in privately owned forests.

2.4.2 Biomass from extensive overgrowth

Extensive overgrowth is another possible source of biomass. We considered it in the biomass districts where the areas with Corine Land Cover codes 221, 222, 223 that are not present. This source of biomass is relatively large because of the ongoing process of abandonment of traditional agriculture use of meadows and pastures (grasslands). It was not utilized for any purposes so far. Moreover, the process of overgrowth causes changes in landscape and threatens some species and habitat types, protected by the Habitats Directive and Birds

Directive of the European Union. With the use of overgrowth, we can achieve two goals: remove the threats to species and habitat types and get new source of biomass for heating.



Picture 3.

Areas of extensive overgrowth and forests

On the base of previous study (Mali et. all 2017), we estimate an average growing stock of overgrowth 100 m^3/ha. The area of overgrowth in the biomass district of Divača is 1017 ha and in biomass district of Pivka is 954 ha. Thus, the total theoretical market potential of biomass from overgrowing areas amounts to 197.100 m^3. When considering biomass potentials (theoretical and practical) from different sources in the biomass district, region or from protected areas in general, we need to take into account all limitations of protected areas and Natura 2000 sites.

2.5 5th step: Economical evaluation of a planned production chain

2.5.1 BIOMASS PRODUCTION TECHNOLOGIES – forest production value chains

Many protected areas have limited budgets, and forest owners and operators are usually not so keen in investing in new technologies due to their high prices. On the other hand, modern technologies are more productive, cost-effective and environmentally friendly, so they can help fulfil requirements of protection regimes. Local biomass chains in protected areas should work towards introducing modern technologies, where economic aspects will certainly have an important role in the decision. For that purpose, the Slovenian Forestry Institute has developed a free access online tool – WoodChainManager (http://wcm.gozdis.si/en). It offers various interactive tools suitable for the organization and optimization of applications in forestry:

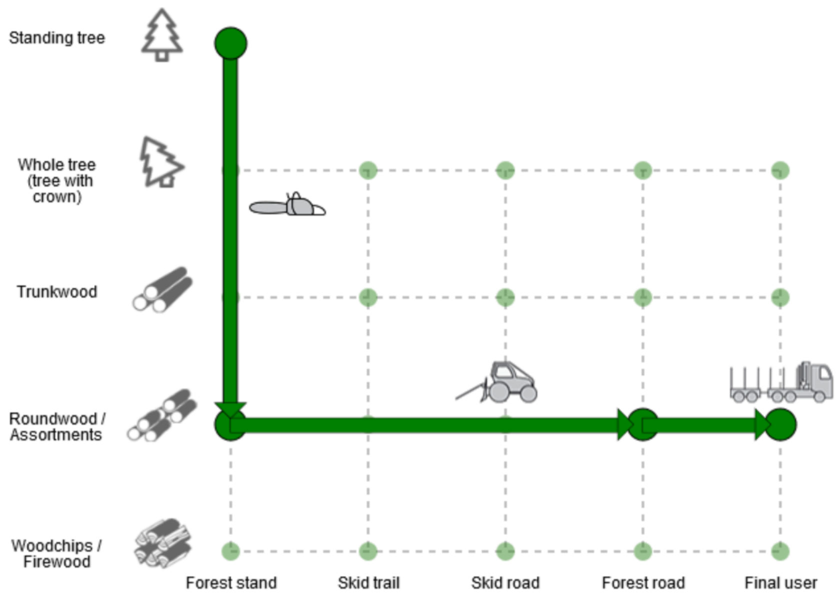
- Creation of interactive transparent descriptions of the forest-wood chain
- Creation of transparent cost calculations of forest machinery
- Determining norms of forestry production
- Converting between volume, weight and energy units

Modern biomass boilers have lower emissions and a higher efficiency, and they are therefore the most suitable choice in protected areas. Slovenia is granting subsidies or favourable credits for this kind of investments, so additional help could also come from the state. These options should be analysed and presented to target groups in the park area to support investments in modern technologies.

A biomass production technology varies along the value chain. Examples below are based on conditions in the biomass districts Pivka and Divača and present the value chain of forest production as well as wood fuel value chains. The most attention is given to the wood chips production chain. Calculations and graphs were prepared with Wood Chain Manager calculation tool developed at Slovenian Forestry Institute. It is freely available on the internet: http://wcm.gozdis.si/en/cost-calculation.

2.5.1.1 *Traditional felling with a chainsaw and skidding with an adapted forestry tractor*

The most common system of wood production is a technology implemented in combination with traditional felling with a chainsaw and skidding with an adapted forestry tractor. This process begins in a forest stand with felling. After felling, the tree is trimmed and cross-cut with a chainsaw with the power of 4 kW. Next follows the collecting and hauling of timber to the forest road with an adapted forestry tractor. An adapted forestry tractor is a tractor which has been completely upgraded for forestry use (safety frame), has a double drum built-in winch (5 tons), a radio-control unit, and forestry chains at least on its back-rubber tires. A simplified illustration of this production chain is illustrated on Picture 4.



Picture 4. *Production chain of timber felling and skidding; (source: Slovenian Forestry Institute, 2018)*

Picture 5 illustrates felling with a chainsaw, whereas Picture 6 shows skidding with an adapted forestry tractor.

Pic

Felling with a chainsaw

Skidding with adapted forestry tractor

The total cost of this production chain is 45.2 EUR/h, whereas the direct material costs chain with the assumption of an average predicted efficiency in an eight-hour working day amounts to 15.3 EUR/m^3 (Table 7).

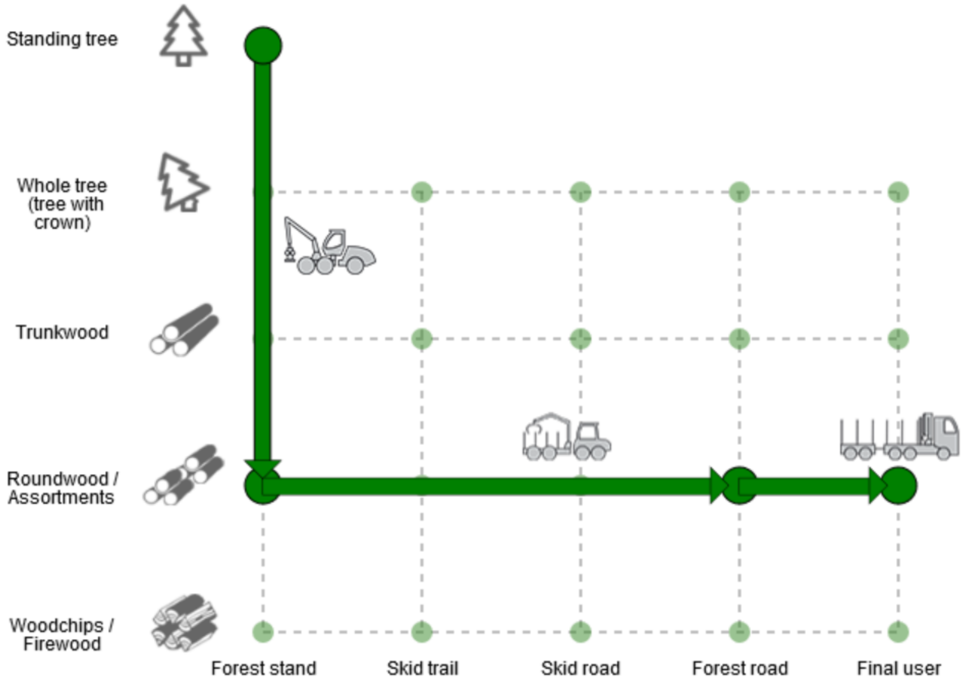
Table 7. Costs of cutting and skidding production chain

Machine	Total material costs of the selected machine (€/h)	Labor cost (€/h)	Total costs of workprocesses (€/h)	Total costs of workprocesses (€/m^3)
Chainsaw (4 kW)	4,44	12	16,44	6,58
4WD agricultural tractor (45-55 KW)	16,78	12	35,11	10,03
Semi-truck with small trailer and crane for roundwood (300 kW)	99,42	12	111,42	4,46

Source: Slovenian Forestry Institute, 2019

2.5.1.2 Fully-mechanized harvesting system

Part of the forests around Pivka is suitable also for fully-mechanized harvesting system. We selected fully-mechanized cutting with the class of middle size harvesters, whose rated engine power is greater than 140 kW. Their weight is more than 21 tons but does not exceed 50 tons. Fully-mechanized cutting requires skid trails with 30 metre spacing. In the event of thick trees in the intermediate zone, which is inaccessible by the machine's cranes (between skid trails), a combination with wood cutter is necessary, which fells trees towards skid trails. Cutting and assortment production (4m length) take place along skid trails and are carried out by a harvester. Cutting is followed by haulage to the forest road with a forwarder. The greatest problem in this technological system is the machine's weight and with it associated possibility of damages being caused to the soil. This technology is limited mainly to soils with good ground bearing capacity and not too wet grounds. Biggest advantage of this production chain is high productivity rates in case of boreal stands. Transport of assortments to end user is done by a truck (Picture 7).



Picture 7. *Production chain of timber by fully-mechanized harvesting system; (source: Slovenian Forestry Institute, 2019)*

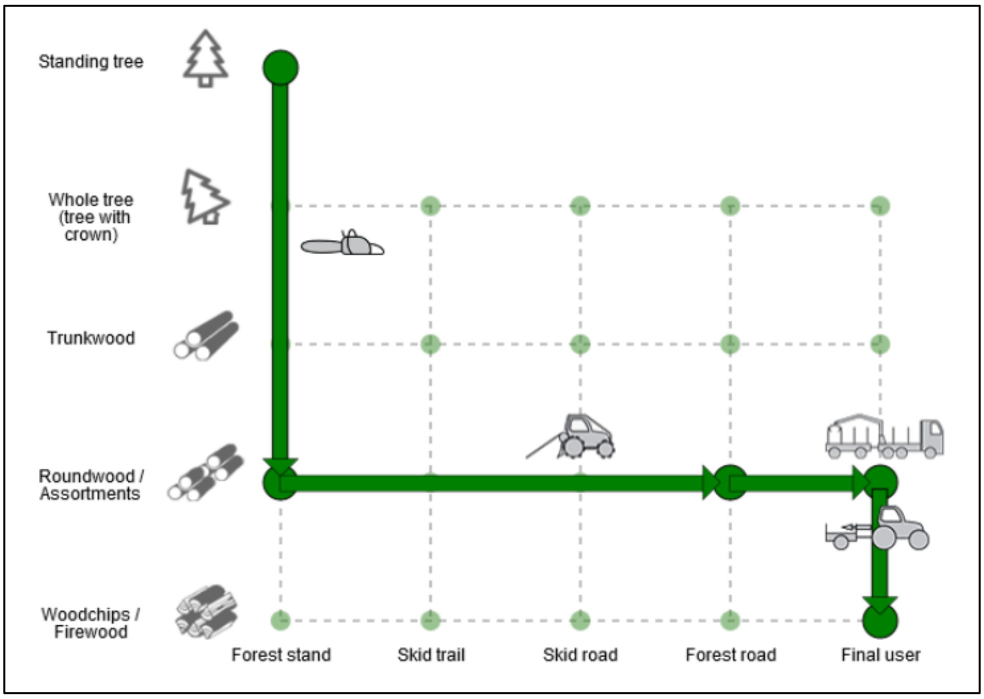
Fully-mechanized harvesting system

Table 8. Costs of cutting and skidding production chain

Machine	Total material costs of the selected machine (€/h)	Labor cost (€/h)	Total costs of workprocesses (€/h)	Total costs of workprocesses (€/m³)
Harvester (140 kW)	112,7	13	125,7	9,67
Forwarder (140 kW)	102,56	12	114,56	7,64
Semi-truck with small trailer and crane for roundwood (300 kW)	99,42	12	111,42	4,46

2.5.1.3 Firewood production chain

The traditional production of firewood is the most widely used method for firewood production in households and agricultural holdings. As in forest production, the manufacturing process begins in a forest stand with felling, delimbing, and crosscutting with a chainsaw with the power of 4 kW. These operations are followed by collecting and hauling of timber to the forest road. This is done with an adapted forestry tractor which has been completely upgraded for forestry use (safety frame), has a double drum built-in winch (5 tons), a radio-control unit, and forestry chains on its tires. Roundwood assortments are transported from the forest road to the end-user by a forestry transport composition. This composition includes a three-axial truck for roundwood with a crane and trailer. Roundwood is cut into 1 m long logs with a chainsaw with the power of 6 kW at the location of the end-user. Logs are then split into chunks (1 m long firewood logs) with a hydraulic horizontal log splitter (up to 30 tons) on a standard tractor. The final step is the production of firewood (length of 33 cm), which is done with a standard tractor and a tractor driven circular saw (Picture 9).



Picture 9. *Traditional firewood production chain; source: Slovenian Forestry Institute, 2018*

The pictures below show examples of a tractor driven circular saw and a hydraulic horizontal splitter.

Picture 10. Tractor driven cirkular saw

Picture 11. Hydraulic horizontal splitter

Table 9 shows direct material costs of the production chain with the assumption of an average predicted efficiency in an eight-hour working day. The table shows that the total costs are 167,4 EUR/h, whereas direct material costs amount to 56,7 EUR/m3.

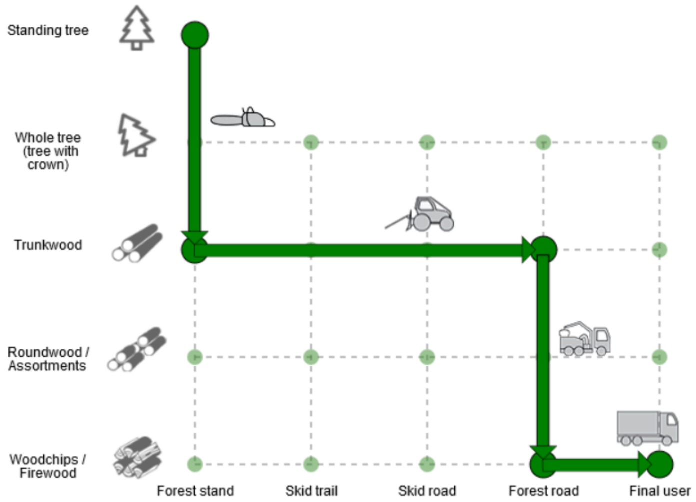
Table 9. Material costs and predicted efficiency of the traditional firewood production chain

Machine	Total cost (EUR/h)	Direct material costs (EUR/m^3)	Predicted efficiency (m^3/8h)	Comment
Chainsaw (4 kW)	4.0	2.1	15.0	Felling
Forestry tractor	41.2	13.2	25.0	Skidding
Forestry transport composition	44.4	5.1	70.0	Roundwood transport
Chainsaw (6 kW)	5.7	1.5	30.0	Cutting to 1 m
Standard tractor	25.8	12.9	16.0	Logs (1 m)
Splitter (30 t)	13.0	6.5	16.0	Logs (1 m)
Standard tractor	25.8	12.9	16.0	Firewood (33 cm)
Circular saw	7.5	2.5	24.0	Firewood (33 cm)
Production chain costs	167.4	56.7		

Source: Slovenian Forestry Institute, 2019

2.5.1.4 Traditional wood chips production chain

This chain provides the traditional way of timber harvesting. The chain starts in the forest stand with cutting, delimbing, and crosscutting with a chainsaw with the power of 4 kW. Timber is then collected and skidded to the forest road with an adapted forestry tractor with a light forestry safety frame, forest chains, and an electro-hydraulic single drum winch with a radio-control unit (6 tons). Roundwood (i.e. pulpwood and fuelwood) is transported from the forest road to the end-user by a forestry transport composition (a three-axle truck for roundwood with a crane and trailer). At the location of the end-user, wood chips are produced using a tractor PTO (Power Take Off) driven chipper with a loading device. This process is illustrated in Picture 12, whereas some of the machinery from this production chain is shown in Picture 13 and Picture 14.



Picture 12. *Traditional wood chips production chain; source: Slovenian Forestry Institute, 2019*

Truck with cargo trailer

PTO driven wood chipper

Table 10 shows the direct material costs of the production chain (based on the assumption of an average predicted efficiency) in the eight-hour working day. The table shows that the total costs of this production chain are 356,9 €/h, at what direct material costs are 22,5 €/m^3.

Table 10. Material costs and predicted efficiency of the traditional wood chips production chain

Machine	Total material costs of the selected machine (€/h)	Labor cost (€/h)	Total costs of workprocesses (€/h)	Total costs of workprocesses (€/m³)
Chainsaw (6 kW)	6,19	12	18,19	7,28
4WD agricultural tractor (45-55 KW)	16,78	12	35,11	10,03
Chipper mounted on truck with crane (max. Wood diameter 80 cm)	221,62	12	233,62	2,34
Semi-truck for carring bulk load (two axes - 200 kW)	57,96	12	69,96	2,8

Source: Slovenian Forestry Institute, 2019

2.5.1.5 Mechanized wood chips production chain

This production chain assumes the production of wood chips on a forest road or at a temporary storage location and transport them over long distances to major customers (i.e. district heating systems). Felling begins in a forest stand and is then followed by delimbing, crosscutting, and collecting the timber with a wheeled harvester with the power of 140 kW. Timber is transported to the forest road by a forwarder with a load capacity of 12 tons. Wood chips are produced on the forest road using a wood chipper on a truck with a loading device. Wood chips are transported to the end-user by a truck with a segment moving floor (cargo floor) trailer for loose material. The pictures below show the machines that are used in this production chain.

Harvester

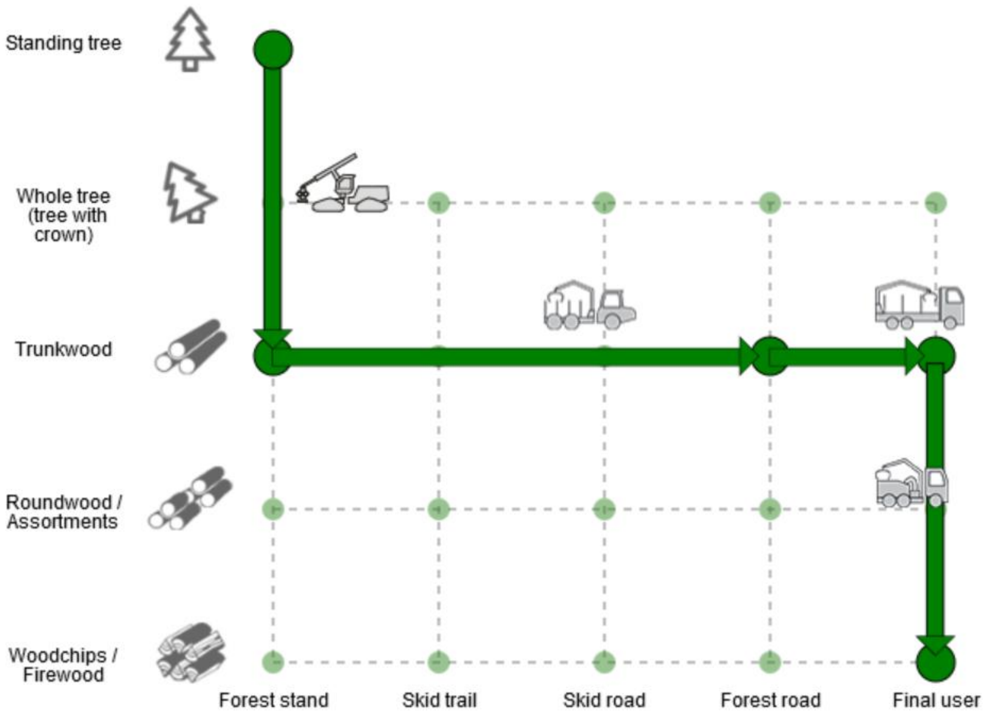
Forwarder

Wood chipper on a truck

Forestry transport composition

Picture 17

Picture 18



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Mechanized wood chips production chain; Source: Slovenian Forestry Institute, 2018

The direct material costs of the production chain are shown in Table 11. The table shows that the total costs of this production chain are 572,0 EUR/h, whereas direct material costs amount to 23,4 EUR/m^3.

Table 11. Material costs and predicted efficiency of the mechanized wood chips production chain

Machine	Total material costs of the selected machine (€/h)	Labor cost (€/h)	Total costs of workprocesses (€/h)	Total costs of workprocesses (€/m^3)
Harvester (140 kW)	119,96	12	131,96	10,15
Forwarder (125 kW)	85,63	12	97,63	6,51
Semi-truck with crane for roundwood (300 kW)	96,82	12	108,82	4,35
Chipper mounted on truck with crane (max. Wood diameter 80 cm)	221,62	12	233,62	2,34

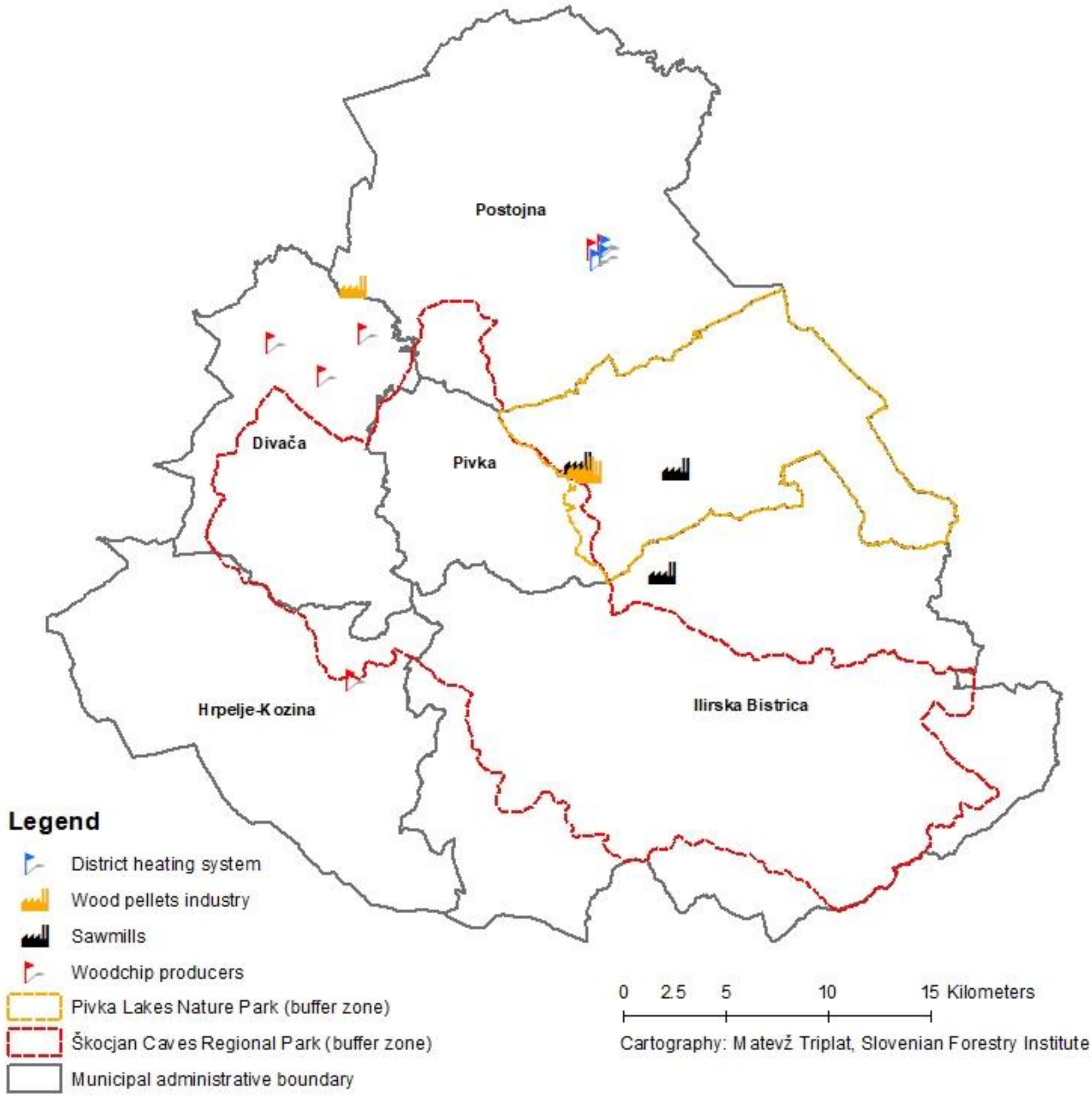
Source: Slovenian Forestry Institute, 2019

2.5.2 WOOD FUEL PRODUCERS

The analysis of wood fuel producers in the biomass district and its surroundings is an essential part of the analysis. Data used in this analysis were collected by Slovenian forestry institute in years from 2017 till 2018.

Information regarding the wood fuels producers was already presented in the Deliverable 3.4.1 in chapter 4.2.8 Private companies inventory operating in the biomass sector. In this chapter we will present the topic of wood fuel producers more in detail.

The most important private beneficiaries in selected BD's are two Slovenian biggest wood pellet mills and sawmilling industry, which is situated in municipality Pivka and Ilirska Bistrica. There are also some small-scale district heating systems and woodchips producers (Picture 20 and Tables 12 and 13).



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Characteristics and distribution of private companies operating in biomass sector

2.5.2.1 Wood chips producers

Wood chip producers are already active in the region. The data presented in this chapter were gathered in the survey which was conducted by Slovenian Forestry Institute in 2018 (Jemec in sod., 2018).

Table 12. Wood chips producers in obalno-kraška and primorsko-notranjska region

Name of the Company	Municipality	Region
Vatovec Jože	Hrpelje-Kozina	obalno-kraška
Bobek Maja	Divača	obalno-kraška
Suša Marijan	Divača	obalno-kraška
Žaga trade d.o.o.	Cerknica	primorsko-notranjska
Branal d.o.o.	Postojna	primorsko-notranjska

In Table 12 wood chips producers in two regions (obalno-kraška and primorsko-notranjska) within our pilot areas are presented. Five bigger wood chips producers, who also sell wood chips operate in regions Obalno-kraška and Primorsko-notranjska. In 2018 they produced 19.200 loos m^3 of wood chips, together.

2.5.2.2 Wood pellets producers

Table 13. Wood pellets producers in obalno-kraška and primorsko-notranjska region

Name of the Company	Municipality	Region
RZ pellets	Pivka	primorsko-notranjska
Profiles	Hruševje	obalno-kraška
Excelza lesarstvo	Postojna	primorsko-notranjska
Opažne plošče Belsko	Postojna	primorsko-notranjska

Four wood pellets producers are located in Regions within our pilot areas (Table 13). Together they produced approximately 65.000 t of wood pellets in year 2018.

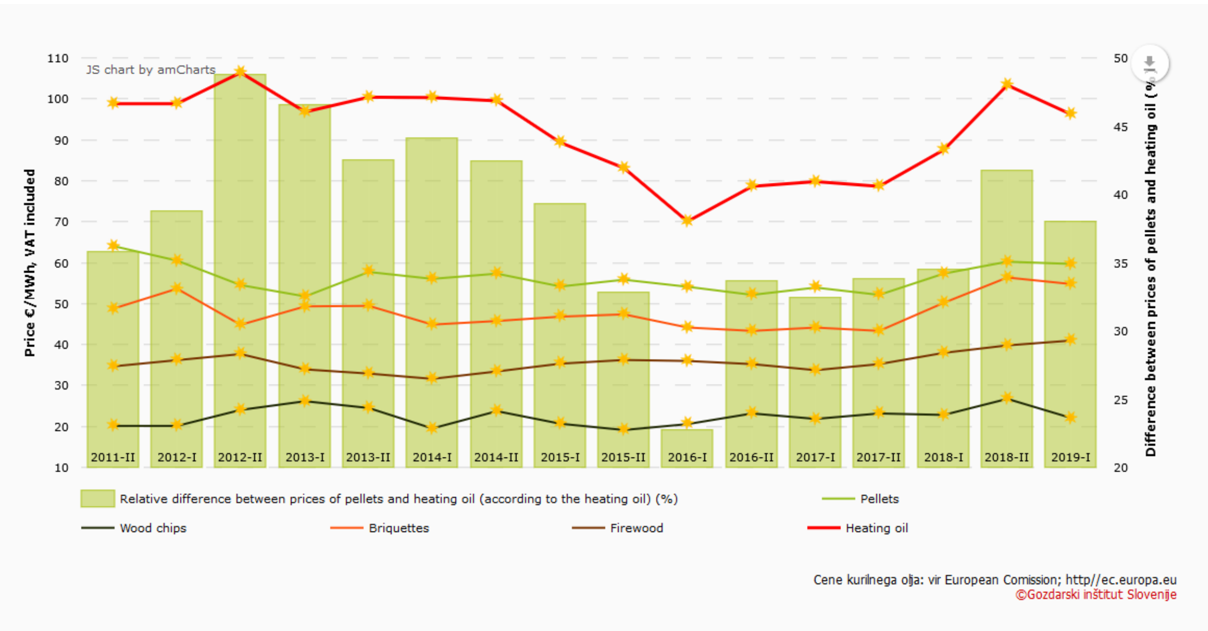
2.5.2.3 Wood briquettes producers

One wood briquette producer is located in Pivka municipality. His average production per year is approximately 4.350 tons.

2.5.3 WOOD FUEL PRICES

The prices of energy products are changing according to their characteristics or quality, while various claims and inadequate declarations quickly mislead consumers. In the following, we are therefore referring to which types of wood fuels prevail in Slovenia and what are their prices. Among the different types of wood fuels firewood is still predominant, followed by wood chips and in recent years wood pellets. Among the producers, the shape and characteristics of wood fuels vary considerably. From this point of view, the market is rather varied, as consumers have a great choice. In the case of firewood, different tree species are available, different sizes (length can range from 20 to 100 cm, diameter from 2 to 15 cm or more) and different humidity (air-dry or moist wood). Wood chips also differ in the degree of processing (or size of the predominant fraction) and water content (dried and green wood chips). In the case of pellets and briquettes, in addition to the mentioned properties, the following are also important: the appropriate particle density or density of plowing, mechanical stability and ash content.

Wood chips are the cheapest form of wood fuels on the market, while prices differ depending on the humidity and the predominant fraction of particles. Because of higher production costs, chips with lower water content and smaller particles are more expensive (Slovenian Forestry Institute, 2017).



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Different prices of wood fuel (in €/MWh) compared to heating oil prices (Slovenian Forestry Institute, 2017)

A comparison of prices of the most common types of wood fuel and heating oil shows a relatively constant price trend, with higher prices at the beginning of the heating season and lower at the end (Picture 21) (Slovenian Forestry Institute, 2017).

2.5.3.1 Prices of wood pellets

Pellets are the most expensive form of biomass. The prices of pellets should depend mainly on quality, but the analysis of the pellets quality on the Slovenian market, carried out in 2016 (the whole study is published on www.s4q.si), show that the price is not always a reflection of their actual quality. Prices of pellets vary according to the quantity and shape of the packaging. Pellets in bulk or in so-called “Big-bags” are cheaper. The greatest demand is for pellets packed in a 15 kg PVC bag and stacked on the pallet, which is why the price is also slightly higher.

Prices of pellets also differ between different groups of providers; pellets directly from the manufacturer are usually the cheapest, while pellets from distributors can be more expensive.

In April 2019 the average prices of pellets amounted to 280.5 €/t (Picture 21) (Slovenian Forestry Institute, 2017).

2.5.3.2 Firewood prices

n the Slovene market, firewood of various tree species, different humidity (from fresh to air-dry) and dimensions is available. Beech firewood, with humidity of about 20% and length 25 cm is predominant.

In April 2019 the average price of firewood was 163 €/t (Picture 21) (Slovenian Forestry Institute, 2017).

2.5.3.3 Wood chip prices

According to the results of the surveys carried out in previous years on the Slovenian market, wood chips of size class P31 are dominant, followed by classes P45 and P100, and the chips with the dominant fraction from 3.15 mm to 16 mm (P16) are rare. As for the humidity, chips with water content of 10% to 25% (property class M20 and M25) are dominant, followed by those with a humidity of 25% to 35%, or more. The dominant particle size and water content are most dependent on the production process, while the remaining quality parameters depend mainly on the raw material used. Consequently, the parameters mentioned above have the greatest impact on the final price of the product. It is commonly believed that, wood chips with small particles in the predominant fraction and with less water content are more expensive, as more energy is needed for crushing and drying a wood biomass. It is therefore understandable that chips with a predominant fraction of 3.15 to 16 mm (P16) and a water content of less than 10% (M10) are generally more expensive than chips with particle size P100 and humidity M50.

Wood chips with humidity of about 30% and a particle size of about 31 mm are sold the most. The price of the delivered chips is also affected by the transport costs, which are charged either on the number of kilometres travelled or on the quantity of delivered chips. Usually, the price of chips without delivery is up to 16% lower.

In April 2019, the average price for wood chips was 75.1 €/t and was 17.4 % lower as in November 2018 (Picture 22) (Slovenian Forestry Institute, 2017).

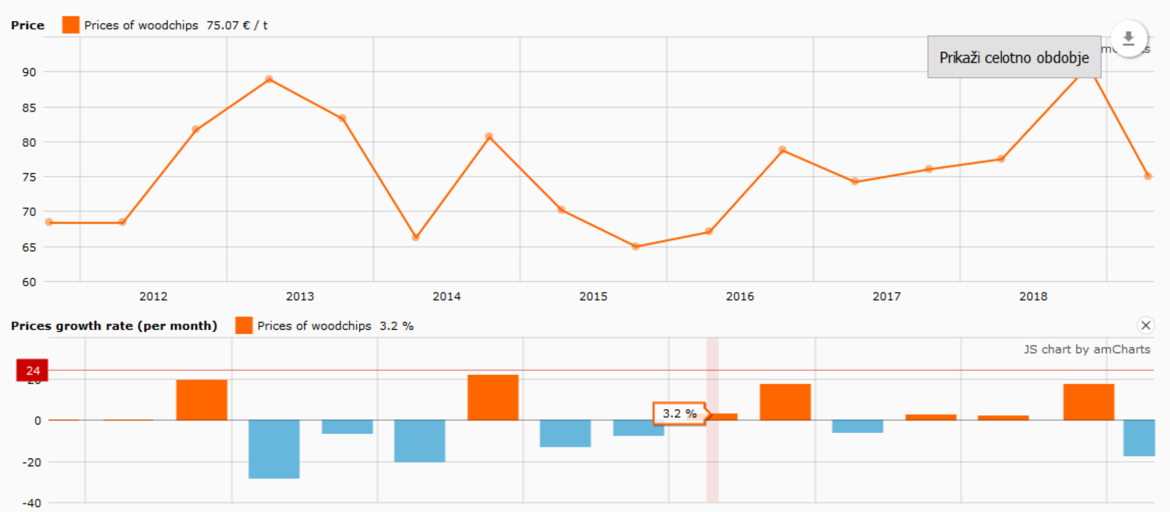

Figure 5: Prices of wood chips (in €/t with VAT) during 2011 and 2017

Picture 22. *Prices of wood chips (in €/MWh VAT) during 2011 and 2017 (Slovenian Forestry Institute, 2017)*

2.5.3.4 Prices of wood briquettes

Briquettes are often used as a substitute for firewood (mostly in fireplaces). Their advantage over firewood is higher energy density (which is reflected in longer combustion time). Due to the raw material used and the manufacturing process, the content of water in briquettes is usually from 12 to 15%. Differences in price can be observed between different packaging methods; the cheapest briquettes are in bulk and most expensive packed at 10 kg in bags or boxes (Slovenian Forestry Institute, 2017).

2.5.4 STORAGE OF WOOD FUELS

Storage is important in relation to buffering biomass either over a longer period somewhere in the supply chain (e.g. to compensate for seasonal effects of biomass supply from forests and nature area, where it is impossible to harvest year-round) or on the short term just before delivering to the final conversion process. The method of wood fuels storage significantly influences their quality. Wood can be stored in the form of round wood or in any intermediate or final form of wood fuels. They can be stored in intermediate warehouses or in warehouses in the immediate vicinity of the heating plant. Regardless of the shape of the fuel and the duration of the storage, it is most important that the wood is dried at a suitable location (airy and dry space). The best storage area for drying wood chips is a covered toughened surface (concrete or asphalt) on a sunny and airy location. The architectural structure of the roof should allow maximum ventilation of the stored material and facilitate the handling of wood chips (height of the area and height of the chips).

Recommendations for the storage of the wood:

- the raw material intended for chip grinding must be stored for at least one summer in the airy and sunny space (natural dryed);
- wood, which is temporarily stored over the summer, has a water content of 25% to 30% when making chips;
- during rainy summer months, wood cover is recommended (wood, paper, textile or plastic sheets are available for covering the wood);
- chips are covered only with materials that allow free circulation of the air;
- the removal of chips from stored piles should be controlled and planned ("the first come in -first goes out");
- caution is needed when working with chips that have been stored for a long time (exposure to fine wood particles and micro-organisms);
- avoiding the storage of chips with a high proportion of needles and leaves; such chips will heat up due to the very intense action of the microorganisms, and the process of rotting will begin within a few weeks, so they should be stored in piles with a maximum height of 7 m and for the short period of time.

The municipal building of Krpanov dom in Pivka, which is heating with wood chips have a small storage for wood chips (50 bulk m^3). Such quantity provides heat for one to two weeks depending on energy demand. In a very hard winter, they need to fill the storage even once per week. The supply of wood chips for Krpanov dom is delivered by a local supplier Instal-M d.o.o. from Ilirska Bistrica. When planning a sustainable forest-wood-energy supply chain it is important to include local supplier. Within the deliverable 3.7.1 we prepared a Forest property Management plan where we described the potential of Pivka municipal forest for wood biomass production and supply of wood fuels mainly from overgrowing areas. In case of wood chips obtained from overgrowing areas in the Pivka municipal forest, the proper storage in the vicinity of Krpanov dom has to be organized. Low quality trees and residues from overgrowing areas can also be left at the roadside to dry and chip right before the use. Round wood should be dried for at least 4 months at the sunny location, wood chips should be produced at this storage outside the town. In this case the bigger storage is not needed, but it requires more organization. For chipping of wood chips an existing wood chips producer should be engaged.

2.5.5 INVESTMENT COSTS

The investment costs are one of the major factors when deciding to switch from fossil to wood fuel. In the case of Krpanov dom municipality is thinking on enlargement of the system with new heat consumers. The needed amount of wood fuel in an extended boiler house can be calculated from data on past consumption of fossil fuels by new heat consumers. In the example of Krpanov dom the main investment is in enlargement of pipelines and not in replacement of the old boiler. The investment can be divided in two phases in the first stage the new pipelines can be installed and in second the boiler house can be extended (if needed). The main issue will be to get enough new consumers (private houses and apartments) to make the investment feasible.

2.6 6th step: Evaluation of possible bottlenecks (SWOT analysis)

SWOT analysis is a strategic planning tool which will help identify strengths, weaknesses, opportunities, and threats related to wood-energy supply chain. It is intended to specify the objectives of the chain and identify the internal and external factors that are favourable and unfavourable to achieving our objectives (establishment of wood-energy supply chain).

When identifying the weaknesses and threats it is important to already think about solutions, how will we tackle the barriers when and if it comes to that point.

In Table 14 strengths, weaknesses, opportunities and threats of the forest-wood-energy production chain in the biomass districts of Pivka and Divača are present. SWOT analysis and possible solutions are presented in detail in deliverable 3.6.1 Regulatory framework and permit route concerning biomass use in the protected areas.

Table 14. SWOT matrix with question: „Where do you see main strengths, weaknesses, opportunities, and threats related to wood-energy supply chain in selected biomass district?"

Strengths	Weaknesses
- Large wood biomass potentials - Developed local wood biomass market (but mainly with firewood) - Available data - Use of low-quality wood biomass from overgrowing agricultural land - Preserving of agricultural land and cultural landscape - No major administrative restrictions in forest management in protected areas - Existing subsidies for switching to wood biomass heating	- Large number of small forest owners - Fragmented forest estate - Low interest for cutting of low-quality wood from abandonment agricultural land - High costs of harvesting on abandonment agricultural land - The green chips market is not developed - Awareness of decision makers for switching to wood biomass heating is too low - Forest owners are not organized and connected (Association of forest owners does not exist in this area)

	- Large quantities of exported wood
Opportunities	**Threats**
- New green jobs development - Higher independency of energy production - Use of domestic resources for energy production - Many public buildings suitable for heating on wood fuels - Low prices of wood fuels compared to other fuels - Rural Development Programme encourages the cleaning of overgrown areas to maintain the grasslands - Improve favourable conservation status of Natura 2000 habitat types and species	- Gasification of the area (competition to wood fuels) - Decline in the price of other alternative fuels - Increase in labour prices - Unavailability of workforce Impoverishment of forest soil due to high biomass outtake

2.7 7th step: Final recommendations for investors

The whole wood-energy chain includes different actors; from forest owners, wood fuel producers to consumers e.g. households, park authorities, local authorities, industries in the area. It is important to include identify key actors when establishing the production chain. An agreement should be prepared for the purpose of stakeholders' involvement in the pilot area. This kind of agreement will help in further establishment of biomass supply chains and will give a kind of formality and commitment to perform agreed steps in the process. The main stakeholders that should sign the agreement are:

A) Local communities (all which are in the pilot area)
B) Forest owners and farmers (owners of agricultural land)
C) Wood fuel producers
D) Representatives of protected areas
E) Representatives of potentials wood fuel users

2.7.1 FOREST OWNERS

Within the forest management area Kras, a part of which covers **the biomass district Divača**, the majority of forests are privately owned (83,6 %). This is the result of the process of denationalization that occurred after 1991. In the same process the municipalities gained the ownership of 5,4 % of forests due to the agrarian communities not claiming their forest in the process.

Privately owned forest holdings are small with a large number of forest parcels and the same holding is owned by a large number of owners. The average forest holding size is 2,18 ha. The average forest parcel is only 0,27 ha big. The private forest owners in biomass district of Divača are not interested in entering into a Slovenian biomass supply chain as they sell the majority of their forest wood biomass to various Italian companies.

State owned forests holdings are also fragmented whilst the municipality owned forest occupy compact and regular areas.

The Biomass district of Pivka lies in two forest management units, Hrašče-Osojnica and Jezerščak.

In the forest management unit Jezerščak the majority of forests are privately owned (89%), whilst the rest is owned by the state (11%) with the main part of the state-owned forests located to the north of the area.

Privately owned forests are divided into 1.077 forest holdings with an average size of 3,24 ha. The majority of private owners own less than 1 ha of forest. All these areas combined account for 6% of the whole forest area. There are 2% of owners that own a forest between 30 and 100 ha large. There are no forest holdings larger than 100 ha.

In the forest management unit Hrašče-Osojnica the largest part of forests is privately owned (76%), followed by state owned forests (20%), the remaining 4% are owned by the municipality.

Privately owned forests are divided into 1.372 forest holdings with an average size of 2,5 ha. The majority (54%) of private owners own less than 1 ha of forest. All these areas combined account for 6% of the whole forest area.

In many protected areas land is privately owned, whereas properties are often small and fragmented, and forest owners are not interested in forest utilization. The solution to this problem is the early inclusion of forest owners in planning in order to identify their needs and to motivate them for forest utilization. As utilization of small-scale forests is not economically cost-effective, forest owners should act together. If united in some kind of organizational form (i.e. cluster, association, etc.), they will manage a larger forest area, so the problem of small-scale forestry would be overcome. Additionally, they would be able to buy or rent machinery together, and act together in the market and have more competitive prices.

2.7.2 MARKET CONDITIONS FOR WOOD FUEL USERS AND PRODUCERS

Improving wood fuel market conditions requires a systematic approach and political commitments, so protected areas as such cannot really influence it significantly. If wood biomass chains are operating in the protected area, an agreement about supplying can be concluded between producers and the park administration. This way, the protected area would use endogenous biomass, and producers would have a market for their products. Also, if wood biomass is being supplied from a protected area, some kind of a trademark or brand can be introduced as a way of certifying that wood was obtained in a sustainable way. It is recommendable for producers to assure and certify good quality wood biomass fuels they produce. The promotion of locally produced wood biomass should be organised by park administration.

Very often, market conditions within the wood biomass production chain itself are weak. This can be overcome by building trust and good business relations between individual actors along the production chain. That is why all the interested stakeholders should be brought together at the very beginning of the planning process.

Within the work package 4 – Transferring, two agreements (Agreement on the Action Plan for unblocking administrative barriers and Agreement on the integration of bioenergy issues in strategies/plans regarding rural areas) will be signed with key stakeholders. With these agreements we try to integrate local key stakeholders and encourage them in organization of the wood-energy supply chain in their local area.

Municipality of Pivka, which has already using wood chips for heating Krpanov dom could sign a contract with a local supplier and use the wood from overgrowing areas in their own forest. In this case they would get some amount of biomass and at the same time preserve the meadows and pastures from overgrowing. We have to be aware that the quantity of biomass from overgrowing is limited so cleaning should be carried out gradually and the biomass supply should be combined with chips from other wood sources.

2.7.3 ENVIRONMENTAL RECOMMENDATIONS

Luzulo-Fagetum beech forests are common within the study area and are not problematic with regard to silvicultural and harvesting practices. Lower intensity of thinning does not cause intense and long-term impacts on stand structure. Haulage is implemented exclusively on forest tracks where damages are more intense. As a consequence, the functionality restoration of the plant community structure will take longer. In case of shelterwood cutting bigger areas are opened. Impacts on stand structure and natural regeneration are bigger. Reversibility is assessed as a long-term process.

Illyrian Fagus sylvatica forests (Aremonio-Fagion) are common within the study area. Due to terrain specifics and accessibility silvicultural and harvesting practices are demanding. Due to terrain specifics thinning with mechanized harvesting causes more intense and long-term impacts on stand structure compared to the previous example. Skidding is implemented exclusively on forest tracks where damages are more intense. As a consequence, the functionality restoration of the plant community structure will take longer. In case of shelterwood cutting impacts on present protected species is medium and long term as living conditions for growth and reproduction are changed outstandingly.

In case of Luzulo-Fagetum beech forests and Illyrian Fagus sylvatica forests (Aremonio-Fagion):

- Leaving decayed wood in the forest is of great importance for Xylobiont and Saproxylic beetles as well as for some bird species. Especially in Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea) there is small amount of wood biomass. Excessive deprivation of biomass as a consequence of chipping could have long term negative impact on animal species.
- Use of heavy machinery for harvesting could impact on increased soil compaction that has negative impacts on ground-active beetles.

Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea) are specific forest stands that are present on small areas where temperature inversion is present. Thinning in accordance to Forestry Management Plans doesn't have impact on stand structure composition and indirectly improves natural regeneration. Long term impacts on life-form spectrum are not present. Haulage is implemented exclusively on forest tracks where damages are more intense. As a consequence, the functionality restoration of the plant community structure will take longer. Consequences of shelterwood cutting are high and irreversible impacts that considerably alter tree species composition. This habitat type is only present on small areas within the biomass districts, where the soil is humid. As the areas where this habitat type is present are very small, they were not eliminated in sections. This is the reason why not much data is present on the presence of these habitat type. From the aspect of biomass production, they are not that important as it is mainly high quality roundwood.

- impacts of use of heavy machinery are high and long term, especially due to extreme conditions and specific terrain.
- Shelterwood cutting increases threat of presence of gully and surface erosion. In case of use of heavy machinery, increase of Soil Bulk Density is expected.

Coppice beech and oak forests are the most common forest within both biomass districts as a result of traditional land use, where biomass is mostly used as fuel wood. Traditional silvicultural and harvesting practices are not expected to have high impact on tree species composition or natural regeneration. Infrastructure for silvicultural and harvesting practices in coppice beech and oak forests is already established. This is reason why no new damages on vegetation and ground are present.

- Traditional silvicultural and harvesting practices are not expected to have high impact on tree species composition or natural regeneration. Extreme increas in logging and excessive deprivation of biomass as a consequence of chipping could have long term negative impact on animal species.

- Thinnnig has smaller impacts on abiotic component than shelterwood cutting has. In case of shelterwood cutting nutrient leaching is increased, litter cover and height as well as deadwood is reduced. All listed represent a threat for surface and gully erosion and increade of Soil Bulk Density.

Where **Tilio-Acerion forests on slopes, screes and ravines** is present,

- the soil load capacity is not high. Heavy machinery used for implementation of harvesting practices could have significant impact on the increased soil compaction and consequently on the presence erosion processes.

Black pine plantations are temporary forest category as a consequence of forest restoration. Natural transfer to deciduous forest is predicted. With rejuvenated cutting the structure and trees composition will be changed to natural deciduous trees. Plantations are left to natural regeneration, rarely used practice is shelterwood cutting that has bigger impact on tree species composition. Clearcuttings are forbidden with legislation and are not in practice.

2.8 8th step: Technical assistance for project documentation preparation and finding funds for investments

In the process of the establishment of biomass energy supply chain a step-by-step implementation is needed. Building biomass energy supply chains needs a support in terms of coordination and organisation.

Technical assistance is crucial to connect different organisations or individuals and help finding the missing links for the chain establishment or encourage and support new ones to develop. By that a chain of all the stakeholders, needed for the establishment, are introduced and collaboration will help to build trust. In the pilot area several organisations already exist such as Slovenian forestry service (support to forest owners in management of forests), Local Energy Agency (support in preparation of technical documentation and support in finding financial resources for investment), management of the protected areas and other.

Besides organisation and coordination, technical assistance is needed to support stakeholders of the biomass energy supply chain with finding funds for investment and guide them through the process of project documentation preparation as well as through the funding process.

Example of good practice is the project of Goriška lokalna energetska agencija GOLEA (local energy agency) that provide technical support in the frame of the European Local Energy Assistance (ELENA) to help prepare and enable full - scale implementation of a planned investments. They are beneficiary of the project Preparation and Mobilisation of Financing for Sustainable Energy Investments in Primorska Region Municipalities (PM4PM), an investment programme located in 22 municipalities of the Primorska Region of Slovenia to improve the energy efficiency of 97 public buildings through deep renovation and integration of renewable energy sourced heating systems.

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