Baltic ForBio

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Supply of Small Bioenergy Plants with wood chips from local forests and landscape

Guidebook

Picture: H. Hartmann

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1 Introduction

1.1 Background

Many municipalities and local institutions (like for instance churches or associations of land and forest owners) have own forests and access to additional sources of woody biomass (like for instance cutting and trimming trees and hedges for reasons of traffic safety and landscape preservation). These potentials for wood fuel are only known at local level and they can only be mobilised involving local partners, who know how to access them and who profit from short transport distances. Combining these sources of woody biomass provides an opportunity to supply small, local bioenergy plants with wood chips. The preconditions are, that plant owner can ensure the reliability, cost-efficiency and quality management of wood chip supply. Supplying small plants with wood chips makes is a demanding task in terms of quality management and logistics because the technical systems are delicate, because storage space is often scarce and because technical devices (such as chippers and wheelloaders) and personnel cannot be hold available exclusively for the plant. These circumstances and the lack of knowledge and experiences prevent plant owners to set up own supply chains to use local resources.

1.2 Group of Activities

The objective of this group of activities was to develop models to supply small scale bioenergy plants with wood chips from local sources and to exemplify them in case studies. Part of this formed the “Case Study Altlandsberg” in Brandenburg/Germany, which concentrated mainly on supply processes, and the analysis of “Business Models, Governance Structures and a Co-operative Form of Small-scale Forest Heat Production Set-ups” in Finland, which concentrated on business models and forms of collaboration.

1.3 Use of the Guidebook

The guidebook summarizes the most important findings and insights with special focus on supply logistics and quality management in wood fuel procurement for small scale bioenergy plants. It is meant for training purposes and first information of potential local bioenergy developers (such as forest companies, private forest owners, other local entrepreneurs and companies) to make reliable plans for starting small scale forest bioenergy business.

The shown recommended procedures are illustrated mainly at the example of the “Case Study Altlansberg” but the information is valid for all small bioenergy project in rural areas and applicable in all project regions.

2 Case Study Altlandsberg

The Case Study Altlandsberg was conducted during the years 2019 and 2020. Main partners were TH Wildau and Castle Property Altandsberg, a local and a regional energy wood company, and the Municipal Forest of the City of Altlandsberg. The aim of this case study was to understand, how local plant owners can strengthen their ability to use local resources by elaboration of novel supply and business models. Technical tests and demonstrations were conducted in order to understand how to develop and establish new supply processes and to gather material (data, foto, video documentation) for training, information and promotion purposes.

The case study shows examplary the steps, that should be applied, when analyzing conditions for forest fuel procurement during the planning process for bioenergy plants from a logistical viewpoint or during strategic planning when setting up own supply chains (instead of buying wood fuel). The basic approach consists of:

- the assessment of local pre-conditions and interests of stakeholder groups
- the formulation of requirements to the supply system
- the analysis of technical and organisational alternatives that can be applied in the given case
- the demonstration of technical and organisational solutions with partners in order to assess their viability.

Modified and adapted to the project objectives, the logistical analysis contained the following steps:

1. Assessment of Local Pre-Conditions
   - Castle Property Altlandsberg
   - Background: City of Altlandsberg
   - Potentials of woody biomass
   - Assets for biomass supply chains
   - Interests of Stakeholder Groups
2. Requirements for the Development of Supply Models
   - Wood fuel quality
   - Supply logistics
   - Cost functions
   - Interests of stakeholders
3. Technical and Organizational Solutions
   - Production processes
   - Logistics
   - Supply chains
4. Demonstrations
   - Local sources of woody biomass
   - Suitable supply chains
   - Technical trials
   - Quality assessment
5. Elaboration of conclusions and report

3 Background – Bioenergy Plant of Castle Property Altlandsberg

The Castle Property Altlandsberg was the Residence of King Friedrich I. and is currently used for events in historic ambiance. On the premises are the castle church, the restored baroque pleasure garden and the former estate buildings. During the last years, the castle property has become quite a point of touristic interest and destination for sightseeing. The estate buildings accommodate nowadays a brewery, a restaurant, the touristic shop and the bioenergy plant, which is part of the "Märkisch-Oderland Energy Bike Trail." The bioenergy plant, that supplies the buildings with heat, is situated in the old depot and was put into operation in the year 2015. It can be fueled by wood chips and pellets and produces 300 MWh per year.Altlandsberg is a small town situated in the north-eastern periphery of Berlin. Inspite of a stronginflux of new residents and some development in the fields of recreation and tourism during the last years, Altlandsberg has maintained it's rural charm and attitude to life. It is part of the landscape „Barnimer Feldmark" with extensive agricultural areas, forests and expanses of water. In the year 2017, the Municipality of Altlandsberg adopted the Integrated Municipal Development Concept – INSEK, which includes the "Integrated Concept for Climate Protection in the City of Altlandsberg" from 2016 and underlines landscape protection and tourism as important parts of sustainable development.

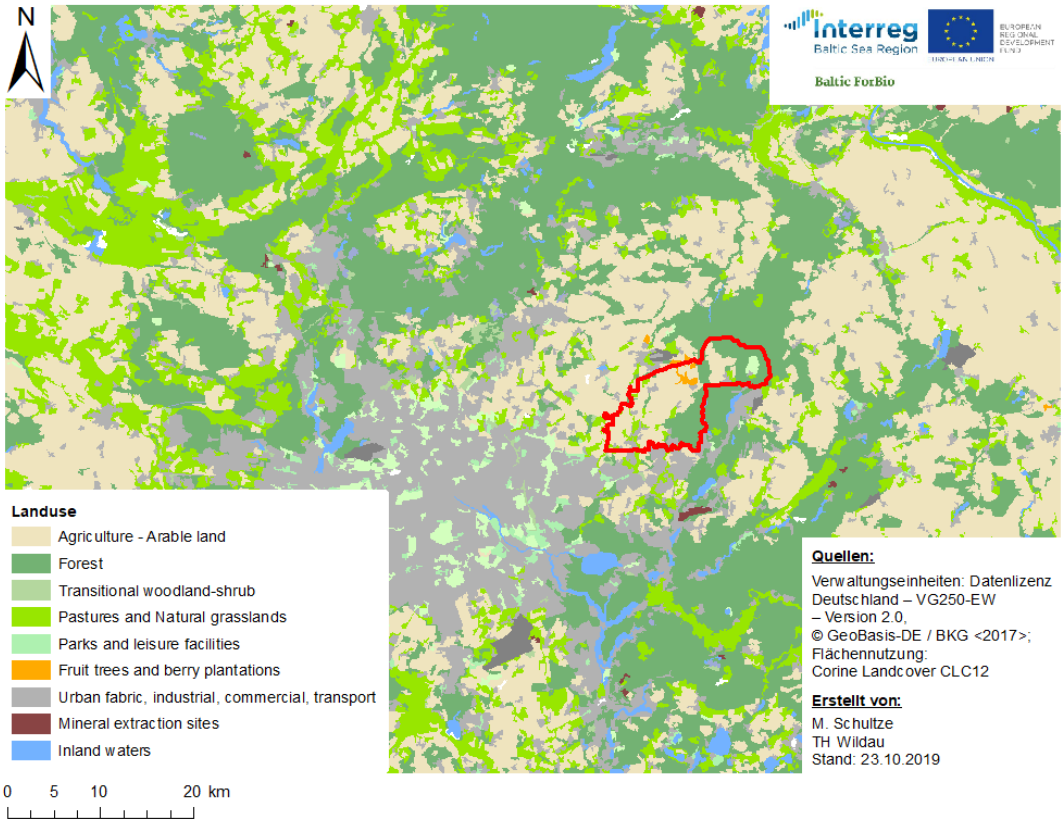

Figure 1: Municipality of Altlandbers (border marked in red) situated in the north-eastern periphery of Berlin and land use in the area

The City of Altlansberg owns about 950 ha of forest. In order to improve forest management and use of wood resources, they established a permanent full-time position for the forest manager. Use of forest fuel from their own municipal forest for heating buildings in Altlandsberg has been one of the goals for some time now. At the time, when the bioenergy plant was planned and put into operation, a small local wood chip company procoduced high quality wood chips from landscape presevation matters (tending of hedgerows, field woods and alleys) and from felling and prunig of trees in the extensive ochards in the vincinity. However, the quality management and supply processes of this company depended largely on manual labor and personal know how of involved persons, and the busines had to change its strategy and is not able to procure appropriate wood chips any more. The period of transition was managed by bying wood chips on the free market. Long deliveries, lack of contact with the suppliers, high prices and severe problems with wood chip quality made plant operations difficult and unprofitable. The new management of Castle Property Altlandsberg and the municipality of Altlandsberg decided to return to the initial supply strategy, which means to use wood fuel grown in the Municipal Forest of the City of Altlandsberg, to involve local farmers and companies and to build longterm partnerships for value creation from wood energy production. The development of a strategy to attain this objectives and road map to put it in place was part of the motivation for Castle Property Altlandsberg to participate in the Baltic ForBio project.

4 Requirements of small-scale bioenergy plants regarding forest fuel supply from local sources

4.1.1 Quantity and Origin of Wood Fuel

The bioenergy plant produces 300 MWh per year using about 400 bulk m³ wood chips per year. Wood pellets are not used for cost reasons.

Potentials of wood fuel were analyzed during the LEADER-project “Supply Chain Energy Wood” in the year 2014. Relevant sources of wood fuel to supply the bioenergy plant in Altlandsberg are measures of landscape preservation (cutting and felling of trees), cultivation of fruit trees (pruning, felling,) and forestry.

The extensive orchards (mainly apple plantations) in the area and in the vincinity of the municipality could deliver about 10.000 bulk m³ of wood chips in average per year. However, this would require large investments and management efforts which are not reasonable with the current situation on wood chip markets. As long as there are so little small scale bioenergy plants as stable high end costumers on the surroundings, farmers are not inclined to cooperation in wood chip supply.

Landcape management in the region is supported by the association “Regionalpark Barnimer Feldmark e.V.”. About 350 km of tree rows, hedgerows and woods alongside touristic pathes and about 1.000 pollard willows need to be pruned on a regular basis. The longterm potential of woody biomass is estimated to be about 4,000 bulk cubic metres of wood chips per year. However, this would require comprehensive planning of tending measures and use of woody biomass including numerous landowners. In order to use these potentials, farmers, municipalities and companies need to collaborate for this purpose.

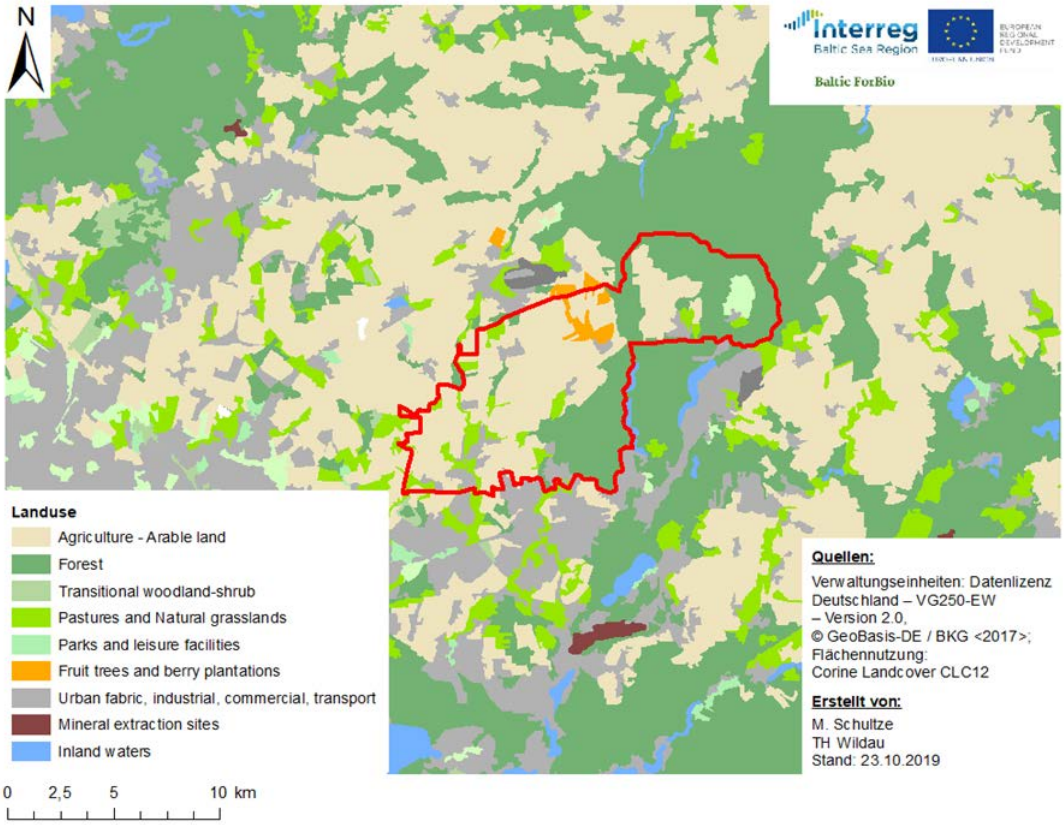

Figure 2: Land use in Altlandberg and surroundings

Forests are mainly in private ownership in the municipality Altlandsberg (Figure 3). The municipal forest of Altlandsberg covers an area of about 950 ha. Most forest stands are mixed, with oak, alder and birch being the most important deciduous trees. Forest stands mainly dominated by pine are used for production of timber and will be converted step by step into mixed stands.

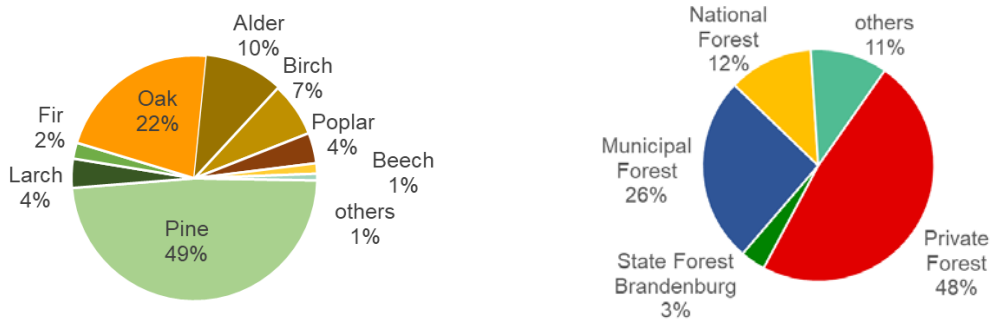

Figure 3: Tree species in the municipal forest Altlandsberg (left) and forest ownership in the municipality of Altlandsberg (right), data source: forest inventory of the Land of Brandenburg, LFB 2018

Altlandsberg's forest is important for tourism and recreation. The european cycle track E1 is passing by and the lake "Bötzsee" is popular for swimming. Forest management includes the requirements of tourism and recreation by maintaining traffic safety, creating pleasant views and ambiance. Nature

preservation is an important part of forest management not only as opposite to wood production but also to compensate for touristic overuse (for instance by riding stables).

Figure 4: Nature preservation (left side, picture. I. Jakobson) and participants of an international study tour enjoying the ambiance (right side, picture: R. Bermanis) in the municipal forest Altlandsberg

Forest fuel in the municipal forest of Altlandsberg comes mainly from harvesting residues (crown material) and from decidious roundwood that cannot be sold for industrial use. Most forest fuel is sold to the bioenergy power plant in Eberwalde, who is a reliable buyer with little rquirements to fuel fuel quality and an own stationary wood chipper. Procurement of wood chips to Castle Property Altlandsberg has not taken place in the past because of the high requirements to wood chip quality and because of the specific delivery process.

4.1.2 Delivery

Altlandsberg has direct access to motorway A10 (Berliner Ring), federal highways B1/5 and B158, and several well built country roads leading to Altlandsberg can also be used for wood fuel delivery. Castle Property is situated directly outside the town center and has two country roads passing. The bioenergy plant is located in the old depot of the castle property, which is part of the ensemble of historic estate buildings surrounding the inner courtyard. The courtyard is used for touristic purposes and has to be kept clean and tidy and without hazards to visitors. In order to avoid inconveniences for the guests and maintain an “orderly” ambiance, there is not open storage for wood chips on the premises and no equipment for the handling of wood chips. Because the property is so well connected to the road network and the court yard is capable of bearing independendly of weather conditions, frequent truck traffic is no problem.

Wood chips are delivered and stored in special containers, that are property of the plant owners. They can be linked to the conveyer system of the bioenergy plant and are placed also in the old

depot building. When a new chip delivery is expected, the empty exchange container will be retrieved by a container truck, filled at the external wood chip storage lot, brought back and swapped with the current container. Standard container trucks can be used for this process. The need for delivery can be announced by the plant operator only a few days in advance, and the delivery has to take place in time. This process is sufficent robust against disturbances and reliable, if the means of transport (container trucks) are available, the access to storage place and bioenergy plant is possible at all times and the external chip storage is sufficiently stocked.

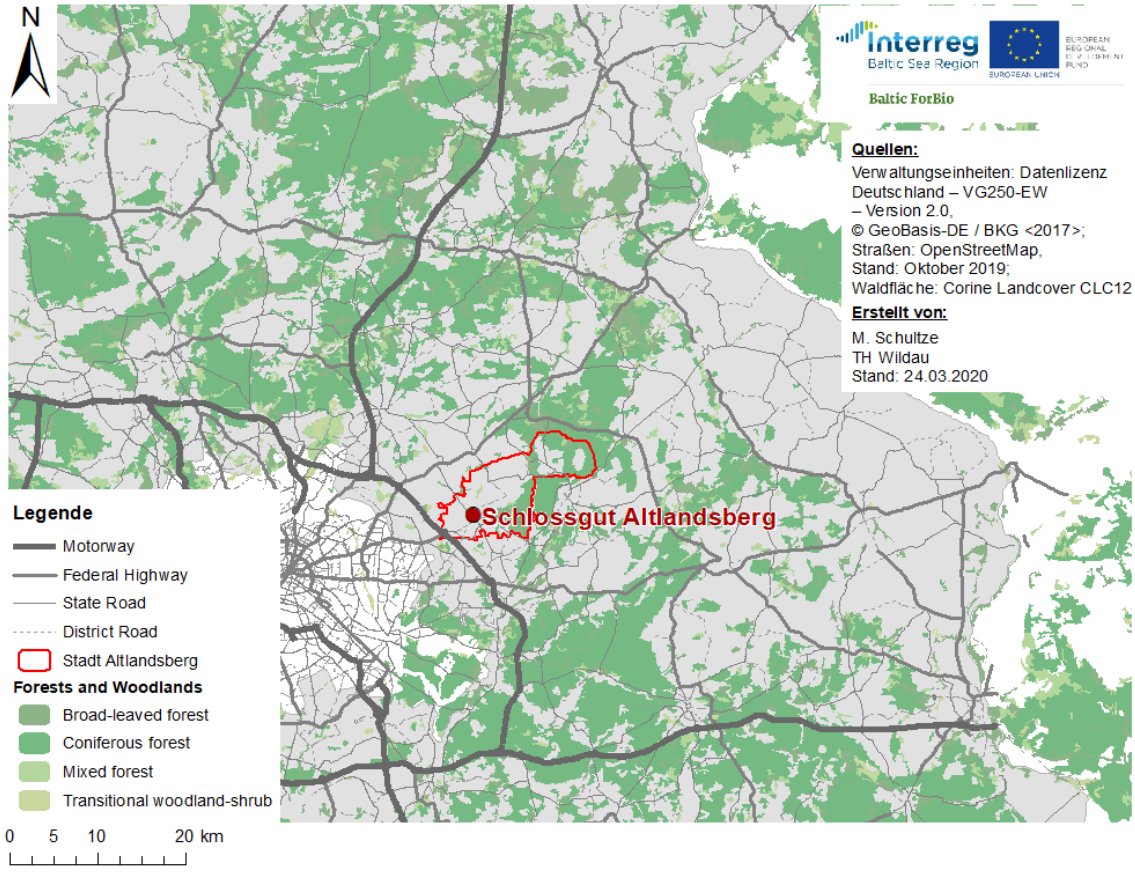

Figure 5: Location of the bioenergy plant in Altlandsberg in the north-eastern rural suburban zone of Berlin and well connected to the motorway A10 (Berliner Ring), federal highways B1/5 and B158, and several well built country roads.

Figure 6: Container Delivery at Castle Property Altlandsberg, pictures: S. Ruebsam

4.1.3 Storage

The wood chip storage at the bioenergy plant has a capacity of 35m³ of wood chips per container at a time, which is stockkeeping for less than two weeks.

Buying wood chips in time on the free market has proved to be a risky strategy for the bioenergy plant operator, because suppliers can use their power (created by the urgent need for wood fuel) to raise prices, deliver bad quality or to refuse repayment in case of complaints. This has negative impact on the technical processes of bioenergy production, on maintenance and service intensity, on organizational processes and staff motivation, and on economic viability of the bioenergy plant.

Additional stock on an external storage place is needed to secure the supply of the bioenergy plant with sufficient quantities of appropriate wood chips. This external storage has to managed independently in a way, that gives both – operator of storage place and operator of bioenergy plant – sufficient security and power to enforce their interests. And it has to bundle all needed functions, that are necessary to maintain sufficient independcy from the free wood chip market, in one organizational unit. The preequisites are

- sufficient infrastructure and buildings for transport, handling and storage
- according equipment for wood chip production, processing, quality improvement, handling and transport
- qualified operator and staff at the storage place.

The storage place has to be accessible for chip trucks all year round independently of weather conditions. The wood chips have to be stored under roof and on fortified, clean ground (to avoid impurities). Equipment for handling must be at hand at all times. Machines for processing and quality improvement (chipper, screen, …) are only needed occasionally when rawmaterial flows are small. Depending on the overall capacity of the storage place (quantity of rawmaterial stored and handled, number of costumers supplied) these machines should be rented at occasions.

If management and of supply relations and procurement of wood chips is not part of the core activity (as it is the case at Castle Property Altlandsberg), the operator of the external storage has toprovide also the networking and relations with suppliers (forestry, landscape management, farmers) and to decide, whicht material to buy.

Quality of wood chips must also be checked before loading them into the delivery containers, and the material must be mixed so that the chip load in the delivery container is of homogenious in terms of water content and particle size.

In summary, the external storage place must provide the following funcions:

- procurement of rawmaterial,
- processing,
- storage,
- quality management, and
- secure short-term supply.

4.1.4 Use of Existing Organizational Structures and Available Resources

Supply chains for small bioenergy plants are characterized by small quantities of material, that need to be produced, processed, handled and transported, and by the high quality of product, that is needed. The earned income is small, so that neither investment in the needed equipment nor the specialisation of a company to this kind of business makes sense. Cooperation with specialised companies, that are located and doing their business elsewhere does not pay because of the call-out charges. Unless there are already several small bioenergy plants with similar requirements in the vincinity, it is better to look out for according equipment and qualified personnell in related branches in the neighbourhood of the plants.

In most cases, basic infrastructure and equipment can be used to keep costs down. Involments local companies has also the advantages, that the support of local population for the bioenergy project can be ensured by doing buisness and local value creation can be boosted. Figure 8 shows the types of local and regional players that support the supply of wood chips for small bioenergy plants in the respective value chain elements and Figure 9 the resources that are needed in the respective value chain elements to create wood chip supply chains for small bioenergy plants at the example of Case Study Altlandsberg.

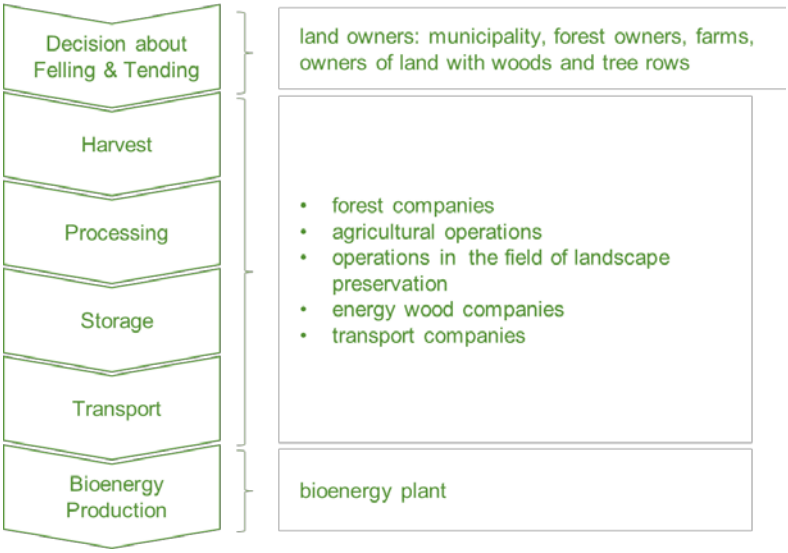

Figure 7: Types of local and regional players that support the supply of wood chips for small bioenergy plants in the respective value chain elements

In the Case Study Altlandsberg, in the end two companies were able to offer together the infrastracture, equipment, services and expertise, that are needed to supply wood chips according to the bioenergy plant's requirements. In addition to the Municipal Forest Altlandsberg as main wood fuel supplier, the owner of fruit tree plantations and a company growin poplar in short rotation agreed to provide wood fuel in case of emergencies. This provides a sufficently robust basis for secure wood fuel supply.

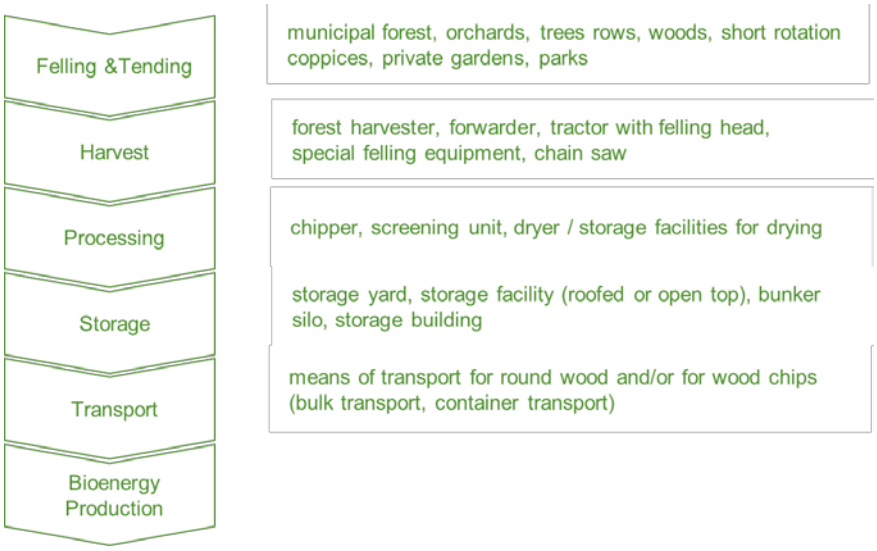

Figure 8: Resources that are needed in the respective value chain elements to create wood chip supply chains for small bioenergy plants

4.1.5 Wood Chip Quality

Wood fuel quality is defined mainly by the parameters
- type of wood fuel,
- water content,
- ash content, and
- particle size.

In the case of the bioenergy plant at Castle Property Altlandsberg the instruction manual states:

- Wood chips, pellets, wood briquets or byproducts of sawmills can be used
- The water content must not exceed 30%.
- The ash content must not exceed 1% and less than 0.5% are ideal.
- The particle sizes should be mainly (to at least 60%) between 3.15 mm and 45 mm Particle size. Small particles / dust with a size <3.15 mm should not have a share of more than 10% max, and particle must not be longer than 200 mm.

Operating experience shows that water contents of more than 30% lead to bad combustion and increased emissions. Particles with excess length congest the spiral conveyors. An alarm, caused by picture sensor, alerts the plant operator and prevents larger damage. Large shares of very fines material/dust and impurities like stones and metal also cause congestion (spiral conveyors and conveyor for ash). Excess ash content increases the quantities of ash, that need to be disposed of, an generally increases the wear of a plant. High ash content is caused by high shares of bark and green material in the wood chips.

5 Quality Management in Wood Fuel Supply Chains

5.1 Choice of Rawmaterial

Wood chips for small bioenergy plants can be produced from whole trees, parts of crowns and other harvesting residues and from the stem of trees. The use of stumps for wood fuel production is not recommended for small bioerngy plants for quality reasons and highly controversial from an ecological viewpoint.

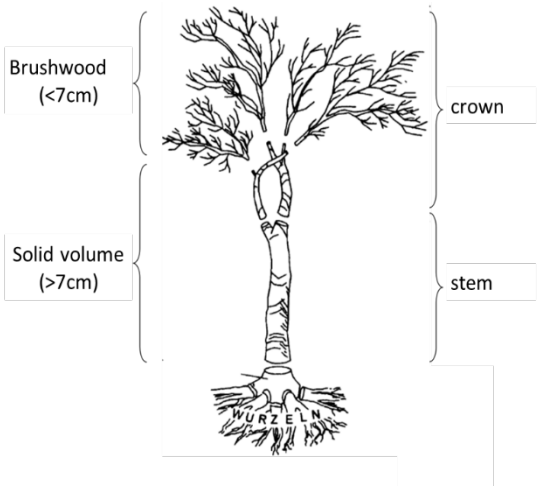

Figure 9: Tree parts for wood chip production, source: Hartmann, H.; Kaltschmitt, M.; Hofbauer, H. (2009), adapted

Decisive for the wood chips quality is the dimension of the used tree parts: Bruschwood with diameters considerably smaller than 7 cm contains high shares of bark (and green material) and are difficult to handle and to process with chippers.

Figure 10: Wood chip quality according to used Rawmaterial for wood chip procution:top left: deciduous round wood; top right: crown material from harvesting older deciduous trees with large parts of solid volume; bottom left: crown material from harvesting young trees with high contents of brushwood and bark; bottom right: material from pruning a blackthorne hedgerow for lanscape preservation.

Figure 11: Wood chip quality according to used rawmaterial: left: wood chips from harvesting small trees under power line near Altlandsberg; right: wood chips from felling trees for lanscape preservation; pictures: H. Hartmann

5.2 Chipping – Technology and Organization

In order to produce high quality chips from different sources, large drum chippers are the best choice. They are able to chip a large variety of material from large roundwood to brushwood very effiiciently, and the size of chips can be influenced reliably.

The high performance of drum chippers are also their main disadvantage, because large quantities of rawmaterial need to be concentrated in one place in oder to use the capacity of that machine. Large chipper can only operate at full capacity if the coinnected working processes are organized accordingly. At the (forest) road side, the material needs to chipped directly into the transportation vehicle. Depending on the transportation distance the number of trucks used for transporting the chips to the storage needs to be chosen in a way, that waiting times and fix costs for the entire system (chipper and trucks) can be kept low.

Figure 12: Drum chipper in detail (left) and common technology and work flow for processing material from trimming trees at the road side (right); pictures: M. Schultze

In oder to produce high quality chips with a little energy consumption as possible drum chippers need frequent maintance work and service. Experienced operators are required to perform the tasks connected to operating the machine (such as sharpening and adjustment of blades). For farmers, municiple operation centers and road maintance staff, who only occasionally have to process material from felling and trimming, small and robust trailer chippers or shredders are the best choice even if they are not able to produce high quality chips using this technology.

Figure 13: Chipping large roundwood with drum chipper into waiting container truck, picture: M. Schultze

5.3 Drying

By drying, the heating value of wood fuel can be increased. The combustion behavior of dry wood fuel is in general better, and less noxious substances are emitted during combustion. Wood fuel with a water content below 30 % can be stored for a longer period (lowerd decomposition rate and less thread of mold formation) and more easily transportet (lower weight).

To save costs, the best way is natural drying by storing the fresh roundwood or tree parts in piles at an adequate place (exposition to wind and sun) before chipping for several months. Water content can be decreased from about 50 % to about 30% by this process. During this storage time and drying, most needles, old leaves, dry-sticks/ brush-wood drop, and the ash content of the produced wood fuel ist lower. Storage piles are normally situated near the forest road, and must be monitored in the framework of forest pest control. The piles may. If piles remain in the forest for a long time, they may also provide living space for valuable species and small animals in which case it may be preferable to leave them to decompostion for nature protection reasons.

The natural drying can be continued after chipping. The natural drying of fresh wood chips in piles is not so recommendable because the risk of fast biomass decay, mould formation or even spontaneous combustion is high. Wood chips should have a water content of less than 40% when putting them into storage. Circulation of air better when chips are not too small. Therefor, sieving of wood chips before storage is recommendable, if contents of bark, green material and fine partcles are high. Air circulation and the drying process can be furthermore improved by the model of storage facility with lean-to roof open for aeration and exposition to wind and sun. The height of wood piles should not exceed 5 m and protected against rain. If storage under roof is not possible, coverage with semi-permeable material in a cone-shaped chip pile is recommendable. Storage on floors with slits or wholes and space for air circulation underneath and installation of air pipes in the wood chip piles can speed up the drying processs conderably, but may be expensive and difficult to use. Regular mixing of wood chips of wheel-loader helps to equalize moisture of wood chips and particle size within the pile.

Figure 14: Storage of wood chips aunder roof, picture: H. Hartmann

Artificial drying of wood chips can be done by using air and heat or mechnically. Using surplus heat from biogas plants for batch drying in modified bulk containers is very common. The chips can be dried to water contents of less than 20% in a very short time. ´By this, storage risks like biomass decay and mold can be avoided. The water content can be predefined and the produced material will contain homogenously the intended water content.

Drying wood chips mechanically is an innovative process using less energy than drying by heat and ventilation. In general, articial drying causes high additional costs and logistical expense. For small wood fuel material flows, natural drying is in most cases the best option.

Figure 15: Batch drying in modified bulk containers using heat from a biogas plants; picture: www.energieholz-brune.de

5.4 Further Quality Improvements

Wood chips should be stored and loaded in a way, that a homogenuous batch of wood fuel (particle size, water content) can be delivered. During storage (esp. in open space and simple silos), water and fine material can be concentrated in parts of the pile. Thorough mixing before loading the material into the delivery container is in such cases mandatory. During mixing and loading, the machine operator of the wheel loader has to avoid to mix impurities (like stones and dirt) into the wood chips.

Figure 16: Storage and loading of wood chips in open space; pictures: H.Hartmann

Depending on the rawmaterial used for wood chip production (diameter, share of brushwood, share of bark and green material) the content of small particles must be reduced to produce wood fuel of sufficient quality. Mobile drum and star screens are very common and improve the quality of wood fuel considerably. Because of the high investment costs, smaller suppliers should cooperate with larger wood fuel companies and hire them/rent the machine in case of need.

Figure 17: Mobile star screen for seperating three fractions, picture: N. Hofnagel

5.5 Supply Chain Example Altlandsberg

The 'Case Study Altlandsberg" shows examplary the steps of analyzing conditions for forest fuel procurement, that should be applied during the planning process when setting up own supply chains (instead of buying wood fuel). The main characteristics of the approach and attainable information has been presented in the preceding chapters. In the case of the bioenergy plant in Altlandsberg the demonstration of technical and organisational solutions with partners and the comparison of achievable wood chip quality gave valuable information how to create a straightforward supply chain for the procurement of wood chips from the municipal forest in Altlandsberg. These findings enable the Castle Property Altlandsberg and the City of Altlandsberg to cooperate more closely in the production of renewable energy and value creation in the municipality.

To put this supply chain in action, the municipal forest Altlansberg and a small local wood fuel company need to cooperate. In addition, a larger wood fuel company needs to be involved to guarantee access to wood fuel supply as fallback option in case of emergencies. In it' basic characteristics, this supply chain can be applied to the procurement of wood fuel from forest and from landscape.

Harvest is done as planned by forest machines or chainsaw. The roundwood or tree parts are stored nearby for at least three to six months (depending on season and weather conditions) in a place where chipping from the pile into the container can be done. The chips are directly loaded in into the waiting container truck and transported to the storage place. The batch of wood chips is stored under roof and with favourable exposition to wind and sun for several weeks and months (again depending on season and weather conditions). Wood chips from different raw materials can be mixed to obtain a sufficient wood chip quality for strorage and use in bioenergy plant. When the bioenergy plant gives the delivery order, the wood chips are mixed directly before loading them into the delivery container, and the supplier or a qualified person entrusted by the supplier checks the wood chip quality by visual inspection. A control sample is taken and handed to the costumer during wood chip delivery. At the bioenergy plant, a quality check using simplified test procedures is performed. Because the particle size has the largest influence on the running and technical performance of the plant, a simplified sieve analyzis is performed. Additionally, specific values, that indicate the quality level of the combusted material (heat production, quantity of ash, disruptions of process) are documented for every batch. In order to ensure the smooth running of the supply chain and the continuous improvement of supply and wood chip quality, a long-run contract with local wood chip company is concluded.

Figure 18: Sieving of wood chips for simplified analysis of particle size – quality assessment on the premises of Castle Property Altlandsberg; picture: S. Ruebsam

6 Recommended Literature

Recommended Literature in German Language

Fachagentur Nachwachsende Rohstoffe e. V. (FNR) [Hrsg.] (2014): Leitfaden Feste Biobrennstoffe, 4., vollständig überarbeitete Auflage, ISBN 9783000153891

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Kaltschmitt, M., Hartmann, H., Hofbauer, H. (Hrsg.) (2009): Energie aus Biomasse – Grundlagen, Techniken und Verfahren, 2., neu bearbeitete und erweiterte Auflage, Springer-Verlag, Berlin, Heidelberg, 1032 S.

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