University Van Hall - Larenstein

The chain of biomass

Analysis for Staatsbosbeheer of the production, logistics and sales of biomass

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ABSTRACT

This graduation paper is an evaluation of the chain of biomass at Staatsbosbeheer. The goal is to get a grasp on all its variables. So that decisions now made out of experience could be found to indeed be the right ones. By naming all the variables and trying to link them to each other, a better insight into the chain of biomass is provided. Most important variables fall in the categories production, logistics and sales of woodchips. The most important variables under production are the woodchips and its properties. The most important variables under logistics are the chipping method, the method of transportation and the choice or must of storage. The most important variable under sales is planning. The conclusion of this evaluation is that there are so many variables that it is nearly impossible to fine-tune them into each other. A few recommendation might help the matter. Another way of storage to assure delivery during summer months when no work is allowed in the forest is to transport (unprofitable) logs to storage sites. By storing them as logs, rot due to heating is prevented and by doing this on a central storage site, the change of protected animals nesting in the piles is reduced. It could also be interesting to classify certain forest in the Netherlands as energy-forest in the form of coppice forest. This would provide an ongoing stream of 'raw material'. Further it would be a good idea to situate more storage sites in the Netherlands on tactical locations, like near a quay or in the South were no permanent storage sites are present now. And at last it is recommended that a model is developed, with the help of a programmer to make it easier for the biomass coordinator and the harvest coordinator to handle the complex chain of biomass.

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Vocabulary

The definitions below are to be considered definitions as provided in this paper, unless otherwise mentioned.

Definitions

Biomass (energy)	biological material from living, or recently living, organisms used as a renewable energy source, in this paper: woodchips, being wood residues for the purpose of creating energy
Chipper (chipping)	a machine used for reducing wood into small particles
Extraction	The removal of forest produce from its place of growth
Feller-buncher	a type of harvester used in logging which gathers several trees before cutting them. It has a tree-grabbing device with circular saw or shear
Felling	the process of downing trees
Forwarder	a vehicle that carries felled logs from the stump to the roadside or landing.
Harvester (harvesting)	a type of vehicle employed in cut-to-length logging of tree
Landing (roadside-)	Any place where round timber or branches and tops are assembled for further transport, commonly with a change of method
Moving / Walking floor	a conveyance system with a moving-floor system to quickly unload loose material without having to tip the trailer or tip the floor
Net Caloric Value (NCV)	the amount of energy released during the complete combustion of a mass unit of a fuel
Power plant	Company that converts heat into energy
Pyrolysis	decomposition of wood by heating, the air supply being limited or non-existent to obtain a much better fuel quality for combustion and gasification applications
Quay	a landing place at which vessels receive or discharge cargo
Shredder	a machine used for reducing wood into smaller chips
Storage / depot	place where woodchips are stored, on sight or at a fixed place
Torrefaction	a mild form of decomposition of wood by heating, the air supply being limited or non-existent to obtain a much better fuel quality for combustion and gasification applications
Unprofitable trees	trees at the bottom of the cascade fall, only when converted into biomass they might *bring in* money
Woodchips	wood which has been subdivided into pieces of a size suitable for burning
Wood drying	reducing the moisture content of the wood for a higher Net Caloric Value

PREFACE

This paper illustrates the assignment I did for Staatsbosbeheer Dienstverlening in regard of my graduation at the University Van Hall-Larenstein. The purpose of this paper is to give an insight in the obscurities surrounding the chain of biomass as it is for Staatsbosbeheer.

I would like to thank the employees from the Productgroep Hout for taking me into the forest, providing me with information and interesting stories and help. You gave me a lot of knowledge, understanding and pleasure during my staying at Staatsbosbeheer.

Also a big 'thank you' belongs to Dennis the Jager, my mentor on behalf of Larenstein, whom I am thankful for the few conservations we had and the motivation I got from them but moreover the trust I received in bringing it all to a good end.

And another special word of 'thanks' for Lotte Leerschool, my sister, for the absolutely beautiful, distinct and rigid drawings in this paper. None of them which may be copied or published without her permission.

Deventer, 8th June 2011
Juul Leerschool

1 INTRODUCTION

The mission of Staatsbosbeheer (from now on: SBB) is to warrant the quality of green surroundings for human, plant and animals[1]. One of the targets to support this mission is the use of renewable raw materials, like wood and biomass[2]. And biomass is what this paper is about. Biomass is, in the regard of energy: "organic matter, especially plant matter, that can be converted to fuel and is therefore regarded as a potential energy source"[3]. Although SBB handles more forms of biomass (grass, shreds, etc.), in this graduation paper the word biomass means woodchips. Woodchips are subdivided pieces of wood with the size of small matchboxes meant for burning.

1.1 Relevance

Besides their ecological and recreational value, our forests are also significant for a sustainable environment. The overall theme of this graduation paper is *biomass*, which has become major with the recent intention of the Dutch government to act on the 'Richtlijn Hernieuwbare Energie' (2009/28/EG) from the European Union[4]. One overall statement from this regulation is that 14% from the national gross final end use of energy has to come from renewable sources in 2020.

Biomass has (besides energy from; water, wind and sun) a big part in this. Already tree quarters of all renewable sources used in the Netherlands is biomass[5]. And with the realization of the world ones running out on fossil fuels and the concern for our environments' health, biomass is major.

1.2 Definition of a problem and research questions

SBB is the biggest player on the Dutch market concerning biomass. And although this is so for some years now, there is still a lot to learn on the subject matter and there are some 'black holes' still to discover. One of the problems is the lack of 'prove' of certain decisions now made, that they are indeed the best decisions that can be made. It is not a problem per se but something worth investigating, because there is not much written on paper about all the variables concerning the chain of biomass. This is why this graduation paper is written and the following research questions will be answered in this paper:

Research question

What opportunities are there for Staatsbosbeheer to tune the production, logistics and sales of biomass in to each other at best?

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[1] Staatsbosbeheer, *Doelrealisatie 2010, prestatieverantwoording aan het ministerie van Economische zaken, Landbouw en Innovatie*, Driebergen, april 2011
[2] Staatsbosbeheer.nl
[3] Dictionary.com Unabridged, *based on the Random House Dictionary*, ©Random House, 2011
[4] Richtlijn 2009/28/EG, *ter bevordering van het gebruik van energie uit hernieuwbare bronnen en houdende wijziging en intrekking van Richtlijn 2001/77/EG en Richtlijn 2003/30/EG,* het Europees parlement en de raad van de Europese Unie, 23 april 2009
[5] Centraal Bureau voor de Statistiek, *Hernieuwbare energie in Nederland 2009*, Den Haag / Heerlen 2010

Sub questions

- What are the most important variables concerning production of biomass, are these influenceable and if yes: in what way and is this measurable?
- What are the most important variables concerning logistics and storage of biomass, are these influenceable and if yes: in what way and is this measurable?
- What are the most important variables concerning sales of biomass, are these influenceable and if yes: in what way and is this measurable?
- In what way and to what extend do the different variables influence the cost- and sales price?
- Is it possible to develop a model with all influenceable variables and their relatedness to influence the production, logistics, storage and sales and how would it look like?

1.3 Objective

This graduation paper is written to get a better insight in the subject biomass as it is for Staatsbosbeheer. Because when it comes to defining everything concerning the chain of biomass, from production to sales, it is quite a task to find and name all variables. Not everything is centrally recorded and most decisions are made on the basis of experience.

The objective of this graduation paper is to get a grasp on the obscurities surrounding the different variables concerning the chain of biomass. Possible by creating some kind of a model that will give insight into the unclear parts of this chain. This graduation paper will document the chain as it is, it will deepen the main variables and will explain how to fine-tune these variables and the why and how. This graduation paper can also be used as an introduction into biomass for readers new in this subject at Staatsbosbeheer.

1.4 Method & accountability

Most of the information concerning the content of this graduation paper was collected via personnel from SBB. Another useful source was Internet and divers sources of literature from the library and available at the office. The interviewing of some key-holders concerning the chain of biomass gave more insight into the subject.

All information was documented in a big dossier and digitally.

Because Staatsbosbeheer is a governmental (thus always in public and often criticized) organization, no actual data and amounts were provided. This made it sometimes difficult to understand or to get a grasp on specific subjects but was further no limit for the content of this graduation paper.

1.5 Content of different chapters

In the following chapter a sketch of the chain of biomass with all its variables as it is for SBB can be found. This chapter is followed by chapter 3 with a deepening of the main variables, their influenceability and their mutual link and their influence on the cost price will be explained. This graduation paper will be concluded in the 4th chapter and some recommendation about major findings will be given in that chapter too.

2 THE CHAIN OF BIOMASS

The raw material for woodchips, being trees, are overall managed by SBB and in this chapter all the steps, from forest to woodchips delivered at the customer are described.

Point of origin for all activities in the forest is the management plan for that specific terrain. According to that plan, sometimes trees need to be harvested. The wood is sold according to the principle of cascade, so preferably in the first place to the furniture industry, paper industry, fiberboard industry, etc. and in the last place as wood for energy.

2.1 Production

The process of harvesting starts after a harvest-coordinator from SBB and an appointed contractor discussed the execution of the work. They discuss price, conditions, machinery used, etc. The contractor also visits the forest to get an idea of the situation on site an receives marking- and measuring lists of the trees in the terrain from the harvest-coordinator. When the contractor has an idea of the extent of the job and both parties agree on the different conditions, a term for the activities to take place is set and the work begins.

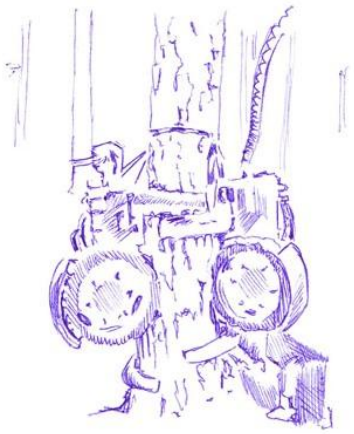
Harvest

The trees will be harvested manually or mechanically.

The manual option is not so common as it used to be and almost only done in sensitive stands or when handling small operations. This way of harvesting involves a man and a chainsaw. Biggest difference with mechanical harvest is that this harvesting method takes far more time.

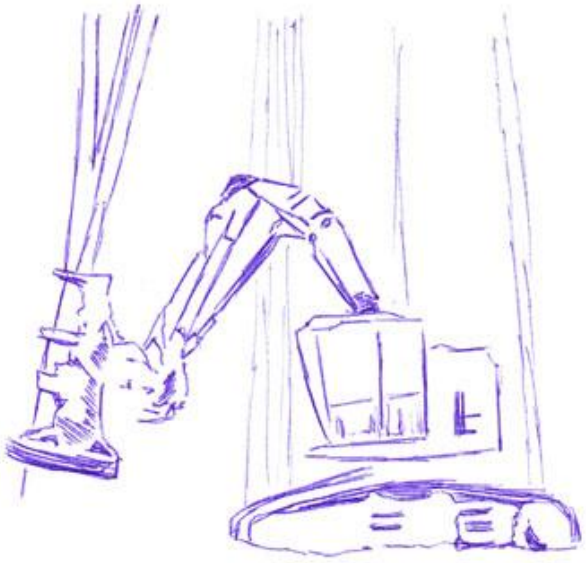
Most harvesting is done with a harvester (01). A harvester is a machine with an hydraulic arm and moveable head (02) which clamps the tree at its stem between two tracks which can rotate and cuts the tree from its stem with an integrated chainsaw (bar saw) or disc saw. Most harvesters can measure the amount of 'useful' timber in the stem and saw it to modem-stored assortments. A harvester also does the topping and trimming of the stem. Depending on the kind of job, the harvester has the possibility to place stems apart from branches and treetops or/and in one and the same direction. A harvester moves on wheels or with continuous tracks around the wheels to limit ground pressure.

01. Harvester



02. Harvester head, detail

Another way of mechanically harvesting trees is with a feller-buncher (03). This machine clamps the stem or several thin stems and saws or cuts them off. A feller-buncher can clamp more bundles at one time. The shear-version actually cuts the stems from their trunk and causes more damage to the stumps in comparison to the saw. This machine places the bundles in stacks on the ground. A feller-buncher moves on wheels or with continuous tracks around the wheels to limit ground pressure.



03. Feller-buncher

2.2 Extraction and Chipping

When the trees are felled they will be extracted out of the forest

Extraction

There are two ways in which this happens.

1. Extraction to a landing and chipping at that place
2. Chipper-combination goes into the forest and chips the stems/branches/treetops

Option 1.
Extraction is done with the help of a forwarder (04). This is a self-loading machine, different sizes, that can be adhered to a tractor or another all-terrain vehicle and picks up the felled trees or branches and treetops. The forwarder brings the material to the central landing and places them into neat stacks on the ground. When the material is collected at the landing (05) a chipper comes and chips the stems, branches and treetops.

04. Forwarder with logs

05. Landing

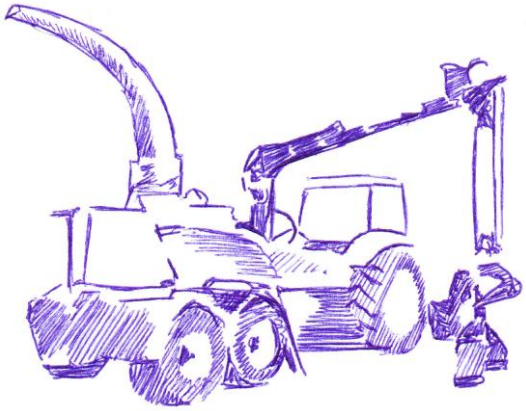
There is one other biomass-specific way of extraction and that is with a so-called press-collector. This is a machine especially designed for the collection of branches and treetops, which can be build on a conventional forwarder. It presses the loaded branches en treetops together and quickens the extraction of chips.

Option 2.
The second option is that a chipper combination (06), being a tractor with a chipper on one side and a bulk carrier on the other, goes into the forest, picks up the stems with a integrated crane and processes them into chips. This combination can look very different and vary in size depending on the combination the contractor has build or owns. A forwarder is not needed in this case.

06. Chipper combination

Chipping

A woodchipper has a fixed steel blade with knives on it which spins at high speed. These knives cut the stems or branches and treetops into chips which are blown out of the chipper via a chute (07). Chippers have a self-feeding system and an integrated sieve to 'catch' chips which are too large and make them go through the chipping-mechanism again. Some chippers move on their own, some have to be moved, some have to be fed by a crane, some by hand, depending on the capacity, its size and the to-be-chipped material.



07. Chipper and tractor with crane

Another option to make woodchips is with a shredder. The difference with a chipper is that a shredder 'beats' the stem (but also for example the roots) into shreds and the chipper cuts it, which creates a whole different quality of end-product.

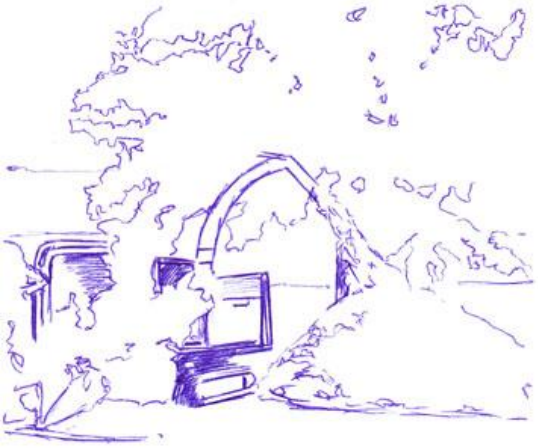
At this moment there are four options the recently chipped wood goes;

1. Chips are blown into a container
2. Chips are blown in a pile on the ground at the landing
3. Chips are blown into a standby truck
4. Chips are transshipped from the bulk carrier (from the chipper combination) into a container, on the ground at a landing or in a standby truck.

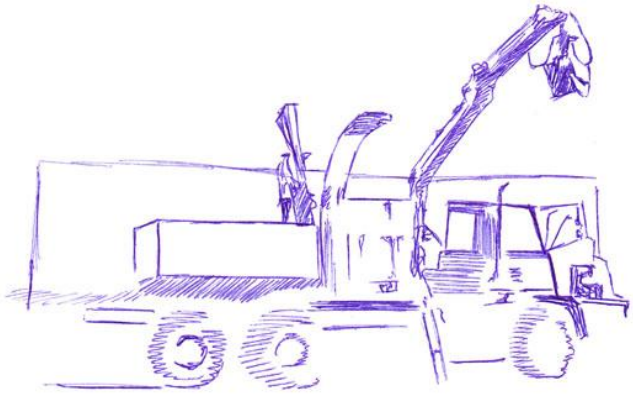
08. Container

Option 1
Containers (08) are placed at the landing near the logs, or piles of branches and treetops. With this option the chipper can work continuously. When a container is full, a truck has to come to move (or pick up and transport) the full containers because of little space in the forest.

Option 2
The chips are blown in a pile (09) on the, preferably paved, ground. A crane is needed to move the chips into the transportation vehicle. This crane can be integrated in the transportation vehicle or one has to be hired separately. A shovel is needed to make neat piles of chips. This is important because the form of the pile decides largely how quick and how well the chips dry.



09. Chips in a pile



10. Chips in truck

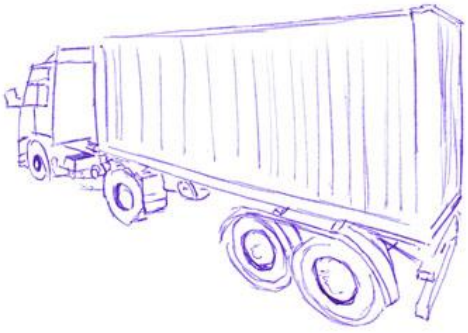
Option 3
The chips are blown into a truck (10). This can be a combination vehicle -often with an extra trailer- or a walking-floor vehicle. More about these vehicles can be read in the next chapter.

Option 4
The chips are transshipped from the chipper combination into a ready standing combination-vehicle, walking-floor, a container or on the ground.

2.3 Transportation

The following four means of transport are used when transporting chips:

1. Combination vehicle
    a. Tractor with container carrier
    b. Container truck
2. Walking Floor truck
3. Ship

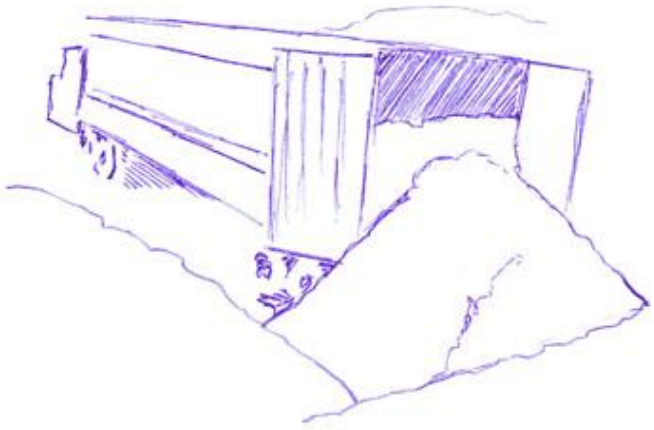


11. Container truck

Option 1
The combination vehicle is a vehicle composed of two (or more) separate units, being a tractor or truck with a trailer behind it (11). These trailers have the possibility to carry containers and can tilt, tip or roll-off. The combinations with the tractor as pulling device are most

maneuverable in the field. They are the slowest on the road and thus most commonly used as transportation in the field. The container combination most often used is a 2x40, this means two containers with the capacity of 40 m3 each. This vehicle weighs unloaded about 24 tons and can thus carry 26 tons of chips before crossing the maximum GVW (gross vehicle weight) of 50 ton that vehicles may weigh on the Dutch roads.

Option 2
A walking-floor vehicle is a vehicle with an ingenious system of moving floor panels to quickly unload loose material (12) without having to tip the trailer or tilt the floor. This vehicle is most profitable option for the road over great distances because of its size. A walking-floor vehicle weighs unloaded about 16 tons, this means it can carry 34 tons of chips before crossing the maximum GVW (gross vehicle weight) of 50 ton that vehicles may weigh on the Dutch roads.



12. Unloading a walking-floor

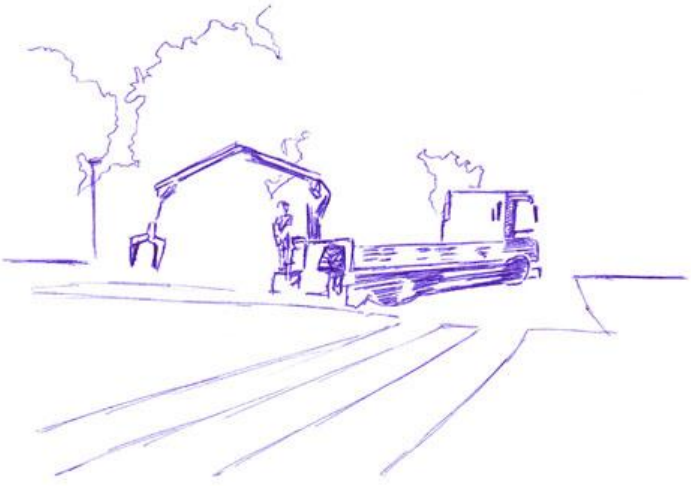
Option 3
When the possibility of unloading at or near the customer at a quay is there, chips can be transported over the water. First the chips are transported over road and then further over the water. Transport over water is a more energy efficient way of transport than road transport with trucks, because of the lesser CO2-emision per ton carrying kilometer. An exception is of course when distance between forest and quay are that long, the truck could as easily drive to customer. Transport over water is also more efficient because of the amount of chips a boat can transport at once, what is an advantage per se. Disadvantages are that a ship has to be loaded quickly so chips have to be ready on the quay, but a quay cannot be occupied too long.

Transport to a foreign country

This is a fairly common option but there is an important extra limitations to take into account: the different maximum freight amount. The maximum GVW (gross vehicle weight) in the Netherlands is 50 ton, in Germany only 40 ton en in Belgium and Denmark 44 ton.

Circumstances

Matters that increase the costs of the production of chips are the conditions of the soil in combination with the season. The rent and transport of steel plates (13) is needed to make the site accessible for heavy machinery and protect the soil. Most contractors own these plates themselves. Another cost can be caused by the necessity to place signs and/or fences to warn roads users or recreationists.



13. Plates in the field

A matter that decreases costs is the possibility over long distances to pick up a return-freight which lowers the costs for transportation substantial.

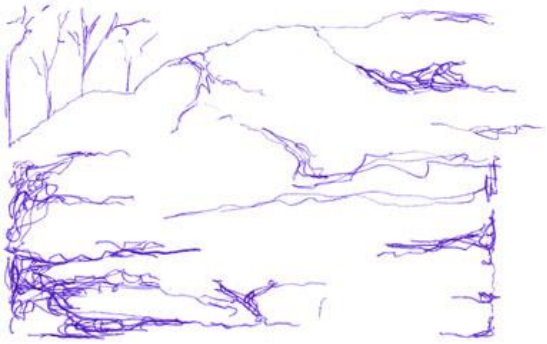
The amount of chips transported is determined by weighing the transport vehicle. Most transport-vehicles have an internal scale but this is said to be inaccurate. Thus most trucks drive to a weighing point to determine the weight of the chips they carry. The truck or truckload is often weighted again at the customers' to get a reliable reference. Boats measure the load they carry by looking at a scale on the outside of the chip how much it sunk after loading.

2.4 Storage

When the chips cannot be transported at once, cannot be sold at once or when they are intended for sales at a later time, they are stored. There are two possibilities when it comes to storing chips. They can be put into temporary depot or brought to a permanent depot.

Temporary depot means that the chips are stored near or on the working site in a pile on the ground (14). This way of storage is not always possible and the size of the storage area is limited. Staatsbosbeheer possesses permanent storage depots for chips in the Netherlands. One is situated in Flevoland and the other in Noord-Brabant.

These depots assure delivery in times when there are no or not enough chipping-projects active. Or they function as source for delivery to clients nearby a deposit-site. A crane or shovel is needed to load the chips into trucks and a shovel to clear the premises.



14. Storage in the forest

Circumstances

When needed, road, grass or field are to be cleared from chips. This will cost the rent of a shovel or simple brooms and working hours to do so.

2.5 Sales

Clients

Staatsbosbeheer has regular customers and sometimes new ones are added. The clients of Staatsbosbeheer are situated in the Netherlands but also in Germany and Belgium or further away. The companies that chips are sold to are mostly power (and heating-) plants and companies (15.) that process the woodchips. These last companies change the properties of the woodchips to obtain a better quality for combustion via for example torrefaction- of pyrolysis.

15. Power-plant

Requirements

Different clients have different requirements. Differences in size, heterogeneity of the chips, moisture content and ash-content, way of supplying and volume of supplying. A common requirement is no 'pollution' of the chips with sand or unnatural materials. Most clients do not want to see any 'green' in their chips too, meaning needles or leaves.

And most recently a new requirement has been asked for: an official standard. Although SBB and its forests are FSC certified this certification does not apply to the woodchips produced. The one certification used by SBB is the Green Gold Label (GGL). The GGL is a certificate scheme for sustainable biomass. On account of customers needs, SBB is at this moment striving to get their woodchips certified according to the NTA 8080 by the end of 2011. The NTA 8080 is a norm for sustainable produced biomass.

Sales

Most of the sales are done via contract. These contracts define the total amount of chips to be delivered in one year. The planning of deliverance is made during the year, via telephone when freights are ready and customers are capable of receiving. The contract also states for what price chips are sold and if they are sold per ton or per GJ.

3 THE MAIN VARIABLES AND THEIR INFLUENCE

In the following chapter the main variables will be defined. There are so many variables all together that, to say something reasonably, only the most important ones are defined. Per subchapter is described what the certain variables are, if they are influenceable, in what way and if this is measurable. Also something will be said about their influence on the cost price.

3.1 Main variables production

3.1.1. The chips

The chips from SBB are mostly meant for combustion (in regard of energy). The flammability is affected by species, moisture content, temperature, dimension and type of wooden structure[6]

As illustrated in the table below woodchips have certain characteristics and properties, there are more known but these are the most important ones. Particle size and moisture content are in this case most interesting because they are influenceable somehow.

The variables of woodchips

Variables chips	**Influenceable**	**Measurement**
Net Calorific value	NO	MJ/Kg
Particle size	YES	P16, P45, P63, P100[7]
Moisture Content	YES	M20, M30, M40, M55, M65[8]
Ash content	NO	A0.7, A1.5, A3.0, A6.0, A10.0+[9]

Calorific value

The calorific value is not influenceable because it is uniform for each species. But it is important in relation with other variables explained later in this chapter and thus defined here. The calorific value of a fuel is the amount of energy released during the complete combustion of a mass unit of a fuel. Not all energy can be used because of the moisture content in wood. The evaporation of this water costs energy which lowers the value considerably. The net calorific value of woodchips is the amount of energy released without the loss of energy through evaporation included. The NCV is for all species on average 19 MJ/kg. It is a bit higher for conifers than broadleaves due to the higher lignin-, resin-, oil- and wax- level. The NCV per kg is calculated for oven-dry wood[10]

[6] Tsoumis, George T., *Science and technology of wood: structure, properties, utilization,* Van Nostrand Reinhold, 1991

[7] The European Committee for Standardization, *Standard for the defining of biomass (CEN/TS 14961),* 2005

[8] The European Committee for Standardization, *Standard for the defining of biomass (CEN/TS 14961),* 2005

[9] The European Committee for Standardization, *Standard for the defining of biomass (CEN/TS 14961),* 2005

[10] Tsoumis, George T., *Science and technology of wood: structure, properties, utilization,* Van Nostrand Reinhold, 1991

Particle size
The size of the particles is important in regard of the combustion- speed and ease. Biomass installations are designed for a particular uniformity of chips. Chips from SBB are sold mostly as P100. This means that the particles can be 100 millimeters at maximum, often they are smaller but the number is just to give a maximum and not often a different standard is asked for. A specific size can be obtained by placing a specific sieve in the chipper.

Moisture content
The moisture content of woodchips is important in regard of combustion because, obviously, water does not burn. Moisture in chips reduces the amount of energy that can be obtained because of the energy needed to evaporate the moisture first. In contracts a certain bandwidth of moisture is allowed (for example, between M40-M55). When chips are freshly cut, with each day, the woodchips will lose moisture, depending on how much sun, rain and wind can get to them. This is different for chips in the same pile, depending on if they lay on the bottom, top, wind side, etc.

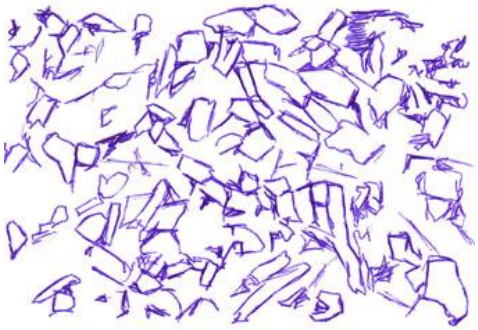
So the drought of chips is influenceable until a certain level and quit important in regards of storage, transport and sales as will be explained later in these chapters. The moisture content can be measured with special equipment.

Ash content
The ash content is important because this is what will be left over after the chips are combusted. Ash is waste what companies need to pay for to discharge. Just like with the MC, the tolerable amount is secured in a contract. The ash content can be measured with special equipment.

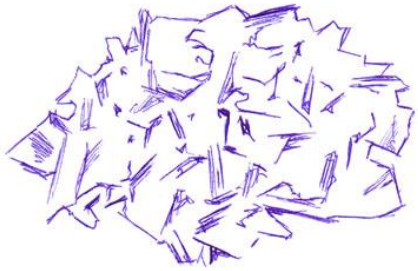
3.1.2 Possible pollution of the chips

Surely pollution of the chips is unwanted but unfortunately sometime inevitable. Often polluted chips are sold with a discount.

'Green' in chips
In a pile of freshly chipped tree- tops and branches sometimes 'green' elements can be perceived (16, 17). These are leaves or needles, and most customers dislike this sight because leaves have a lower combustion level (needles higher!) than woodchips and the chlorine, sodium and potassium, just like with needles, is corrosive for the ovens. Usually the amount of 'green' is not specifically measured but done at sight. Leaves in chips is an exception because most harvesting takes place in the months the trees do not carry leaves. Reducing the amount of green can also be done by a sieve or by blowing needles of somewhat dried treetops and branches before chipping them. There are chippers that have this 'feature'.



16. 'Polluted' chips



17. High quality chip

Sand in chips

Sand in chips is also an unwanted item in chips. It is almost inevitable with the standard way of chipping that branches/treetops that lay on the ground get sand on them. This is also the case when chips are blown into a pile on the (unpaved) ground, the ones at the bottom will get dirty. This can aggravate when it for example rains of trucks drive by these piles and splash mud. Only with the earlier explained way of cutting and immediately chipping the trees into a container they will not get polluted. The sand will increase the amount of ash. Usually chips with a large amount of sand in them will be declined by the customer or are sold with a discount.

3.2 Main variables logistics

3.2.1 Chipping method

With the chipping method is meant: the place where chips are blown in (truck, container) or on (the ground). As outlined in chapter three, the recently chipped wood can be captured several ways. Sometimes the site only allows or excludes one specific way and sometimes it is bound by the machinery available from the contractor. But mostly it is a choice from the biomass-coordinator in consultation with the contractor (and transporter) depending on the follow-up step of transport.

The different methods of chipping have their own advantages and disadvantages.

Advantages and disadvantages per chipping method

Chips in container:	**Chips in a pile on the ground**	**Chips in a stand-by truck**
+ chipper can work continuously	+ chipper can work continuously	- Occasionally chipper has to wait on truck
+ Transportation does not have to wait until loaded	- Transportation has to wait until loaded	- Transportation has to wait until loaded
- Occasionally extra: truck to move the containers	- Occasionally extra: crane to load transportation	- Road has to drivable
- Containers take in a lot of space in the area	- Extra: shovel to make neat piles	+ Chips are transported directly
	- Extra pollution of the chips because of laying on the ground	

A chipper is an expensive machine when it cannot be used for what it is build for and there are a few real scenario's when that happens. Hold-up due to machinery breakdown, traffic jams, in between filling more trucks, etc. Smart planning cannot guarantee these things not to happen and the only prevention is to let the chipper function apart from other steps of the chain. This is the case when chipping in a pile on the ground or into a container in the field.

The method of chipping is influenceable because it is a decision made between the biomass coordinator, harvest coordinator and contractor. Depending on different criteria like; destination of the chips, speed of transport or soil or availability of machinery, etc. Which method is best is not measurable but comes forth out of earlier steps or is made in accordance to steps to follow in the chain of biomass.

3.2.2 Transportation

When planning transportation the following circumstances are important; the total amount of chips to be transported, the availability of transportation vehicles, accessibility of the area, the distance between source and depot or customer, the drought of the material (with reference to the weight) and the possibilities of unloading.

Variables concerning transport

Variables transportation	**Influenceable**	**How**
Amount of chips to be transported	YES/NO	Depends on customers wants and how much is available
Accessibility of the area	YES/NO	Depends on soil, weather and weight- and type of tires of transport
Distance to customer or depot	YES	Choice of biomass coordinator
Drought of the chips (i.r. to the weight)	YES	Through storage
Possibility of unloading	NO	Depends on customer

The amount of chips to be transported depends on what the customer wants and how much is available. The bigger the amount of chips and the longer the distance they need to be transported, the more cost-efficient it is to use a way of transportation that can carry vast amounts.

When having bad weather and susceptible soil it becomes difficult or even destroying to enter the terrain with heavy vehicles. Three choices follow; 1. Wait for better weather conditions or 2. Protect the soil with steel plates or 3. Choose for a lighter form of transport. The choice will depend on the conditions.

The biomass coordinator knows at what place and when chips will be ready and knows what customers need. This is the way transport is planned. Preferably chips are transport to the customer most near a chipping site.

The drought of the chips in the case of transport is important because of their weight. The lighter the chips, the bigger amount of chips can be transported. This until the point the transport can carry nothing more. This is again depending on the capacity of the transportation vehicle and the maximum load it can carry (which again can vary if the transport goes to a foreign country). Apart from this it is off course the question what the customer wants. At least, dryer chips can be obtained through storage what will be discussed in the following sub-chapter.

There are two main ways of transporting chips; with trucks by road or over water with (a) boat(s). They both have their own advantages and disadvantages per se and in comparison to each other.

The biomass coordinator decides which way the chips are transported, this in consultation with the transporter and in regard of the customer.

<u>Road transport</u>

Truck  Customer

A truck drives from the site where it picked up the woodchips straight to the customer. The calculation of costs for traffic by road than goes as follows:

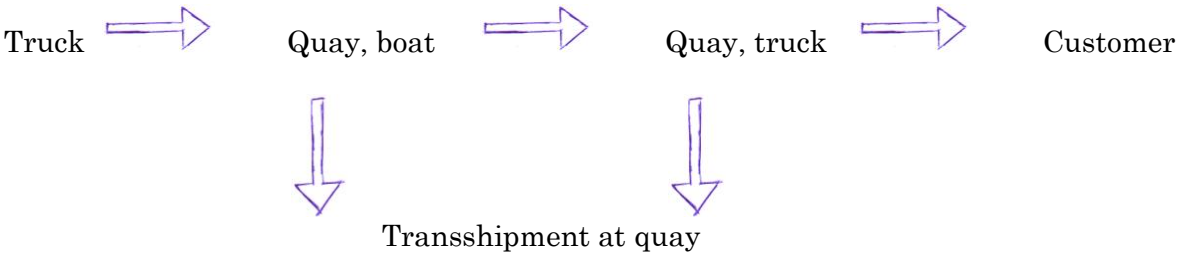
Costs vehicle * kilometers per vehicle * number of vehicles

Vehicle costs including: man hours, fuel and lubricants, etc.

The pro's and con's of transport by road

+	-
Product goes straight from the working site to the customer	Worst for the environment concerning CO2 emission[11]
Flexible in choice selection of route	possible delay due to traffic jams
Quick unloading	
Chips are protected from weather influences	

Water transport



Here the truck carrying woodchips goes to a quay were a boat is waiting and unloads its freight there. It is than transshipped into the boat who sails to a quay near the customer. It there unloads the chips, or on the quay or into a ready standing truck who drives the chips to the customer. The calculation of costs for traffic over water by boat than goes as follows:

Forest > harbor:	Costs vehicle* kilometers per vehicle * number of vehicles
Load:	Loading costs * demurrage * hours (or days)
Water transport:	Costs boat * kilometers (or hours)
Offload:	Offloading costs * demurrage * hours (or days)
Harbor > customer:	Costs * number of vehicles

The pro's and con's of transport over water

+	-
Can transport vast amounts at once	Transshipment costs extra money and time
Least damaging for the environment concerning CO2-emission[12]	Sluice-costs
	Dependable on location of harbor

[11] http://www.transport-online.nl/site/transportnieuws/index.php?news=6416
[12] http://www.transport-online.nl/site/transportnieuws/index.php?news=6416

3.2.3 Storage

In the first place, storing can be a choice based on stock management. Another reason for putting chips into storage is, when chips cannot be sold directly. As said in chapter 2.4 there are different ways of storing chips. But important for the cost price is the choice or must to store chips and the consequences it has.

Effects of storage on chips

Quality	Possibility of rot
Moisture content	Will decline
Calorific value	MJ/Kg will increase
Size	Will shrink (insignificantly)
Color	Will turn more dark

A process of chips in storage is that freshly chipped wood causes heating. This until the point that chips in the middle of the pile get so warm the process of rot starts and causes mass loss. The extend and speed in which this happens is different for each pile of chips depending on the weather, wood species, underground, optional covering or roof, 'pollution' of the chips with needles/leaves, etc. According to the following summary, per moisture percentage chips have a maximum storage period.

Maximum storage period according to moisture content

M10	long-term storage (under dry circumstances)
M20	long-term storage
M30	maximum a year of storage
M45	maximum a month of storage
M50	only ventilated storage[13]

A thing that also changes with chips in storage is that the moisture content will drop. Provided that it is not raining or chips are protected against weather conditions. The chips will get lighter in weight with the loss of water which is favorable in the case of transport because more chips can be transported at once, as told in the preceding chapter about transport. The heating value per Kg gets higher with the loss of moisture and when sold per GJ (instead of per ton), the chips are worth more per Kg.

The change in size that happens due to the loss of water during storage is so minimal that it is not important.

The changing of color is only an physical change and also neglectable.

Apart from the physical changes of the woodchips during storage it is a fact that storage always increases the cost-price. This because of the extra handling costs of loading a truck and transporting (when in permanent depot) the chips from the place of depot to the customer. Plus, in the case of permanent depot, the cost of the rent of the terrain or shed to store chips. Storage could be made profitable when chips are sold according to their calorific value. But this is all depending on the conditions in the contract.

[13] BioMassaal 3e uitgave, *Biomassa als bron van energie*, Renovius nv, Overpelt.

3.3 Main variables sales

3.3.1 Contracts

Sales are done via contract or per single order.

Contracts are mostly yearly contracts with a fixed amount of chips to be delivered in that year for a certain price. Specific dates are never mentioned because this depends on the more or less unstable needs for chips.

When it is known by a harvest-coordinator that appropriate chips will be available soon, he gets into contact with the biomass coordinator who gets into contact with a customer. They discuss date of delivery and maximum freights a day, and when not specified in the contract, quality of the chips. This way of sales leads to a certain amount of freedom but also responsibility in planning.

Harvest coordinator ⇒ biomass coordinator ⇒ customer

With un-scheduled orders the biomass coordinator gets in to contact with the harvest-coordinators to see if there are chips available somewhere that fit the specific requirements of this customer. If this is not the case, the biomass coordinator will see if there are chips in depot somewhere and make a deal.

Customer ⇒ biomass coordinator ⇒ harvest coordinator

These un-scheduled orders collide with the orders on contract. The biomass-coordinator has to be sure enough chips are available for the customers on contract before selling chips un-scheduled. This is done by keeping chips in depot and the planning of chipping projects.

3.3.2 Planning

The planning of the sales of chips is important because of a few factors; the Flora- en faunawet, contract-fulfillment (preliminary subchapter) and seasonally features that influences the process of biomass.

There is an important Dutch law which influences the harvest of biomass called the 'Flora- en faunawet'. By this law a lot of domestic animal- and plant species are protected. This law states that work in the forest needs to be done according to the 'Gedragscode Zorgvuldig Bosbeheer' and one of its prohibitions is that almost no work is allowed in the forest during the breeding season between the 15th of March and the 15th of July[14]

Although less chips are needed during summer months, the need for it does not completely stop during these months. And more important is the fact that companies start buying chips (or request them upon contract basis) at the end of the summer with the coming months in mind. This 'problem' is solved by storing chips to assure delivery in the summer months. Some seasonally features make it necessary for activities to take place on a specific time in the year. For example: heavy machinery cannot go into the

[14] Het Bosschap, *Gedragscode Bosbeheer 2010-2015, hulpmiddel bij het naleven van de Flora- en Faunawet*, Driebergen, december 2010

forest with heavy rainfall because of damage to the soil or harvest should preferably not take place when all leaves are still on the trees because of unwanted 'green' in chips.

Another variable within planning is the option on booking a return freight. Meaning, when a transporting vehicle unloaded its freight, it picks up another freight to return home with. This requires serious planning but when possible, minimizes costs quit much. Especially on transporting over long distances.

3.3.3 Sales price

Woodchips are sold per ton or in GJ per kg. This can make a difference in price per weight. Chips are usually sold directly, thus fresh (forestry jargon: green), meaning the MC is relatively high and they are thus sold per ton. But some customers pay for the NCV of the chips and in this case it would be profitable when chips are dryer.

When sold per ton it is favorable that chips are sold as fresh as possible. The moisture content is than high and they will thus bring in more money. When sold per GJ it is favorable that the chips are as dry as possible so that the calorific value will be higher. There are limits on both sides. It is not the intention to put chips in water before sales and there is also a limit on extra money that can be earned with GJ/Kg.

3.3.4 Certifications

There are several certifications available for woodchips. Although SBB and its forests are FSC certified this certification does not apply to the woodchips produced. The one certification used by SBB is the Green Gold Label (GGL). The GGL is a certificate scheme for sustainable biomass and only sold to on customer at this moment.

On account of customers needs, SBB is now striving to get their woodchips certified according to the NTA 8080 by the end of 2011. The NTA 8080 is a norm for sustainable produced biomass[15]

[15] www.staatsbosbeheer.nl

4 CONCLUSION AND RECCOMENDATIONS

4.1 Conclusion

The way to tune all the variables concerning biomass into each other is, in one word, planning. Planning is the key to everything. Unfortunately this is easier said than done due to the many different circumstances surrounding the different steps in the chain of biomass. All is now done by one person at SBB, by experience. It was quit the task to gather all the variables, which gave to realize what a task it must be to handle them all.

The most important variable concerning production is the woodchips and their influenceable properties. These are their size, which is influenceable by choice, and its moisture content, which is influenceable through storage, which is influenceable by planning so. There are laboratory methods for measuring these properties and an European standard for defining them.

The most important variables concerning logistics are the chipping method, transportation and storage. The method of chipping is dependable on the follow-up step: do (and can) the chips stay in the forest (storage) or not (when sold or going to permanent storage). So this is not totally influenceable but depends on the customer or/and the choice to put the chips in storage. The way of transport depends on which way is most beneficial in terms of money. The choice lays between road or water transport. It is measurable when all circumstances are taken into account. Storage is done to assure delivery on all times or when chips cannot be sold (favourable) directly. Storage can influence the sales price, there are set amounts for calculating this. Storage makes the cost price rise.

The most important variables concerning sales is planning. This pretty much covers all variables because most are influenceable through choice. And for the ones not-influenceable, they have to be planned around. The key to planning is in the hands of the biomass coordinator.

The variable most influencing the cost price is transportation, the variable most influencing the sales price is storage.

It is nearly impossible to develop a model with all the variables covered, even with only the main ones. But it would be enormously serviceable to have such a model. It would take more input from SBB, their specific needs on specific occasion and customers, prices, dates, places, quality's and so on to design such a model. And a programmer with understanding of modeling.

4.2 Recommendations

In this chapter some recommendations are done. These recommendation come forth out of the research after all the variables concerning biomass. Most of the recommendations sprung from the simple question, why are things not done via this or that way? Recommendations are grouped per theme.

Production

The harvest of whole (unrendable) trees and transportation of them to a central depot. This instead of leaving chips in the forest with the change on rot or protected animals

housing in a pile. The benefit always being able to produce woodchips and the prolonged storage period because of not chipping the logs. Maybe this is possible at one of the current storing sites, otherwise a depot should be found.

The planting of a coppice (or sprout) forest is another recommendation. A forest destined for the production of biomass with benefits being a vast source of biomass.

Storage

Benefits of a storage site is being able to assure Just-In-Time delivery, quantity (through collection) and quality (through mixing and drying) that the customer wants. Bu one or more extra storage sites in the Netherlands would not be to much. With extra sites more demands could be fulfilled in a cheaper way because of the positioning of the storage sites being spread over the country. Smart positioning would be in the South and West of the country and for example at a quay somewhere. This possession of own storage sites spread over the Netherlands has a big effect on sales because of being in control of the quantity and quality of woodchips and being able to assure this to customers. A higher price could be asked for a better quality of chips. It is also beneficial in means of the environment. The downside on possessing an own storage site(s) is the costs for the rent of the terrain and the extra handling costs of machine's to look after the premises.

Planning

To deal with the subject planning an automated program for biomass with exactly the amount and quality of woodchips that will be produced combined with customers needs, with dates and places combined in it. On one side the biomass coordinator puts in customers' needs and on the other side the harvest coordinators put in what will be available. Data needed: the quality, quantity, dates and addresses. The program would than link one to another and release a big part of the job for both sides.

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